Routledge Open Business and Economics

CROWDSOURCING IN MANAGEMENT RESEARCH

A NEW TOOL FOR SCIENTIFIC INQUIRY

Regina Lenart-Gansiniec

Crowdsourcing in Management Research

Crowdsourcing in Management Research explores the evolving landscape of academic research in the context of contemporary legal, social, cultural, and technological shifts. The book delves into the intricate processes and challenges associated with managing crowdsourcing initiatives in science. It sheds light on the essential competencies required by those initiating crowdsourcing projects, offering practical insights for effective implementation. Furthermore, the text explores the future directions of crowdsourcing in science, considering the influence of emerging technologies such as blockchain, digital storytelling, gamification, metaverse, augmented reality, and artificial intelligence. As one of the few comprehensive resources available, the book serves as a valuable guide for scholars, researchers, and graduate students interested in crowdsourcing paradigms. It emphasizes accessibility by avoiding unnecessary jargon and caters to non-specialist readers, including booksellers and librarians. The geographical and temporal relevance of the work is underlined, providing a contemporary perspective on the subject. The inclusion of well-known and topical case studies enhances the book's relevance, while groundbreaking content ensures its significance in the rapidly evolving field of management research.

Regina Lenart-Gansiniec is an Associate Professor in the Institute of Public Affairs at the Faculty of Management and Social Communication of the Jagiellonian University in Krakow, and doctor habilitatus in economic sciences in the field of management sciences. She is the author, co-author, and editor of monographs and about one hundred and twenty-five Polish and foreign scientific articles devoted to the issues of management, especially crowdsourcing, knowledge management, and organizational behaviour. She is also a principal investigator and participant in eight international research projects and a reviewer and member of the Editorial Board of many recognized scientific journals and scientific conferences in Poland and in the world.

Routledge Open Business and Economics

Routledge Open Business and Economics provides a platform for the open access publication of monographs and edited collections across the full breadth of these disciplines including accounting, finance, management, marketing and political economy. Reflecting our commitment to supporting open access publishing, this series provides a key repository for academic research in business and economics.

Books in the series are published via the Gold Open Access model and are therefore available for free download and re-use according to the terms of Creative Commons licence. They can be accessed via the Routledge and Taylor & Francis website, as well as third party discovery sites such as the Directory of OAPEN Library, Open Access Books, PMC Bookshelf, and Google Books.

Note that the other Business and Economics series at Routledge also all accept open access books for publication.

Digital Transformation in Educational Organizations
Leadership, Innovation and Industry 4.0
Paweł Poszytek

Philosophy and Leadership
An Evolution of Leadership from Ancient Times to the Digital Age
Lukasz Sulkowski, Zdzisława Dacko-Pikiewicz and Katarzyna Szczepańska-Woszczyna

Crowdsourcing in Management Research
A New Tool for Scientific Inquiry
Regina Lenart-Gansiniec

For more information about this series, please visit: Routledge Open Business and Economics - Book Series - Routledge & CRC Press

Crowdsourcing in Management Research

A New Tool for Scientific Inquiry

Regina Lenart-Gansiniec

Routledge
Taylor & Francis Group
NEW YORK AND LONDON

First published 2024
by Routledge
605 Third Avenue, New York, NY 10158

and by Routledge
4 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

Routledge is an imprint of the Taylor & Francis Group, an informa business

Library of Congress Cataloging-in-Publication Data
Names: Lenart-Gansiniec, Regina, 1978– author.
Title: Crowdsourcing in management research : a new tool for scientific inquiry / Regina Lenart-Gansiniec.
Description: New York, NY : Routledge, 2025. |
Series: Routledge open business and economics | Includes bibliographical references and index.
Identifiers: LCCN 2024007935 | ISBN 9781032770451 (hardback) |
ISBN 9781032772868 (paperback) | ISBN 9781003482253 (ebook)
Subjects: LCSH: Knowledge management. | Human computation. |
Organizational learning.
Classification: LCC HD30.2 .L455 2025 | DDC 658.4/038—dc23/eng/20240329
LC record available at https://lccn.loc.gov/2024007935

This project was financed from the funds provided by the National Science Centre, Poland awarded on the basis of decision number DEC-2019/35/B/HS4/01446. Translation of this publication and open access has been supported by a grant from the Faculty of Management and Social Communication under the Strategic Programme Excellence Initiative at Jagiellonian University.

ISBN: 978-1-032-77045-1 (hbk)
ISBN: 978-1-032-77286-8 (pbk)
ISBN: 978-1-003-48225-3 (ebk)

DOI: 10.4324/9781003482253

Typeset in Times New Roman
by codeMantra

Contents

Figures and tables

Figures

Tables

Introduction

Since 2006, crowdsourcing has been a promising and rapidly growing area of scientific and research inquiry. This growing interest is due, among other things, to the crowdsourcing potential for unlimited access to many heterogeneous sources of knowledge, creating asynchronous, transnational teams consisting of professionals from a given industry, scientists, and amateurs interested in performing a specific task. The basis of crowdsourcing is the wisdom of the crowd, according to which a group of people has broader knowledge than individual people and can therefore develop more valuable solutions. Moreover, thanks to the "parallel path" effect, tasks can be performed by a group faster and more accurately than if they were performed by one person.

With regard to crowdsourcing *per se*, in recent years, research attention has focused mainly on the potential benefits of crowdsourcing, its limitations, motivations and characteristics of the virtual community, and the functionality of online platforms. It has been associated with co-creation, open innovation, solving organizational problems, acquiring innovative ideas from the virtual community, development of new products/services, knowledge management, organizational learning, and creation values.

The above-mentioned potential of crowdsourcing *per se*, and also the legal, social, cultural, and technological changes observed for two decades, which force growing requirements and constantly modified expectations towards academic teachers, make both theoreticians and practitioners of management inclined to the possibilities of using crowdsourcing in the context of creating scientific knowledge. Crowdsourcing has the potential to enable research workers to engage in scientific projects with not only qualified experts or other researchers but also broadly understood members of the general public.

The indicated changes that are important for the creation of scientific knowledge are related to the need to intensify scientific productivity, build interdisciplinary, international scientific teams, scientific cooperation and openness, transparency, inclusiveness, and responsiveness of scientific research. In particular, it is emphasized that openness and transparency are to become norms for the scientific community. It seems equally important to include people from

DOI: 10.4324/9781003482253-1

outside the scientific community in the creation of scientific knowledge. The above-mentioned expectations and changes force scientific workers to look for ways of creating scientific knowledge that are complementary to the traditional ones and will enable the implementation of all expectations and postulates.

Moreover, the rapid development of information and communication technologies has become something more than only a catalyst for remodelling the way of creating scientific knowledge towards openness and transparency. Those technologies offer new opportunities to engage a wide range of people in the implementation of various research tasks, including collecting data, formulating research questions, or, more broadly, making decisions regarding research directions. The already mentioned rapid development of information and communication technologies is also a natural consequence of starting a discussion on the possibilities of using crowdsourcing to create scientific knowledge.

Additionally, the interest of scientific workers in the possibility of using crowdsourcing to create scientific knowledge was initiated by the popularization of the use of the Internet by scientific workers to conduct research and the growing potential of unlimited access to research participants, where, according to the data published in Internet World Stats, in 2009 the number of Internet users around the world was nearly 2 billion, in 2015 over 3 billion, and in 2021 over 5 billion.

In this approach, the creation of crowdsourcing platforms was also of great importance for the development of crowdsourcing in science. For example, in 2005, Amazon launched the Amazon Mechanical Turk (MTurk) platform, which is based on the crowdsourcing mechanism. Initially, the intention of its creator, Jeff Bezos, was to use the MTurk platform as a tool for organizations to assign simple tasks to members of the virtual community. However, the potential of this platform was also noticed by academics, and they began to treat it as a complementary way of conducting scientific research, implementing scientific projects, and as the strategy for organizing the work of researchers. The second most popular crowdsourcing platform, Prolific (https://www.prolific.co), was established in 2014. Since the very beginning, it has been strictly dedicated to scientists and intended to recruit respondents for scientific research. The following years, due to the interest of scientists in crowdsourcing, brought the development of further scientific crowdsourcing platforms.

Moreover, the development of crowdsourcing in science also results from the intensification of the "gig economy". It can be noted that in over 30 years, the so-called Gigers will dominate the labour market. It is also signalled that this trend also includes the creation of scientific knowledge. Finally, the COVID-19 pandemic has intensified the need to mobilize a large and diverse community, as well as communicate and collaborate in the acquisition and processing of scientific data using online solutions.

To sum up, the reported legal, social, cultural, and technological changes; the development of information and communication technologies; the use of the

Internet to conduct scientific research; the development of the “gig economy”; and also the COVID-19 pandemic, have made crowdsourcing in science the centre of attention of theory and management practices. Its potential stems from the fact that crowdsourcing allows researchers for going beyond the bubble of intra-university research teams, while ensuring results similar to those carried out using traditional scientific research methods.

Academics’ interest in crowdsourcing in science is reflected in the number of publications. However, despite the intensity, most of them still focus on the functionalities of crowdsourcing platforms and the possibility of using them to conduct scientific research. It is even said that the Amazon Mechanical Turk platform is one of the most and most intensively researched crowdsourcing platforms. In June 2022, the author of this book obtained the following results: 107,000 records (keyword: “Amazon Mechanical Turk”), and in January 2023: 110,000 hits (keyword: “Amazon Mechanical Turk”). These are usually articles, reports, book chapters, and books on, among others, data quality in relation to research conducted using crowdsourcing in science. These were also science blogs that included a guide to the Amazon Mechanical Turk platform. In addition, there are publications in which researchers describe methods for improving the quality of crowdsourcing data; analyse the demographics of people working on crowdsourcing in science platforms; and present the characteristics and functionality of the crowdsourcing platform, ways of recruiting virtual communities for scientific tasks, and present the possibilities of replicating the obtained results using crowdsourcing in science.

The intensity of publications regarding crowdsourcing in science initiatives and crowdsourcing platforms is accompanied by their practical application by researchers. The author of this publication identified 98 such publications in June 2022. Those articles were published in prestigious journals, including *Psychology & Marketing*, *Journal of Organizational Behavior*, *Management Decision*, *Information Systems Research*, *Management Science*, *Personnel Review*, *Leadership Quarterly*, *Academy of Management*, and *Journal of Business Research*.

Signalled changes, expectations, and trends in the creation of scientific knowledge, taking into account cooperation with other researchers and people from outside the scientific community, are reflected in the so-called “good practices” (e.g. Policy of the National Science Centre regarding open access to publications, Kodeks Etyki Pracownika Naukowego Polskiej Akademii Nauk), but also regulations and directives (e.g. Article 3, Point 2 of Ustawa z dnia 20 lipca 2018 r. Prawo o szkolnictwie wyższym i nauce; OJ 2022.574; Guidelines of the European Commission’s Community Research and Development Information Service; Responsible Research and Innovation, Science and Technology directives). Moreover, universities provide detailed guidelines and recommendations for researchers on their websites regarding the use of crowdsourcing in scientific work, for example: Lehigh University in Bethlehem (https://research.cc.lehigh.edu/crowdsourcing), Laboratory for Innovation Science at the University of Harvard (https://lish.harvard.edu/developing-best-practices-crowdsourcing), and UC Berkeley (https://matrix.berkeley.edu/research-article/crowdsourcing-social-research). And the ExCitesS group at University College London has developed a free open-access course titled "Introduction to Citizen Science and Science Crowdsourcing" (https://extendstore.ucl.ac.uk/product?catalog=UCLXICSSCJan17).

Considering the above, everything indicates that crowdsourcing in science is important not only from the point of view of researchers but also from the point of view of academics, the social environment, decision-makers, and publishers. Despite the undisputed growing popularity and potential benefits of academics using crowdsourcing in science to create scientific knowledge, the literature indicates that it evokes various, extreme emotions: from admiration to concerns and a cautious approach. Some supporters claim that crowdsourcing in science is a response to the indicated changes and new challenges faced by scientific workers. Other opponents claim that crowdsourcing in science is a kind of "digital store" based on the exploitation of members of the virtual community, because they perform work for a symbolic fee. In addition, concerns are raised about the quality of the obtained data, the threat of automation of scientific work using bots, fraud, violations of intellectual property rights, data theft, and identity. Opponents also talk about the insufficient potential of crowdsourcing for creating scientific knowledge and poor adaptation to the specific nature of scientific research.

Despite various, often contradictory opinions on the potential of crowdsourcing for creating scientific knowledge, it cannot be ignored that it is a research problem important not only from the point of view of theory but also from the point of view of practice – it is some part of the challenges and expectations regarding the openness of creating knowledge in scientific research. With regard to crowdsourcing in science, the vast majority of literature abounds in publications devoted to the potential possibilities of using a specific platform to implement various stages of the research process: from the conceptual phase to the empirical phase, ending with the deductive-application phase. The literature also provides a whole range of potential benefits and possibilities of using crowdsourcing in science including, among others, formulating research questions; collecting, processing, and analysing research data; inviting participants to surveys, research, experiments, panels, focus groups, statistical analyses, and transcriptions; testing research at an early stage; establishing cooperation and looking for collaborators for joint research; collecting assessments and opinions about the idea for the research project or article; solving problems arising from various research tasks; determining the reliability and generalization of results; and disseminating the results of conceptual or empirical research.

The literature also provides findings regarding not only the benefits for both academics and virtual communities, and society in the broader context, but also the barriers of crowdsourcing in science, profiling of crowdsourcing projects, potential and characteristics of members of virtual communities, ways of motivating them, the quality of the results obtained thanks to their work, and the possibility of their control and verification.

Our knowledge about crowdsourcing in science is still far from complete. There is some lack of empirical studies and theoretical knowledge constructions. The monograph fills the identified research gap, providing a lot of important information on crowdsourcing in science as a tool for research.

This book consists of five chapters. The first chapter is devoted to the origins of crowdsourcing in science. In particular, the essence of the democratization of science and its manifestations were presented: public participation in science and scientific openness. The next part presents the issues of scientific cooperation, its typology, and importance for research work. Then, some attention was paid to the technicization of science and its manifestations, including the Science 3.0 paradigm and the platformization of science. At the same time, it should be emphasized that the reasons for the development of crowdsourcing in science discussed in this chapter must be treated as inseparable, as they are strongly interconnected and constitute a comprehensive picture of the country's origins. Both democratization and pressure for scientific cooperation, technicization, platformization of science, and the evolution of crowdsourcing *per se* have a simultaneous impact on the development of crowdsourcing in science.

The second chapter dives deep into the concept of crowdsourcing as applied to science. It includes an in-depth exploration of the core principles behind crowdsourcing in science; a comparative analysis between the paradigms of crowdsourcing in science, citizen science, online citizen science, crowd science, crowd research, and open innovation in science; and a balanced discussion on the pros and cons associated with implementing crowdsourcing in scientific research.

The third chapter shifts focus to the practical aspects of running and managing crowdsourcing initiatives in science. This chapter serves as an indispensable resource for those seeking to navigate the complexities of managing crowdsourcing initiatives in the field of science. By providing a step-by-step framework, addressing challenges, and offering real-world case studies, it empowers readers with the knowledge and tools necessary to effectively lead and optimize crowdsourcing projects for scientific discovery.

The fourth chapter serves as a guide to achieving success in crowdsourcing in science endeavours. This chapter serves as a practical guide for researchers, project managers, and institutions aspiring to integrate crowdsourcing seamlessly into their scientific pursuits. By examining the essential competencies, understanding the researchers' mindset, and mastering the art of managing human resources, readers will be equipped with the knowledge and strategies necessary to navigate the road to successful crowdsourcing in the dynamic landscape of science.

The final chapter offers a forward-looking perspective on the challenges and growth trajectories in the realm of crowdsourcing in science. It presents an original proposal for future research directions on crowdsourcing in science, as well as considerations on the future of crowdsourcing in science in the opinion of the surveyed academics. By addressing contemplating potential scenarios, and examining the interplay between crowdsourcing and technological evolution, it serves as a compass guiding researchers, practitioners, and stakeholders into the exciting and ever-evolving realm of crowdsourcing in science.

The author of this book is aware that this book is a starting point for further scientific discussions on crowdsourcing in science, which is due to three reasons. First, an increase in the interest of academics in crowdsourcing in science can be observed – as evidenced by an increase in the number of publications in which academics use crowdsourcing platforms, scientific conferences, and, in general, scientific discussions. Second, some scientific journals out of hand reject texts in which research was conducted using crowdsourcing in science (e.g. the *Journal of Vocational Behavior*). Third, the attitudes or perceptions of crowdsourcing in science by academics are different: for some it is an innovative business model, for others it is a simple waste of time.

The author's intention is to provide an impulse for further discussions and scientific reflections on crowdsourcing in science and its potential, challenges, and limitations. And finally, due to the insufficient recognition of the sensitive topic of individual antecedents of crowdsourcing in science, the intention of the author of this book is to contribute to the discussion on the potential support for scientific workers in the field of crowdsourcing in science. Therefore, the book includes proposed implications for practice. Their aim is to provide scientific institutions with recommendations regarding support for academics who are considering or intend to use crowdsourcing in science.

1 Origins of Crowdsourcing in Science

There are many sources or reasons for the interest in and development of the concept of crowdsourcing in science. They refer, among others, to the conditions for searching for complementary ways of creating scientific knowledge (Eklund et al., 2019; Uhlmann et al., 2019), in particular, those initiated by the dynamics of the environment of higher education institutions, but also by constant social changes and the progress of information and communication technologies (Smart et al., 2019) aimed at technicization, including platformization of science (da Silva Neto, Chiarini, 2022). We can also point to the broader context of the origins of crowdsourcing in science related to scientific cooperation (Beck et al., 2022). Moreover, the evolution of crowdsourcing *per se* can be noted towards expanding its potential applications for the creation of scientific knowledge (Beck et al., 2022).

The aim of this chapter is to present the origins of crowdsourcing in science. However, according to the author, each of the above-mentioned reasons or circumstances should be treated as reasons or circumstances that happen simultaneously. They are interconnected, and their division in this chapter results only from the need for contractual structuring. When selecting them, the recommendations included in the scientific literature (Pelacho et al., 2021) and reports of THIS Institute (the research institution) (Lichten et al., 2018; Strang, Simmons, 2018) were followed.

The first part of this chapter focused on the democratization of science and its manifestations, such as public participation in science and scientific openness. The second part focused on scientific cooperation, its manifestations, and forms. The third and last part of this chapter is devoted to the technicization of science with particular emphasis on Science 3.0 and the platformization of science.

This chapter is based on two literature reviews conducted by the author. The first was an umbrella review that aimed at providing a general assessment of available publications on crowdsourcing in relation to management and quality sciences. The second was a systematic domain-based literature review of the concept using a framework approach concentrated on establishing the current state of knowledge on crowdsourcing and identifying future research directions in relation to this topic.

DOI: 10.4324/9781003482253-2

1.1 Democratization of Science

Democratization of science refers to opening of science to participation in creation of scientific knowledge by various stakeholders not only coming from the scientific community but also from the outside. Democratization of science also refers to the creation of conditions that enable members of society to participate in the implementation of research processes (Kurtulmuş, 2021). The basis of the democratization of science refers to epistemic justice, society's influence on various aspects of science, legitimization, inclusiveness, co-decision, common debate, mutual respect, and understanding the needs of all parties involved in the creation of scientific knowledge (McCormick, 2007).

The democratization of science does not refer to the influence of society on the results of scientific research (Plotke, 1997), but is associated with the need to disperse the sources of knowledge creation, to strengthen the responsibility of researchers for the effects of research, to open access to research results (Ziman, 2000), and to strive to blur the boundaries between scientists and people from outside the scientific community in the context of creating scientific knowledge and their involvement in creation of scientific knowledge (Collins, Evans, 2002). Moreover, in line with democratization of science, scientific research should take into account the current needs of society (Ziman, 2003).

Generally, several sources can be noted for the emergence and spread of the idea of democratization of science. In particular, they refer to:

1. questioning the autonomous vision of the "republic of science" by Polanyi (1962),
2. negating the ethos of science by Merton,
3. developing the concept of knowledge society,
4. developing the so-called "Science and Technology Studies",
5. disseminating postulates of the social orientation of science (Schroyer, 1984), and
6. developing the so-called "new economics of science" (Dasgupta, David, 1994).

These will be introduced below.

First, the signalled "republic of science" emerged in 1962 in an essay by Polanyi, Ziman, and Fuller entitled "The republic of science: its political and economic theory". In line with the authors' assumptions, the conduct of scientific research aimed at achieving specific social goals was criticized. It was also noted that the creation of scientific knowledge should not be organized by public authorities. However, its creation should be based on values including tradition, public freedom, and self-organization, which fits into the idea of the "invisible hand of the market", consistent with the classic model of economy by Smith (Festre, 2021). In short, Polanyi and his colleagues turned to the neoliberal, conservative analogy of the free market to explain scientific activity. Opponents of the "republic of science" claimed, among other things, that it is a utopian vision of idealized liberal democracy based on a free market economy of competing individuals, which may lead to an oligarchic struggle for influence and status quo conservatism (Redner, 1987).

Second, the democratization of science is often positioned in the context of questioning the Mertonian ethos of science. However, before the positions of researchers questioning Merton's norms are presented, it is justified to present the norms in question. They were first included in a short note by Merton published in 1942 under the title "A Note on Science and Democracy" in the first issue of the "Journal of Legal and Political Sociology". These norms, in Merton's intention, are guidelines that should be followed by every scientist when creating scientific knowledge. They are often referred to in the literature as "Mode 1", where the creation of scientific knowledge is linear only at the university level.

The signalized norms proposed by Merton constitute the basis of the "ethos of science" defined as "an emotionally charged set of norms and values that somehow bind an individual who deals with science. Norms are expressed in the form of guidelines, orders, preferences, and permissions. They are legitimized in terms of institutional values. These imperatives, transmitted through commands and examples and reinforced by sanctions, are internalized to varying degrees by the scientist, thus shaping their scientific conscience or, if one prefers a modern term, their superego" (Merton, 1942, p. 605).

Thus, Merton (1942) proposed four norms to regulate research activities including the following:

- Universalism – the creation of scientific knowledge is carried out in accordance with previously established criteria and principles.
- Communalism – the creation of scientific knowledge is possible thanks to cooperation between researchers.
- Disinterestedness – the activities of scientists are subject to rigorous objective criteria.
- Organized scepticism – researchers' work is supervised by criteria based on empirical and logical issues, not dogmas or personal beliefs.

The norms proposed by Merton were questioned over time. They did not seem to fit the modern understanding of the process of creating scientific knowledge. In response to Merton's norms, researchers formulated "counter-norms" that strengthen the role of the researcher and the importance of their personal beliefs (moral virtue of rationality and non-rationality), achieving rationality conditioned on the scientist's emotional commitment, social and psychological features (particularism), awareness of protective control during scientific work (solitariness), serving society (interestedness), and the scientist's faith in their work and doubt in the findings of other researchers (organized dogmatism)

(Mitroff, 1974). It was emphasized that science should lead to achieve social goals and be used to solve important current social problems.

Thus, in opposition to the creation of scientific knowledge in "Mode 1", in 1990, Gibbons and co-authors proposed the postulates of "Mode 2" (Newig et al., 2019). Some researchers refer to this mode as "post-academic science" (Ziman, 2000), "post-normal science" (Turnpenny et al., 2011), or "academic capitalism" (Slaughter et al., 2004). "Mode 2" is a response to the increasing pressure on researchers in the context of specialization, intensifying scientific productivity, and declining public trust in the results of scientific research. In this view, "Mode 2" postulates conducting scientific research to be more valuable if carried out in transdisciplinary and heterogeneous teams that include scientists and members of society. This is due to the fact that scientific knowledge should be practical and needs to contribute to solving social problems. This is also reflected in the triple helix model that provides for relationships between universities, industry, and government.

Then it was postulated that scientists should create creative knowledge environments, in which they would involve members of society and other interested entities in the creation of scientific knowledge. Scientists should use mechanisms of technology transfer and commercialization, which fits into the idea of "Mode 3". This is reflected in the quadruple and quintuple helix and post-normal science. The quadruple helix model indicates that the following four stakeholder groups should participate in the creation of scientific knowledge:

1 industry/business,
2 state/government,
3 recipients of media and culture, and
4 society.

In turn, the fivefold helix, in addition to those mentioned above, also includes the broadly understood environment in the creation of scientific knowledge. Both "Mode 3" and the quadruple and quintuple helix models fit into the idea of "post-normal science". Third, although the term "knowledge society" was proposed by Drucker in 1969, it was further developed in the mid-nineties by Mansell (1998) and Stehr (1994) (Välimaa, Hoffman, 2008). The concept of the knowledge society emerged in the literature under the influence of criticism of the concept of information society (Anderson, 2008). It was recognized that knowledge, not information or information systems, is valuable. The basis of the knowledge society is therefore knowledge as a resource that stimulates the development of the entire society and facilitates the creation of new economic and social configurations. In this approach, new valuable knowledge is created through the interaction of many people with similar interests (Backer, 1991).

Fourth, another contribution to the democratization of science is offered through the development of the so-called Science and Technology

Studies (Domènech, 2017). The relevant literature indicates that the emergence of Science and Technology Studies as an interdisciplinary field dates back to the publication of Kuhn (1962) entitled "The Structure of Scientific Revolutions". However, the publication is not the basis for the development of Science and Technology Studies, but it rather started some discussion on the possibility of defining patterns of conduct in creating scientific knowledge, taking into account social interactions. The field of Science and Technology Studies has emerged from many disciplinary roots, particularly anthropology, economics, philosophy, history, politics, law, and sociology (Jasanoff et al., 1995). Based on the essence of Science and Technology Studies, various stakeholders are considered to be experts and then they are invited to question scientists' findings and to identify new, previously unexplained scientific problems. To put it simply, Science and Technology Studies assume that the identification of scientific problems is possible by looking at the context of the phenomenon, taking into account the mutual exchange of observations and perspectives and the combination of scientific, technical, and social efforts, where members of society become co-creators of scientific knowledge. As a result, creation of scientific knowledge aims at looking for answers to questions about how the world is understood by various stakeholder groups, which allows for a broader perspective.

Fifth, in response to criticism of the postulates separating creation of scientific knowledge from current social problems, the postulate of social orientation of science emerged (Schroyer, 1984). This led to some discussion on the need to look for ways to support openness and cooperation in science, as well as more efficient and effective ways of solving social problems. Scientific knowledge indisputably existed in various contexts, conditions, and social dynamics and should therefore be socially constructed (Bijker et al., 1989). Moreover, for the creation of scientific knowledge, it is important to go beyond specialized research or scientific institutions (Gibbons et al., 1994), accumulate existing knowledge, and include people with various skills in scientific research on the basis of distributed cooperation. Therefore, it is necessary to involve many people in the creation of scientific knowledge, which will ensure the development of such knowledge and will also strengthen scientific knowledge potential.

Sixth, it should be noted that the increasing importance of democratization of knowledge is a consequence of the development of the so-called new economics of science, which is recognized in the literature as "one of the cornerstones of our understanding of the mechanisms of scientific openness and cooperation" (Beck et al., 2022, p. 2). The new economics of science "uses game-theoretic insights into incomplete information to synthesize the classic Arrow and Nelson approach in examining the implications of information characteristics for allocative efficiency in action research, on the one hand, with a functionalist analysis of the institutional structure, reward systems and behavioural norms of 'open science' environments – related to the sociology of science in the tradition of Merton – on the other" (Dasgupta, David, 1994, p. 487). Quoting the entire message of Dasgupta, David (1994) was important to show the multiplicity of perspectives that the new economics of science encompasses. It takes into account the issue of open science, creation, and dissemination of knowledge with the participation of many people. It was then noticed that knowledge-related processes were more costly and time-consuming when they were carried out by one person.

Additionally, the new economy of science questions the value of knowledge created only by research teams, which results from their limited resources. Moreover, it points to the need to open up science and organize research with scientists from various academic centres and with members of society. This may bring intangible benefits in the form of popularization of science and transparency of science, which may prove helpful in "shaping better scientific and technological policies" (Dasgupta, David, 1994, p. 518) and increasing scientific reliability.

Under the influence of the detailed and outlined changes, the traditional approach to conducting scientific research began to be questioned. In the traditional approach, researchers carry out individual research processes independently or in small research groups. It was then found that that method required greater allocation of intangible and tangible resources, which ultimately led to limited possibilities of implementing scientific projects. Moreover, that way of working significantly extends the time of conducting scientific research. Therefore, due to those limitations, it was indicated that it was necessary to create scientific knowledge in larger research teams, taking into account the interests of the community, the applicability of scientific knowledge, and maintaining a balance between the use of material and non-material resources.

All this means that the democratization of science assumes the need to build social trust in science, the researcher's entering into dialogue with members of society, and their involvement in making decisions regarding research tasks. As a result of the democratization of science, the following is observed: an increase in the influence of society members on various aspects of science, equal opportunities for access to the results of scientific research, and possibilities for members of the community to participate in the implementation of scientific research that they are interested in. Additionally, democratization of science increases the use of participation mechanisms by scientists, which improves the access and application of knowledge dispersed in society and identification of public needs. In this approach, science can become a public asset. Democratization of science is therefore associated with a two-way flow of information about scientific research and its results. This comes down to blurring the boundaries between researchers and society, conducting inclusive scientific research that will have both theoretical and applied value.

In addition to the indicated benefits, democratization of science allows for increased scientific productivity (Bakker et al., 2012), access to resources required to create scientific knowledge, better use of knowledge dispersed in society, and the emergence of alternative research paradigms, which allows researchers for delving deeper into a given research topic. Democratization of science is postulated in the literature as a remedy for society's growing scepticism and lack of trust towards science. Manifestations of democratization of science include, in particular, public participation in scientific research and scientific openness. They are presented below.

Public participation in science is considered to be "the newest paradigm that has become established in the academic sphere" (López-Pérez, Olvera-Lobo, 2018, p. 2). It refers to collaboration between scientists and members of the public in carrying out scientific projects. However, this participation is not only related to engaging the community in the implementation of various research tasks. In a broader perspective, public participation in science includes scientific creativity and public discourse. This comes down to dialogue, communication, but also transparency of the decision-making process and creation of science, as well as the significant influence of society on those decisions of researchers that have social consequences.

Public participation in science is a broad concept because it combines the above-mentioned dialogue, openness, but it also involves egalitarianism, communication requirements, scientific cooperation, social activism, and community involvement in all stages of scientific research.

The very concept of public participation in science began to develop in the 1960s with the emergence of movements postulating bridging the distance between the government and citizens and citizens' interest in participating in debates and making political decisions that affect them. Then, in the 1980s, there was some change in the relationship between science and public opinion, as the discourse expanded from participation of citizen groups in decision-making in the context of scientific issues to the participation of the society as a whole. The intention of public participation in science was then to build legitimacy for the work of scientists, but also to gain access to unique knowledge that was located beyond the boundaries of the university. Initially, the public was to be involved only in the risk assessment of scientific research, but over time citizens began to be involved in making scientific decisions.

Public participation in science, according to the literature, involves four levels that take into account public participation and involvement in scientific activities (Haklay, 2013). At the first level, participation is limited to providing resources only. In the literature, crowdsourcing is placed at this level, but, in the author's opinion, such an approach is excessively narrow. In both crowdsourcing in business and crowdsourcing in science, the involvement of community members may mean including them not only in individual research tasks, but also in the entire research process (not only in providing resources). The second level, according to Haklay (2013), involves inviting community members, after prior training, to perform simple tasks, in particular, collecting research data with the support of the researcher. The next level, called participatory science, involves engaging the public in collecting data without the help or support of the researcher. Additionally, members of the public can propose research questions. At the fourth and final level, both researchers and members of the public have an equal stake in creation of knowledge, and they are involved in decision-making regarding research ideas, data collection and analysis, publication development, and use of results. Hence, taking into account the definition of scientific crowdsourcing adopted for the purposes of this work, it is a manifestation of the highest level of public participation in science.

Society's participation in science, depending on the level of participation, may take various forms. In particular, they include contractual projects, contributory projects, collaborative projects, and co-created projects. Their specificity is briefly presented below.

- Contractual projects focus on directing research questions to the community, with limited opportunities for public participation. Scientists are mainly producers of knowledge, and members of society are its consumers (Bonney, 1996; Krasny, Bonney, 2005, Bonney, 2007).
- Contributory projects come down to scientists involving the public in data collection. Citizen science stands out among those projects (Bonney, 1996; Krasny, Bonney, 2005, Bonney, 2007).
- Collaborative projects involve scientists submitting research questions and a request for data collection to the public. In addition, members of the public may be involved in other research activities, such as developing and refining a data collection protocol, analysing, interpreting data, and presenting research results to other members of the public, scientists, and policymakers. Monitoring stands out in collaborative projects (Whitelaw et al., 2003).
- Co-created projects come down to public participation in designing individual stages of the research process. In co-created projects, members of the public sometimes formulate research questions and then, together with scientists, look for answers (Cornwall, Jewkes, 1995; Fernandez-Gimenez et al., 2008).

Taking into account the specificity of co-created projects, crowdsourcing in science is definitely one such example. Public participation in science provides benefits for both members of the public and scientists. First, for members of the public, the opportunity to engage in science projects contributes to the development of their science-related skills (Braschler et al., 2010), in particular, in data collection and analysis. Moreover, such participation may influence a change in the attitudes of society members towards science. They will have better understanding of its specificity (Devictor et al., 2010), which may ultimately contribute to increasing trust in scientists and their work (Fernandez-Gimenez et al., 2008).

From the perspective of academics, involving society in scientific research increases their ability to establish research cooperation and expands the scope and scale of scientific research and their integration. Due to the fact that the research process is opened to members of society, social needs are taken into account. Additionally, public participation in science contributes to increasing creativity in the research design process and the likelihood of applicability of scientific research results. Finally, such participation is also seen as a means to legitimize scientific research and reduce opposition to change by achieving broad social consensus.

Another manifestation of the democratization of science, apart from public participation in science, refers to scientific openness. In short, scientific openness is connected with the transformation that science is undergoing as a result of globalization and new technologies. It comes down to access of all interested parties to information and other resources, transparency of the resources used by researchers, exchange of knowledge between the researcher and society, and verifiability of the scientific research process.

Scientific openness is recognized in the literature as a kind of philosophy, a superior category of new forms of organizing scientific work, an element of science ethics, and the basis for the mandate of the science system to produce and disseminate new verifiable knowledge. In the scientific field, openness may be combined with social epistemology, which translates into sharing information with the public in order to increase the productivity and effectiveness of scientific research, conduct research replication, and obtain social support for scientific research. This is connected with the responsibility of scientists for the optimal use of public funds. Scientific openness also means transparency of the research process, which provides the opportunity to obtain scientific objectivity, research replication, as well as feedback from other researchers and people interested in research results. Scientific openness is a diverse concept. The umbrella term here is the concept of open science, which includes lower-level concepts, such as open access, open source, open archive, open data, open peer review, and citizen science.

Open science refers to sharing and developing knowledge through collaborative networks (Vicente-Saez, Martinez-Fuentes, 2018), which enables obtaining creative solutions to scientific problems, transparency in the creation of scientific knowledge (Wolfram et al., 2020), and involving people outside the scientific community (members of society, organizations, decision-makers) in scientific research (Ledford, 2015 Van Noorden, 2015), as well as disseminating and popularizing research results (Molloy, 2011).

Features of open science include transparency, openness, and reproducibility of the research process (Nosek, Bar-Anan, 2012; Nosek et al., 2012). Transparency is associated with peer review (Cook et al., 2018). Openness leads to sharing of research materials and data for better understanding, verification, improvement, and reuse (Molloy, 2011). Finally, the last feature of open science refers to reproducibility, which is related to replication and the ability to achieve consistency of research results (Silberzahn et al., 2017; LeBel et al., 2018).

Open science is associated with the possibility of increasing scientific credibility, citations of scientific publications, popularization of research results, potential possibility of finding collaborators, and sources of financing for scientific research (McKiernan et al., 2016). Open science provides objective credibility through formal correctness and reproducibility, which further builds public trust in science. In this way, open science refers to eliminating potential threats of falsifying scientific research. It also leads to building social consensus and enables access to free, high-quality, standardized data (Allen, Mehler, 2019).

Open access is one of the manifestations of open science (Bisol et al., 2014). This refers to public disclosure of new knowledge (Czarnitzki et al., 2015), including description of research designs, research protocols, and data (McKiernan et al., 2016); sharing knowledge about new discoveries and methods of obtaining them (Schmidt et al., 2016); and sharing ideas. In this approach, the scientific process becomes collaborative (Grand et al., 2016). As Scheliga and Friesike (2014) point out, open access to research resources speeds up the research process.

Open sources related to software development and the availability of source codes in a given scientific project make up another manifestation of open science. This provides all interested parties with the right to copy, modify, analyse, and expand the codes free of charge (Grand et al., 2016).

In turn, open archiving refers to placing documents or source resources, publications, or materials in publicly available, free scientific repositories (Castelli, 2003). This enables indexing, searching, and sharing of data sets.

Open data refers to collecting and then making available of diverse materials to all interested parties for the purpose of using those resources, without restrictions on copyright or use. In this sense, open data accelerates the research process by facilitating reuse and enrichment of data sets (Piwowar et al., 2007), detection of false claims and inaccuracies, replication (Ioannidis, Khoury, 2011), increasing citation rates, research impact (Piwowar et al., 2007), and building social networks (Wallis et al., 2013; Peters et al., 2016).

Open peer review refers to a process in which reviewers and authors know each other's identities during the review process. However, reviewers are not limited to researchers only. They may also involve interested members of the community (Ford, 2013). This is in opposition to reviewing in the "blind" model, where the author(s) of the publication and the reviewers are anonymous (Kriegeskorte, 2012). The "blind" peer review model is often criticized for bias and unfairness (Rath, Wang, 2017). However, in relation to open mutual evaluation, it is indicated that it allows for improving the reporting of research results and allows for eliminating works that do not meet standards of the scientific community in the field of scientific publications (Ford, 2013). In short, open peer review is related to transparency and openness of reviewing scientific publications with the aim of improving them.

Citizen science refers to scientific work undertaken by members of the public in collaboration with or under the guidance of professional scientists and scientific institutions (Booney et al., 2009) and partnerships between scientists and the public in scientific research (Mäkipää et al., 2020). It is also society's participation in the collection of large amounts of data (Lukyanenko et al., 2014; Levy, Germonprez, 2017) in order to increase the ability of science to respond to current social problems (Eitzel et al., 2017). In particular, citizens are invited by researchers to carry out projects in the fields of biology, geography, ecology, art, history, and education (Heigl et al., 2019). Indirect effects of citizen science include increased trust in science, public understanding of science (Doyle et al., 2018), and increased scientific knowledge of amateur volunteers (Brossard et al., 2005; Huang et al., 2008; Haklay et al., 2021).

To sum up, in accordance with the demands of scientific openness, in addition to transparency, exchange of ideas and knowledge, verifiability, and dissemination of scientific research results, the democratization of science emphasizes the need to bridge the gap between researchers and society. This comes down to expanding access and participation of various stakeholders in research processes and results (Bartling, Friesike, 2014; Gassmann et al., 2015). It is also important to build relationships between academic and community partners based on transparent expectations, needs, and benefits achievable by each party.

1.2 Scientific Cooperation

Another issue that may constitute a reason for researchers' interest in the issue of crowdsourcing in science undoubtedly refers to the postulate of intensifying scientific cooperation. It is certainly a natural consequence of the democratization of science. Additionally, it is indicated that scientific cooperation is a promise of scientific progress, which fits into the interdisciplinary research area called "Science of Team Science" (Hall et al., 2018). This area not only provides knowledge about the conditions for effective scientific teams, but also draws attention to the need to include, in addition to people from the scientific community, stakeholders from social, organizational, political, and technological environments in scientific cooperation. This will allow the researcher to gain access to diverse knowledge and a multi-perspective view of the research problem (Wieczorek et al., 2021).

The concept of cooperation itself refers to the performance of specific activities by many people. Cooperation is therefore organized work in which all participants share a common goal that is superior to various individual goals. In relation to scientific cooperation, the following terms can be noted in the literature: collaboration in science. Regardless of the nomenclature adopted, scientific cooperation refers to interactions between two or more scientists in terms of sharing knowledge, implementing research tasks or other mutual goals. The basis of scientific cooperation is communication and creating a climate of trust among collaborators.

In addition to the term "scientific cooperation", it is also possible to distinguish the following terms: collaboration research and academic collaboration.

However, these concepts are not identical and cannot be used interchangeably (Wieczorek et al., 2021). We can talk about research cooperation when scientists perform specific research tasks while implementing a project. However, academic cooperation refers to implementation of not only joint research, but also to the exchange of ideas, observations, and research results. According to this understanding, academic cooperation may be a "natural consequence" (Mitręga, 2016, p. 19) of academic networking, which refers to communication between researchers aimed at "implementing scientific goals" (Mitręga, 2016, p. 9). Summarizing the above considerations, the author believes that scientific cooperation is a broader concept than the concepts of "research collaboration" and "academic collaboration". This position results from the fact that in relation to scientific cooperation, academics work together to achieve a common goal and share knowledge. This purpose may include a variety of tasks, not just scientific projects (as in research collaborations) or the exchange of ideas or research results (as in academic collaborations).

Scientific cooperation may take on various types or kinds, taking into account criteria, such as duration, dynamics of undertaken activities, effects, intensity of contacts, disciplinary concentration, method of establishment, focus, actors involved, and geographical scope (Table 1.1). Of course, the diversity of scientific cooperation presented in the table does not exhaust all possible types. Their choice was dictated by the fact that they are the most frequently mentioned in the literature and fit into current trends in scientific cooperation. During their presentation, the alphabetical order was maintained in relation to the division criteria.

From the perspective of duration, scientific cooperation can be short and long term. Short-term scientific cooperation is ad hoc and refers to a specific, precise goal. It is usually undertaken for the duration of a project or the provision of scientific materials. However, long-term scientific cooperation is referred to in the literature as the "black box of cooperation" and refers to connections between scientists that are oriented towards learning, improving knowledge resources, and expanding them. Long-term scientific cooperation concerns the implementation of individual research processes, development of research ideas, and access to data and research equipment.

With regard to the dynamics of undertaken activities, scientific cooperation may be dynamic or static. In the case of static cooperation, we may be dealing with spontaneous cooperation without any predetermined course of action. Such scientific cooperation requires a minimum of effort. However, dynamic scientific cooperation refers to mutual dependence, learning, problem solving, and support at every stage. Due to the above-mentioned dependencies, dynamic scientific cooperation is approaching cooperation based on a common, rather long-term goal and undertaking broad-based joint activities. Moreover, in dynamic scientific cooperation, detailed rules are established that regulate the expectations and responsibilities of individual participants.

Table 1.1 Types of scientific cooperation

Division criteria	*Types*	*References*
Duration	• long-term • short-term	Dusdal, Powell (2021)
The dynamics of undertaken activities	• static • dynamic	Staudt et al. (2012)
Effects	• scientific publication • research projects • production (co-creation, co-production) • sharing of resources	Wagner, Leydesdorff (2005)
Intensity of contacts	• of a loose nature • of a specific nature	Lewis et al. (2012)
Disciplinary concentration	• intradisciplinary • interdisciplinary • cross-disciplinary • multidisciplinary • transdisciplinary	Sonnenwald (2006)
Method of establishing	• direct • via information and communication technology	Skarlatidou et al. (2019)
Targeting	• cooperation between science and business • cooperation between science and government • cooperation between science and non-governmental organization • cooperation between science and the community	Sonnenwald (2006)
Involved actors	• individual scientists (natural persons) • corporate actors	Coleman (1991)
Geographical scope	• remote cooperation • distributed cooperation • scientific cooperation • international cooperation	Sonnenwald (2006)

Source: Own elaboration.

From the perspective of the effects of scientific cooperation, we can distinguish those established as part of a specific task, e.g. developing scientific publications, implementing research projects, or sharing resources. In addition, co-creation and co-production can be mentioned. Co-creation refers to an open, active, and creative process in which diverse actors (e.g. researchers, institutions, communities) participate in all phases of the research process and interact directly and indirectly, which leads to the parties involved gaining benefits based on the use and exchange of resources. Co-creation may lead to a situation in which the results obtained are more likely to be accepted and sustainable than those developed through traditional research approaches. However, scientific co-production refers to involvement of various stakeholders with resources in scientific activities and processes, such as defining the problem, developing research questions, designing research, collecting data, analysing data, creating meaning, and disseminating knowledge. It therefore involves collaboration between scientists, non-scientists, representatives of government organizations, and/or other societal stakeholders who are interested in the creation of scientific knowledge. In scientific co-production, the researcher integrates multiple sources and types of knowledge in order to support decision-making processes and initiate social changes.

From the point of view of the next criterion, i.e. the intensity of contacts, scientific cooperation may be loose or specific. Scientific cooperation of a loose nature refers to joint discussions, comments, or providing feedback, and therefore does not concern the implementation of detailed research tasks. However, specific scientific cooperation involves joint planning, conducting research, and publishing results.

Within the diversity of views on scientific cooperation from the point of view of disciplinary concentration, the following types can be distinguished: intradisciplinary, interdisciplinary, cross-disciplinary, multidisciplinary, and transdisciplinary. Intradisciplinary cooperation refers to a situation where participants have knowledge from the same discipline or field and are oriented towards generating new knowledge in the same discipline. Interdisciplinary collaboration involves the integration of researchers from two or more disciplines. In this view, collaborators typically come from different disciplines and integrate their knowledge to create new knowledge. Cross-disciplinary cooperation refers to borrowing concepts, theories, or ideas from different disciplines and using them to solve specific problems. In multidisciplinary collaboration, researchers use knowledge from different disciplines but do not integrate or synthesize this knowledge. Transdisciplinary cooperation refers to going beyond the boundaries of individual disciplines, questioning traditional divisions, and integrating all knowledge related to a specific problem.

Moving on to the next criterion for the division of scientific cooperation, i.e. according to the method of establishing it, we can distinguish direct cooperation and cooperation via information and communication technology. Direct scientific cooperation is activated through face-to-face meetings, such as discussions in the workplace, at conferences or during other deliberately planned meetings. This cooperation facilitates scientific discussions, creating a common language, and establishing new agreements or projects. However, cooperation via information and communication technologies (e.g. social media, online discussion groups, blogs, chats, and other technological solutions) promotes openness, which helps, among others, in creating research teams combining specialists from various disciplines and countries. However, despite its potential benefits, it does not facilitate dialogue or discussion because it is asynchronous. However, it is increasingly indicated that scientific cooperation via technology is not limited only to communication but means that scientists reach for online platforms in order to involve online communities in the implementation of research processes.

From the point of view of the next criterion, which is targeting, cooperation between science and business, government, non-governmental organization, and communities is distinguished. In the case of cooperation between science and business, this mainly concerns the transfer of knowledge or research and development work. However, scientific cooperation with the community (also known as participatory action research) comes down to the cooperation of scientists with the broadly understood community, which is involved in a specific research process, e.g. design, data collection, or monitoring.

Involved actors who may be various participants recognized as elementary actors form another category of the division of scientific cooperation. "Elementary actors" are "social entities capable of taking various actions and are interested in exercising control over various types of resources" (Czerniawska et al., 2019, p. 111). Elementary actors may be natural persons or corporate actors, including teams or institutions. Natural persons are interested in access to resources, while corporate actors are interested in obtaining, exchanging, and exercising control over resources.

With regard to the geographical scope, the literature indicates the following types of scientific cooperation: remote collaboration, distributed collaboration, scientific collaboration, and international collaboration. Remote and distributed cooperation takes place using communication and IT solutions, where distributed cooperation refers to entering into dialogue with other researchers, discussing ideas, sharing information, know-how in online communities, creating innovative solutions, and open-source software projects using new communication technologies (e.g. crowdsourcing platforms). Remote cooperation, however, involves written communication (via e-mail) or oral communication (using a dedicated application).

In turn, scientific collaborations refer to cyclical interpersonal interactions and are oriented towards contacts between researchers – which provides access to data, sources, artifacts, and tools necessary to carry out research tasks. International scientific cooperation refers to a situation in which scientists come from different countries and work together on an issue or implement a project, which may provide them with increased scientific productivity, recognition, and better access to research financing.

Despite the diversity of scientific cooperation, it is generally a means for scientists to achieve various types of goals, which can be grouped in financial, resource, and positional terms:

- in terms of finances – sharing the costs of a scientific project and achieving a greater leverage effect by sharing data;
- in terms of resources – sharing knowledge, skills, and techniques between researchers, which contributes to the accumulation of knowledge. Thanks to scientific cooperation, researchers can become part of a formal or informal network of scientists, which can facilitate the diffusion of knowledge

and skills, improve the flow and exchange of knowledge, and its production, solving complex scientific problems, creating teams characterized by high diversity, increasing creativity through the exchange of ideas, gaining or sharing access to expensive or unique resources, including skills, knowledge and experience, improving the quality of researchers' work and expanding the scope of research;
- in terms of positional approach – increasing the social impact of scientific research, improving the recognition, visibility, and citation of researchers' scientific achievements, and increasing public trust in the results of scientific research.

The literature indicates that a scientist's choice of the type of cooperation may depend on the potential results, the represented discipline or scientific field, and individual preferences. From the point of view of potential results, the researcher may be interested in collaboration within their own institution, as it will promote the creation of a team spirit. Otherwise, researchers will be interested in initiating international cooperation because they will be rewarded for it in their workplace or they will become more recognizable in the world.

The choice of the type of scientific cooperation by a researcher may also depend on what discipline or field of science they represent. For example, experimental disciplines such as physics or natural sciences require scientists to have access to expensive equipment – so international scientific cooperation may prove useful here.

The choice of the type of scientific cooperation may also depend on the individual nature of the scientific project, but also on the researcher's ability to engage business organizations or other institutional partners. The choice of form of scientific cooperation is also influenced by the potential research task or tasks. For example, a researcher may be interested in establishing cooperation in jointly writing a scientific publication or applying for financial resources to financing institutions.

Despite various forms of scientific cooperation, it is increasingly recommended that researchers move towards the use of technology in order to improve its establishment and continuation. Those demands result primarily from the potential opportunities offered by information and communication technologies. First, those technologies allow for reducing the costs of cooperation, communication, and distribution of information within the organization of scientific work. Second, those technologies are relevant in the context of emerging large-scale collaborative configurations, consisting of involved actors, relationships and knowledge, especially distributed knowledge. They allow for involving various stakeholders, which may take the form of distributed creation of scientific knowledge at every stage: from sharing resources, to solving scientific problems, to searching for inspiration and ideas for scientific research.

Recent research shows that scientific cooperation or, more broadly, the creation of scientific knowledge should move towards the widespread use of information and communication technologies to create scientific knowledge. In particular, it is emphasized that the issue of technicization of science with particular emphasis on its platformization relating to the use of online platforms in various areas of the economy and spheres of life. However, online platforms refer to systems that are built on extended software, where functionality is shared by applications operating with interfaces. In this perspective, those platforms may prove useful not only for communication between researchers or knowledge exchange or, more broadly, online interactions. They are important, among other things, in building a community focused on creating scientific knowledge, which includes not only other scientists, but also people from outside the scientific community – which fits into the idea of democratization of science.

1.3 Technicization and Platformization of Science

The technicization of science is a natural consequence of the development of information and communication technologies, fast computer networks, media convergence, massification, and globalization of the processes of obtaining, processing and using information, the increase in information resources (Hey, Trefethen, 2003; Jankowski, 2007), the pressure of sharing data and communication between scientists with different audiences, and the increasing importance of reputation and the adoption of reputation management systems in scientific careers (Burgelman et al., 2010).

The technicization of science refers to the pervasive use of information and communication technology (Buecheler et al., 2010) to create scientific knowledge (Fausto et al., 2012). As part of the technicization of science, it is emphasized that technologies allow for unlimited possibilities of combining heterogeneous bodies of knowledge, which means that knowledge landscapes can quickly move between each other. Finally, it is possible to co-presence communication in one unique IT system based on knowledge exchange. This allows you to move away from conducting research alone or in small research teams to creating scientific knowledge not limited by time and space and dispersed cooperation between scientists and various stakeholders (Meyer, Schroeder, 2009).

The penetration of technicization into the sphere of science fits into the overarching concept of Science 3.0, which is treated in the literature as a separate paradigm (Smart et al., 2019). The indicated Science 3.0 paradigm is a consequence of the Science 1.0 and Science 2.0 paradigms, also referred to as e-Science. The emergence of the Science 3.0 paradigm was intensified by the emergence of the idea of Cyberscience, the popularization of online scientific research, and the platformization of science.

While Science 1.0 focused on conducting scientific research without the use of information and communication technologies, Science 2.0 refers to a scientific culture that uses the possibilities of Web 2.0 and the Internet (Bartling, Friesike, 2014) as a medium for sharing, acquiring, processing, storing, and generating data (Fausto et al., 2012; Teif, 2013). In practice, Science 2.0 comes down to opening data, researchers using tools such as blogs, social media, online forums, content aggregators to increase the reach of scientific publications and community interest in research results (Ioannidis, 2005; Procter et al., 2010; Fortson et al., 2011; Fausto et al., 2012). Science 2.0 was supported by the desire to reproduce the scientific process and improve the credibility of science (Szkuta, Osimo, 2016).

The development of the "Science 3.0" paradigm is a response to the unequal distribution of influence on scientific research while increasing resources, especially financial ones, concentrated in prestigious scientific units and blurring the boundaries between scientific and popular science production (Burgelman et al., 2010). Science 3.0 refers to researchers posting publications online (called preprints) before submitting them to a journal for peer review. In practical terms, Science 3.0 has the following features:

- creating an aggregated system of science blogs (Teif, 2013);
- putting scientists into dialogue with citizens and interested organizations (Teif, 2013);
- using online platforms and repositories for collecting and sharing data (Lukyanenko et al., 2019);
- using semantic networks and artificial intelligence to integrate data and support citizen input (Cornell et al., 2013);
- creating research networks with members of the public, jointly implementing scientific processes, and designing future research directions (Cornell et al., 2013); and
- mapping, with public participation, current research problems that need to be solved (Cornell et al., 2013).

Broadly speaking, Science 3.0 combines analysis and modelling with research synthesis and design and focuses on researchers solving social problems with public involvement. Additionally, Science 3.0 calls for openness, inclusiveness, platformization of science (Watson, Floridi, 2018), and the so-called "wisdom of crowds" (Ravetz, Ravetz, 2016). In particular, platformization contributes to the development of new, alternative ways of conducting scientific activities (Veletsianos, 2016), an ecosystem of science, creating, sharing, and collecting data using specialized, often dedicated to science, online platforms (Lukyanenko et al., 2019).

In short, the postulates of Science 3.0 aim at accessibility, openness, and transparency of scientific research, including members of society and researchers from other scientific units in the creation of scientific knowledge, as well as the use of solutions based on collective intelligence. As a result, Science 3.0 enables scientists not only to communicate or conduct research with other researchers but also to establish permanent cooperation.

The postulates of the technicization of science and Science 3.0 (Shneiderman, 2008; Buecheler et al., 2010) are reflected in three ideas that shall be discussed below. Their order results from the desire to present them taking into account their chronological emergence. In particular, the idea of e-Science, cyberscience, virtualization of scientific research, and platformization of science (Albers et al., 2020) is involved.

First, e-Science refers to global collaboration of diverse stakeholders in key areas of science using information and communication technology (Pacheco et al., 2018). In practice, this refers to the exchange of knowledge or information between geographically dispersed researchers. Knowledge in the form of publications or other materials is located in online repositories (Bravo, Diez, 2007). In addition, e-Science refers to processing of large data sets, information retrieval, and publishing scientific content on the Internet (Koschtial et al., 2021).

Second, in addition to online scientific research, cyberscience fits into the Science 3.0 paradigm. It focuses on conducting decentralized and distributed research activities based on networked peer production using information and communication technologies. In short, scientists collaborate with other researchers from various research centres, which is reflected in correspondence via e-mail, providing feedback on preprint publications, online debates, exchange of data using electronic databases (Nentwich, 2005). This fits into broadly understood scientific communication. At the same time, the creator of the concept of cyberscience, Nentwich (2005), recognized that the creation of scientific knowledge requires the participation of scientists in complex diffusion networks involving individual, collective, and corporate actors. In this perspective, information and communication technology will not only accelerate the ability to build the above-mentioned diffusion networks, but also scientific progress in general and the possibility of verifying researchers' findings (Nentwich, 2005).

Third, popularizing virtualization of scientific research is related to the ongoing changes in the area of technological and communication solutions. Such research involves using the Internet as a medium to collect research data and to locate and access bibliographic materials available online (Hewson et al., 2003). The first attempts to conduct scientific research via e-mail can be noted with the development of the Internet in the mid-nineties of the last century. In the following years, with the release of Internet Explorer, not only did online research intensify but also a discussion began around the ethical aspects of this type of research. When in 2004, O'Reilly proposed the term Web 2.0 to describe a new approach to using the Internet, a discussion began about the broader use of Internet technology to conduct scientific research (Hiremath, Kenchakkanavar, 2016). In short, the reason for conducting scientific research using technological solutions is the rapid pace of technological development, in particular the possibility of communicating via computer and the ongoing changes around Internet technologies.

Conducting scientific research using the Internet contributes, among other things, to saving time and research costs, as well as access to data in graphical form, the ability to generate various summaries and sending reminders to people who have not responded – as is the case with online surveys. Moreover, the Internet as a medium for conducting scientific research facilitates access to a large, geographically dispersed group of potential research participants and increases the level of anonymity and perceived privacy. In addition to the benefits of conducting scientific research via the Internet, it can also be a source of limitations and burdens. The literature notes that such a lack of direct presence of the researcher reduces the possibility of control over research participants. This may therefore increase the abuse of Internet users' honesty and integrity, which may intensify communication difficulties (Strickland et al., 2003). And finally, it seems that the most important burden refers to digital exclusion, which means that only people who have access to the Internet, computer equipment and, more broadly, who are able to use computer technologies, participate in the research. Although the intention of this subchapter is not to provide information on how to conduct scientific research online, but only to indicate that it is one of the premises of crowdsourcing in science – one more limitation cannot be forgotten, i.e. the deindividuation effect, which leads to the fact that members of the virtual community may tend to make more extreme statements online than outside virtual reality (Law et al., 2017).

Fourth, the last manifestation of Science 3.0 and the technicization of science refers to its platformization. The literature describes various types of online platforms that offer the potential to create scientific knowledge. However, the main differentiating criterion is their purpose and the way they are managed and administered by scientists. They can therefore be digital platforms that do not require any intervention – they are self-service, where the researcher can directly contact members of the virtual community. There are also platforms that are intermediary in nature, enabling the administration of research tasks on behalf of the scientist. There are also platforms that enable researchers to enter into direct interactions between other scientists and Internet users. Among the online platforms dedicated to science, there are archives and repositories that are intended to facilitate scientific communication and popularize the results of scientific research.

Many authors tend to believe that the platformization of science is the future of scientific research (Kenney, Zysman, 2016; van Dijck et al., 2018; Poell et al., 2019; de Silva Neto, Chiarini, 2022). These optimistic views result from the unlimited possibilities of online platforms in terms of establishing scientific cooperation, accelerating knowledge diversification, exchanging intangible resources, freedom of scientific cooperation, and lowering institutional barriers.

However, as with online scientific research, the use of digital platforms to produce scientific knowledge is not without its burdens. In particular, concerns about violation of methodological rigor, potential sampling errors (Stritch et al., 2017), Internet users' bias and their unethical behaviour related to attempted fraud and abuse for commercial purposes are highlighted (Xia et al., 2017). In summary, it should be emphasized that a natural consequence of not only the platformization of science, but more broadly the development of the "Science 3.0" paradigm is crowdsourcing in science (Kamstrup, Husted, 2020).

Bibliography

Albers B., Shlonsky A., Mildon R. (eds.) (2020), *Implementation science 3.0*. Springer, Switzerland.

Allen C., Mehler D.M.A. (2019), Open science challenges, benefits and tips in early career and beyond, *PLoS Biology*, 17(5), e3000246.

Anderson R.E. (2008), Implications of the information and knowledge society for education, In: Voogt J., Knezek G. (eds)., *International Handbook of Information Technology in Primary and Secondary Education*, Springer International Handbook of Information Technology in Primary and Secondary Education, vol 20. Springer, Boston, MA, 5–22.

Backer T.E. (1991), Knowledge utilization: The third wave, *Science Communication*, 12(3), 225–240.

Bader V. (2014), Sciences, politics, and associative democracy: Democratizing science and expertizing democracy, *Innovation: The European Journal of Social Science Research*, 27(4), 420–441.

Bartling S., Friesicke S. (ed.) (2014), *Opening science*. Springer, Cham.

Beck S., Brasseur T.-M., Poetz M., Sauermann H. (2022), Crowdsourcing research questions in science, *Research Policy*, 51(4), 104491.

Bijker W.E., Hughes T.P., Pinch T.J. (ed.) (1989), *The social construction of technological systems*. MIT Press, Cambridge.

Bisol G.D., Anagnostou P., Capocasa M., Bencivelli S., Cerroni A., Contreras J., Enke N., Fantini B., Greco P., Heeney C., Luzi D., Manghi P., Mascalzoni D., Molloy J.C., Parenti F., Wicherts J.M., Boulton G. (2014), Perspectives on open science and scientific data sharg: An interdisciplinary workshop, *Journal of Anthropological Sciences*, 92, 179–200.

Bonney R. (2007), Citizen science as a tool for conservation in residential ecosystems, *Ecology and Society*, 12(2), 1–11.

Bonney R., Cooper C.B., Dickinson J., Kelling S., Phillips T., Rosenberg K.V., Shirk J. (2009), Citizen science: A developing tool for expanding science knowledge and scientific literacy, *BioScience*, 59(11), 977–984.

Braschler B., Mahood K., Karenyi N., Gaston K.J., Chown S.L. (2010), Realizing a synergy between research and education: How participation in ant monitoring helps raise biodiversity awareness in a resource-poor country, *Journal of Insect Conservation*, 14(1), 19–30.

Bravo B.R., Díez M.L.A. (2007), E-science and open access repositories in Spain, *OCLC Systems & Services: International Digital Library Perspectives*, 23(4), 363–371.

Brossard D., Lewenstein B., Bonney R. (2005), Scientific knowledge and attitude change: The impact of a citizen science project, *International Journal of Science Education*, 27(9), 1099–1121.

Buecheler T., Sieg J., Füchslin R., Pfeifer R. (2010), *Crowdsourcing, open innovation and collective intelligence in the scientific method: A research agenda and operational framework*, Artificial Life XII – Twelfth International Conference on the Synthesis and Simulation of Living Systems, http://ecas.issuelab.org/resources/29661/29661.pdf.

Burgelman J.C., Osimo D., Bogdanowicz M. (2010), Science 2.0 (change will happen….), *First Monday*, 15(7), https://firstmonday.org/ojs/index.php/fm/article/view/2961/2573.

Burgelman J.C., Pascu C., Szkuta K., Von Schomberg R., Karalopoulos A., Repanas K., Schouppe M. (2019), Open science, open data, and open scholarship: European policies to make science fit for the twenty-first century, *Frontiers in Big Data*, 10(2), 1–6.

Castelli D. (2003), Open archive solutions to traditional archive/library cooperation, *LIBER Quarterly: The Journal of the Association of European Research Libraries*, 13(3–4), 290–298.

Coleman J.S. (1991), Natural persons, corporate actors, and constitutions, *Constitutional Political Economy*, 2, 81–106.

Collins H.M., Evans R. (2002), The third wave of science studies: Studies of expertise and experience, *Social Studies of Science*, 32(2), 235–296.

Cook B.G., Lloyd J.W., Mellor D., Nosek B.A., Therrien W.J. (2018), Promoting open science to increase the trustworthiness of evidence in special education, *Exceptional Children*, 85(1), 104–118.

Cornell S., Berkhout F., Tuinstra W., Tàbara J.D., Jäger J., Chabay I., de Wit B., Langlais R., Mills D., Moll P., Otto I.M., Petersen A., Pohl C., van Kerkhoff L. (2013), Opening up knowledge systems for better responses to global environmental change, *Environmental Science & Policy*, 28(60), 60–70.

Cornwall A., Jewkes R. (1995), What is participatory research?, *Social Science & Medicine*, 41(12), 1667–1676.

Czarnitzki D., Grimpe C., Pellens M. (2015), *Access to research inputs: Open science versus the entrepreneurial university*, ZEW Discussion Papers 14–018, ZEW - Leibniz Centre for European Economic Research.

Czerniawska D., Fenric W., Bojanowski M. (2020), Aktorzy, relacje i sieci – o współpracy naukowej nie bibliometrycznie, *Nauka i Szkolnictwo Wyższe*, 1–2(53–54), 107–133.

da Silva Neto V.J., Chiarini T. (2022), The platformization of science: Towards a scientific digital platform taxonomy, *Minerva*, 1–29, https://doi.org/10.1007/s11024-022-09477-6.

Dasgupta P., David P.A. (1994), Toward a new economics of science, *Research Policy*, 23(5), 487–521.

Devictor V., Whittaker R.J., Beltrame C. (2010), Beyond scarcity: Citizen science programmes as useful tools for conservation biogeography, *Diversity and Distributions*, 16(3), 354–362.

Domènech M. (2017), Démocratiser la science: A continuing challenge today, *Revue d'Anthropologie des Connaissances*, 11(2), 125–132.

Doyle C., Li Y., Luczak-Roesch M., Anderson D., Glasson B., Boucher M., Brieseman C., Christenson D., Coton M. (2018), What is online citizen science anyway? An educational perspective, https://arxiv.org/abs/1805.00441.

Dusdal J., Powell J. (2021), Benefits, motivations, and challenges of international collaborative research: A sociology of science case study, *Science and Public Policy*, 48(2), 235–245.

Eitzel M.V., Cappadonna J.L., Santos-Lang C., Duerr R.E., Virapongse A., West S.E., Kyba C.C.M., Bowser A., Cooper C.B., Sforzi A., Metcalfe A.N., Harris E.S., Thiel M., Haklay M., Ponciano L., Roche J., Ceccaroni L., Shilling F.M., Dörler D., Heigl F., Kiessling T., Davis B.Y., Jiang Q. (2017), Citizen science terminology matters: Exploring key terms, *Citizen Science: Theory and Practice*, 2(1), 1–20.

Eklund L., Stamm I., Liebermann W. (2019), The crowd in crowdsourcing: Crowdsourcing as a pragmatic research method, *First Monday*, 24(1), 1–14.

Fausto S., Machado F.A., Bento L.F.J., Iamarino A., Nahas T.R., Munger D.S. (2012), Research blogging: Indexing and registering the change in science 2.0, *PLoS One*, 7(12), e50109.

Fernandez-Gimenez M.E., Ballard H.L., Sturtevant V.E. (2008), Adaptive management and social learning in collaborative and community-based monitoring: A study of five community-based forestry organizations in the western USA, *Ecology and Society*, 13(2), 1–4.

Festré A. (2021), Michael Polanyi's vision of government and economics: Spanning Hayek and Keynes, *Journal of Government and Economics*, 4, 100026.

Ford E. (2013), Defining and characterizing open peer review: A review of the literature, *Journal of Scholarly Publishing*, 44(4), 311–326.

Fortson L., Masters K., Nichol R., Borne K., Edmondson E., Lintott C., Raddick J., Schawinski K., Wallin J. (2011), Galaxy zoo: Morphological classification and citizen science, *Advance Machine Learning Data Mineral Astronomy*, https://arxiv.org/abs/1104.5513.

Gassmann O., Widenmayer B., Friesike S., Schildhauer T. (2015), Opening science: Towards an agenda of open science in academia and industry, *Journal of Technology Transfer*, 40(4), 581–601.

Gibbons M., Limoges C., Nowotny H., Schwartzman S., Scott P., Trow M. (1994), *The new production of knowledge: The dynamics of science and research in contemporary societies*. Sage Publications, London, Thousand Oaks, New Delhi.

Grand A., Wilkinson C., Bultitude K., Winfield A.F. (2016), Mapping the hinterland: Data issues in open science, *Public Understanding of Science*, 25, 88–103.

Haklay M. (2013), Citizen science and volunteered geographic information: Overview and typology of participation, In: Sui D., Elwood S., Goodchild M. (eds.), *Crowdsourcing geographic knowledge*, Springer, Dordrecht, 105–122.

Haklay M., Dörler D., Heigl F., Manzoni M., Hecker S., Vohland K. (2021), What is citizen science? The challenges of definition, In: Vohland K., Land-Zandstra A., Ceccaroni L., Lemmens R., Perelló J., Ponti M., Samson R., Wagenknecht K. (eds.), *The science of citizen science*, Springer, Cham, 13–34.

Hall K.L., Vogel A.L., Huang G.C., Serrano K.J., Rice E.L., Tsakraklides S.P., Fiore S.M. (2018), The science of team science: A review of the empirical evidence and research gaps on collaboration in science, *American Psychologist*, 73(4), 532.

Heigl F., Kieslinger B., Paul K.T., Uhlik J., Dörler D. (2019), Opinion: Toward an international definition of citizen science, *PNAS*, 116(17), 8089–8092.

Hewson C. (2003), Conducting research on the internet, *Psychologists Leicester*, 16(6), 290–293.

Hey T., Trefethen A. (2003), The data deluge: An e-science perspective, In: Berman F., Fox G.C., Hey A.J.G. (eds.), *Grid computing: Making the global infrastructure a reality*, Wiley and Sons, Hoboken, 1–17.

Hiremath B.K., Kenchakkanavar A.Y. (2016), An alteration of the web 1.0, web 2.0 and web 3.0: A comparative study, *Imperial Journal of Interdisciplinary Research*, 2(4), 705–710.

Huang B., Wang W., Bates M., Zhuang X. (2008), Three-dimensional super-resolution imaging by stochastic optical reconstruction microscopy, *Science*, 319(5864), 810–813.

Ioannidis J.P.A. (2005), Why most published research findings are false, *PLoS Medicine*, 2(8), e124.

Ioannidis J.P.A., Khoury M.J. (2011), Improving validation practices in "omics" research, *Science*, 334, 1230–1232.

Jankowski N.W. (2007), Exploring e-science: An introduction, *Journal of Computer-Mediated Communication*, 12(2), 549–562.

Jasanoff S. (1995), Procedural choices in regulatory science, *Technology in Society*, 17(3), 279–293.

Kamstrup A., Husted E. (2020), Crowdsourcing and digital platforms, In: Parker M., Stoborod K., Swann T. (eds.), *Anarchism, organization and management: Critical perspectives for students*, Routledge, London, New York, 169–183.

Kenney M., Zysman J. (2016), The rise of the platform economy, *Science and Technology*, 32(3), 61–69.

Koschtial C. (2021), Understanding e-science. What is it about?, In: Koschtial C., Köhler T., Felden C. (eds.), *E-Science. Open, social and virtual technology for research collaboration*, Springer, Cham, 1–10.

Krasny M.E., Bonney R. (2005), Environmental education through citizen science and participatory action research: The Cornell Laboratory of Ornithology and Garden Mosaics examples, In: Mappin M., Johnson E.A. (eds.), *Environmental education or advocacy: Perspectives of ecology and education in environmental education*, Cambridge University Press, Cambridge, 292–319.

Kriegeskorte N. (2012), Open evaluation: A vision for entirely transparent post-publication peer review and rating for science, *Frontiers in Computational Neuroscience*, 6(79), 1–18.

Kurtulmuş F. (2021), The democratization of science, In: Ludwig D., Koskinen I., Mncube Z., Poliseli L., Reyes-Galindo L. (eds.), *Global epistemologies and philosophies of science*, Routledge, London, New York, 145–154.

Law E., Gajos K.Z., Wiggins A., Gray M.L., Williams A. (2017), *Crowdsourcing as a tool for research: Implications of uncertainty*, Proceedings ACM Conference on Computer Supported Cooperative Work and Social Computing, https://www.eecs.harvard.edu/~kgajos/papers/2017/law17-crowdsourcing.pdf.

LeBel E.P., McCarthy R.J., Earp B.D., Elson M., Vanpaemel W. (2018), A unified framework to quantify the credibility of scientific findings, *Advances in Methods and Practices in Psychological Science*, 1(3), 389–402.

Ledford H. (2015), How to solve the world's biggest problems, *Nature*, 525(7569), 308–311.

Levy M., Germonprez M. (2017), The potential for citizen science in information systems research, *Communications of the Association for Information Systems*, 40, 22–39.

Lewis J.M., Ross S., Holden T. (2012), The how and why of academic collaboration: Disciplinary differences and policy implications, *Higher Education*, 64(5), 693–708.

Lichten C.A., Ioppolo B., d'Angelo C., Simmons R.K., Jones M.M. (2018), Citizen science: Crowdsourcing for research, The Healthcare Improvement Studies Institute, https://www.thisinstitute.cam.ac.uk/wp-content/uploads/2018/05/THIS-Institute-Crowdsourcing-for-research-978-1-9996539-0-3.pdf.

López-Pérez L., Olvera-Lobo M.D. (2018), Public engagement in science via Web 2.0 technologies. Evaluation criteria validated using the Delphi Method, *Journal of Science Communication*, 17(02), 1–21.

Lukyanenko R., Parsons J., Wiersma Y.F. (2014), The IQ of the crowd: Understanding and improving information quality in structured user-generated content, *Information Systems Research*, 25(4), 669–689.

Lukyanenko R., Parsons J., Wiersma Y.F., Maddah M. (2019), Expecting the unexpected: Effects of data collection design choices on the quality of crowdsourced user-generated content, *MIS Quarterly*, 43(2), 1–12.

Mäkipää J.-P., Dang D., Mäenpää T., Pasanen T. (2020), *Citizen science in information systems research: Evidence from a systematic literature review*, Proceedings of the 53rd Hawaii International Conference on System Sciences, https://scholarspace.manoa.hawaii.edu/bitstream/10125/64311/0460.pdf.

McCormick S. (2007), Democratizing science movements: A new framework for mobilization and contestation, *Social Studies of Science*, 37(4), 609–623.

McKiernan E.C., Bourne P.E., Brown C.T., Buck S., Kenall A., Lin J., McDougall D., Nosek B.A., Ram K., Soderberg C.K., Spies J.R., Thaney K., Updegrove A., Woo K.H., Yarkoni T. (2016), How open science helps researchers succeed, *Elife*, 7(5), e16800.

Merton R.K. (1942), A note on science and democracy, *Journal of Legal and Political Sociology*, 1, 115.

Merton R.K. (1968), *Social theory and social structure*, The Free Press, New York.

Merton R.K. (1973), An intertemporal capital asset pricing model, *Econometrica*, 41(5), 867–887.

Meyer E.T., Schroeder R. (2009), Untangling the web of e-Research: Towards a sociology of online knowledge, *Journal of Informetrics*, 3(3), 246–260.

Mitręga M. (ed.) (2016), *Networking akademicki jako czynnik produktywności pracowników naukowych*. Uniwersytet Ekonomiczny w Katowicach, Katowice.

Mitroff I.I. (1974), Norms and counter-norms in a select group of the Apollo moon scientists: A case study of the ambivalence of scientists, *American Sociological Review*, 39(4), 579–595.

Molloy J.C. (2011), The open knowledge foundation: Open data means better science, *PLoS Biology*, 9(12), e1001195.

Nentwich M. (2005), Cyberscience: Modelling ICT-induced changes of the scholarly communication system, *Information, Community & Society*, 8(4), 542–560.

Newig J., Jahn S., Lang D.J., Kahle J., Bergmann M. (2019), Linking modes of research to their scientific and societal outcomes. Evidence from 81 sustainability-oriented research projects, *Environmental Science & Policy*, 101, 147–155.

Nosek B.A., Bar-Anan Y. (2012), Scientific utopia: I. Opening scientific communication, *Psychological Inquiry*, 23(3), 217–243.

Nosek B.A., Spies J.R., Motyl M. (2012), Scientific utopia: II. Restructuring incentives and practices to promote truth over publishability, *Perspectives on Psychological Science*, 7(6), 615–631.

Pacheco R.C.S., Nascimento E.R., Weber R.O. (2018), Digital science: Cyberinfrastructure, e-science and citizen science, In: North K., Maier R., Haas O. (eds.), *Knowledge management in digital change*, Springer, Cham, 377–388.

Pelacho M., Ruiz G., Sanz F., Tarancón A., Clemente-Gallardo J. (2021), Analysis of the evolution and collaboration networks of citizen science scientific publications, *Scientometrics*, 126(1), 225–257.

Peters I., Kraker P., Lex E., Gumpenberger C., Gorraiz J. (2016). Research data explored: An extended analysis of citations and altmetrics, *Scientometrics* 107(2), 723–744.

Piwowar H.A., Day R.S., Fridsma D.B. (2007), Sharing detailed research data is associated with increased citation rate, *PLoS One*, 2(3), e308.

Poell T., Nieborg D., Van Dijck J. (2019), Platformisation, *Internet Policy Review*, 8(4), 1–13.

Procter R., Williams R., Stewart J., Poschen M., Snee H., Voss A., Asgari-Targhi M. (2010), Adoption and use of Web 2.0 in scholarly communications, *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 368(1926), 4039–4056.

Rath M., Wang P. (2017), *Open peer review in the era of open science: A pilot study of researchers' perceptions*, ACM/IEEE Joint Conference on Digital Libraries, IEEE, pp. 1–2.

Ravetz J., Ravetz A. (2016), Seeing the wood for the trees: Social Science 3.0 and the role of visual thinking, *Innovation: The European Journal of Social Science Research*, 30(01), 1–22.

Redner H. (1987), The institutionalization of science: A critical synthesis, *Social Epistemology*, 1(1), 37–59.

Scheliga K., Friesike S. (2014), Putting open science into practice: A social dilemma?, *First Monday*, 19(9), https://journals.uic.edu/ojs/index.php/fm/article/view/5381/4110.

Schmidt B., Gemeinholzer B., Treloar A. (2016), Open data in global environmental research: The belmont forum's open data survey, *PLoS ONE*, 11(1), e0146695.

Schroyer T. (1984), On finalization in science, *Theory and Society*, 13(5), 715–723.

Shneiderman B. (2008), Science 2.0, *Science*, 319, 1349–1350.

Silberzahn R., Uhlmann E.L., Martin D.P., Anselmi P., Aust F., Awtrey E., Bahník Š., Bai F., Bannard C., Bonnier E., Carlsson R., Cheung F., Christensen G., Clay R., Craig M.A., Dalla Rosa A., Dam L., Evans M.H., Flores Cervantes I., Fong N., Gamez-Djokic M., Glenz A., Gordon-McKeon S., Heaton T.J., Hederos K., Heene M., Hofelich Mohr A.J., Högden F., Hui K., Johannesson M., Kalodimos J., Kaszubowski E., Kennedy D.M., Lei R., Lindsay T.A., Liverani S., Madan C.R., Molden D., Molleman E., Morey R.D., Mulder L.B., Nijstad B.R., Pope N.G., Pope B., Prenoveau J.M., Rink F., Robusto E., Roderique H., Sandberg A., Schlüter E., Schönbrodt F.D., Sherman M.F., Sommer S.A., Sotak K., Spain S., Spörlein C., Stafford T., Stefanutti L., Tauber S., Ullrich J., Vianello M., Wagenmakers E.-J., Witkowiak M., Yoon S., Nosek B.A. (2017), Many analysts, one dataset: Making transparent how variations in analytical choices affect results, *Advances in Methods and Practices in Psychological Science*, 1(3), 337–356.

Skarlatidou A., Ponti M., Sprinks J., Nold C., Haklay M., Kanjo E. (2019), User experience of digital technologies in citizen science, *Journal of Science Communication*, 18(01), 1–8.

Slaughter S., Slaughter S.A., Rhoades G. (2004), *Academic capitalism and the new economy: Markets, state, and higher education*. Johns Hopkins University Press.

Smart P., Holmes S., Lettice F., Pitts F.H., Zwiegelaar J.B., Schwartz G., Evans S. (2019), Open science and open Innovation in a socio-political context: Knowledge production for societal impact in an age of post-truth populism, *R&D Management*, 49(3), 279–297.

Sonnenwald D. (2006), Challenges in sharing information effectively: Examples from command and control, *Information Research*, 11(4), 1–18.

Staudt C., Schumm A., Meyerhenke H., Görke R., Wagner D. (2012), *Static and dynamic aspects of scientific collaboration networks*, Proceedings International Conference on Advances in Social Networks Analysis and Mining, https://ieeexplore.ieee.org/document/6425714.

Strang L., Simmons R.K. (2018), *Citizen science: Crowdsourcing for systematic reviews*. THIS Institute, https://www.thisinstitute.cam.ac.uk/research-articles/citizen-science-crowdsourcing-systematic-reviews/.

Strickland O.L., Moloney M.F., Dietrich A.S., Myerburg S., Cotsonis G.A., Johnson R.V. (2003), Measurement issues related to data collection on the World Wide Web, *Advances in Nursing Science*, 26(4), 246–256.

Stritch J.M., Pedersen M.J., Taggart G. (2017), The opportunities and limitations of using Mechanical Turk (Mturk) in public administration and management scholarship, *International Public Management Journal*, 20(3), 489–511.

Szkuta K., Osimo D. (2016), Rebooting science? implications of science 2.0 main trends for scientific method and research institutions, *Foresight*, 18(3), 204–223.

Teif V.B. (2013), *Science 3.0: Corrections to the science 2.0 paradigm*, https://arxiv.org/pdf/1301.2522.

Turnpenny J., Jones M., Lorenzoni I. (2011), Where now for post-normal science? A critical review of its development, definitions, and uses, *Science, Technology, & Human Values*, 36(3), 287–306.

Uhlmann E.L., Ebersole C.R., Chartier C.R., Chartier C.R., Errington T.M., Kidwell M.C., Lai C.K., McCarthy R.J., Riegelman A., Silberzahn R., Nosek B.A. (2019), Scientific utopia III: Crowdsourcing science, *Perspectives on Psychological Science*, 14(5), 711–733.

Välimaa J., Hoffman D. (2008), Knowledge society discourse and higher education, *Higher Education* 56, 265–285.

Van Dijck J., Poell T., De Waal M. (2018), *The platform society: Public values in a connective world*, Oxford University Press, Oxford.

Van Noorden R. (2013), Open access: The true cost of science publishing, *Nature*, 495(7442), 426–429.

Veletsianos G. (2016), *Social media in academia: Networked scholars*. New York, London, Routledge.

Vicente-Saez R., Martinez-Fuentes C. (2018), Open Science now: A systematic literature review for an integrated definition, *Journal of Business Research*, 88(C), 428–436.

Wagner C.S., Leydesdorff L. (2005), Network structure, self-organization, and the growth of international collaboration in science, *Research Policy*, 34(10), 1608–1618.

Wallis J.C., Rolando E., Borgman C.L. (2013), If we share data, will anyone use them? Data sharing and reuse in the long tail of science and technology, *PLoS One*, 8(7), e67332.

Watson D., Floridi L. (2018), Crowdsourced science: Sociotechnical epistemology in the e-research paradigm, *Synthese*, 195(2), 741–764.

Whitelaw G., Vaughan H., Craig B., Atkinson D. (2003), Establishing the canadian community monitoring network, *Environmental Monitoring and Assessment*, 88(1–3), 409–418.

Wieczorek A.L., Mitręga M., Spáčil V. (2021), Dynamic academic networking concept and its links with English language skills and research productivity–non-Anglophone context, *PLoS One*, 16(2), e0245980, https://doi.org/10.1371/journal.pone.0245980.

Wolfram D., Wang P., Hembree A., Park H. (2020), Open peer review: Promoting transparency in open science, *Scientometrics*, 125, 1033–1051.

Xia H., Wang Y., Huang Y., Shah A. (2017), *Our privacy needs to be protected at all costs crowd workers' privacy experiences on Amazon Mechanical Turk*, Proceedings of the ACM on Human-Computer Interaction, 1–22, https://dl.acm.org/doi/10.1145/3134748.

Ziman J. (2000), *Postacademic science: Constructing knowledge with networks and norms*. *Beyond the science wars: The missing discourse about science and society*, State University of New York Press, Albany, 135–154.

Ziman J. (2003), *Real science. What it is, and what it means*. The Cambridge University Press, Cambridge.

2 The Characteristics of Crowdsourcing in Science

The beginnings of researchers' interest in the issue of crowdsourcing in science can be noted with one of the first publications devoted to this very issue (2010). Buecheler et al. (2010) in a publication titled "Crowdsourcing, open innovation and collective intelligence in the scientific method: a research agenda and operational framework" stated that "crowdsourcing is important (...) for research because it describes research collaboration that radically increases the pool (of potential) scientific collaborators" (p. 680). Along with this publication, there has been a gradual increase in publications focusing on the potential of crowdsourcing for creating scientific knowledge (Aguinis, Lawal, 2013).

Moreover, crowdsourcing in science has started being perceived as a new paradigm of scientific cooperation, which is consistent with scientific openness and inclusiveness (Pan, Blevis, 2011). It has begun to be considered, among other things, as an alternative strategy for organizing the work of researchers (Lukyanenko et al., 2019) or as a model of practicing science (Aristeidou et al., 2017; Uhlmann et al., 2019), which may prove useful to support scientific research (Law et al., 2017). Crowdsourcing has also begun to be perceived as an integral part of the everyday life of scientists (Franzoni, Sauermann, 2022; Schlagwein, Daneshgar, 2014; Steelman et al., 2014; Uhlmann et al., 2019) and crucial in the context of reducing the costs of conducting scientific research, increasing the scale and impact of scientific research, democratizing science, and accelerating scientific discoveries (Edgar et al., 2016). Moreover, crowdsourcing in science has also been recognized as a way that will enable scientists to create scientific knowledge that will contribute to solving social problems (Djenontin, Meadow, 2018).

The aim of this chapter is to organize the current scientific achievements of management and quality sciences in the field of crowdsourcing in science. The first part presents definitions and features of crowdsourcing in science. The second part of the chapter illustrates location of crowdsourcing in science against the background of other concepts considered in the literature to be related or synonymous, such as citizen science, online citizen science, crowd science, crowd

DOI: 10.4324/9781003482253-3

research, and open innovation in science. Then, the third part of this chapter presents advantages and disadvantages of crowdsourcing in science.

The basis of this chapter is provided by a hybrid systematic review of academic and grey literature. The choice of a systematic literature review was dictated by the fact that, due to the early state of knowledge, it may prove useful due to its potential to identify, evaluate, and interpret all available evidence (Lenart-Gansiniec, 2021).

The systematic literature review followed the following five stages: (1) development of the research question(s), (2) identification of keywords, (3) definition of inclusion and exclusion criteria, (4) identification of literature relevant to the adopted research question(s), (5) analysing the collected literature.

First, the systematic literature review conducted addressed the following six research questions:

- RQ1. What is the current state of research on crowdsourcing in science?
- RQ2. What are the directions for future research on crowdsourcing in science?
- RQ3. How is crowdsourcing in science understood in the literature?
- RQ4. What are the processes of crowdsourcing in science formulated in the literature, and what are their characteristics?
- RQ5. What is the meaning of crowdsourcing in science as formulated in the literature?

Second, due to the fact that crowdsourcing in science is often referred to by other terms, the literature search was expanded to include additional keywords. To determine them, the Thesaurus available in the Web of Science and Scopus databases was used, in accordance with the recommendations included in the literature (Bramer, 2018). This allowed us to identify the following keywords: "online citizen science", "crowdsourcing citizen science", "crowdsourced science", "crowdsourcing science", "citizen cyberscience", "virtual citizen science", "crowd science", "crowd research", "scientific crowdsourcing", "science 2.0", "crowdsourcing in science", "crowdsourcing research", "crowdsourcing for science", "academic crowdsourcing".

The literature on the subject was selected using two electronic databases, such as Web of Science and Scopus. The choice of those databases was dictated by the fact that Web of Science is considered one of the most prestigious databases (Gasparyan et al., 2013). In turn, the Scopus electronic database is considered to be a reliable source of information. Moreover, limiting searches to only one electronic database may be insufficient and result in the omission of important publications. To search for grey literature, the Google Scholar search engine was used. Additionally, this choice resulted from some desire to provide a complete picture of the state of knowledge.

First, an initial search was performed on both Web of Science and Scopus. The filtering criterion was identified keywords in the "All field" search field, separated by the "OR" hyphen, according to Boolean logic. The initial search was performed on 1 March 2021, resulting in a total of 5,025 hits (Web of Science: 164; Scopus: 4861).

Second, referring to the methodology of a systematic literature review, in particular, the identification of all useful publications from the point of view of the formulated research questions and the purpose of the review, the following inclusion criteria were adopted:

- publication status – only full-text, peer-reviewed scientific articles – to ensure high quality of the results obtained and open access to their full content;
- language of publication – only English – to ensure the universal nature of the literature review and to avoid scientific bias;
- identified keywords in the title or abstract or keywords – to identify publications strictly devoted to crowdsourcing in science;
- due to the demand to conduct interdisciplinary research on crowdsourcing (Bucheler, Sieg, 2011), the search was not narrowed down to the areas of business, economics and management.

Fourth, after searching the identified keywords in the title or abstract or keywords, a total pool of 665 publications was obtained (Web of Science: 142; Scopus: 523). Searches were then performed taking into account the inclusion criteria. A total pool of 255 potentially relevant research articles was obtained (Web of Science: 79; Scopus: 176). Then, duplicate publications were removed, which resulted in obtaining 70 scientific articles. Next, they were assessed in terms of adequacy to the research questions, which was done by reading the full texts of scientific articles. At this stage, four research articles were eliminated due to the fact that: (a) they were not relevant and despite mentioning crowdsourcing in the abstract or title and did not discuss it as a main construct, (b) despite the keywords, the research concerned citizen science, (c) publications in which researchers did not provide a definition of crowdsourcing in science.

In addition to the systematic literature review, a grey literature review was conducted to identify the full scope of knowledge about crowdsourcing in science. For this purpose, using the same keywords (as for the academic literature), the literature was collected using a snowballing technique combining backwards and forward searches (Webster, Watson, 2002). In practice, each publication's reference section (backward search) and Google Scholar search (forward search) were reviewed. This identified 10 additional publications (3 by backward search; 7 by forward search). Ultimately, 76 scientific articles were qualified for further analysis.

First, we started by assessing each collected publication to extract the most important findings in the form of authorship, year of publication, place of publication, main conclusions, and recommendations, according to data extraction (Petticrew, Roberts, 2008). Next, the findings included in individual publications were compared, combined, and summarized. For this purpose, thematic analysis was used (Braun, Clarke, 2006). For the identified 76 articles, a hybrid inductive-deductive approach was adopted, depending on the specific research question formulated. The deductive approach to coding the collected material assumes the adoption of predetermined codes. They may come from previous literature (Glinka, Czakon, 2021). With respect to the deductive approach, codes derived from the literature on crowdsourcing per se and scientific research methodology were adopted. This choice was due to the fact that crowdsourcing in science comes from crowdsourcing per se (Bassi et al., 2020) and is useful for implementing individual research processes. The inductive approach assumes the emergence of topics directly from publications by reading and interpreting raw text data (Corbin, Strauss, 1990).

Details of the coding approach adopted are provided below, taking into account the research questions formulated as part of this literature review. In accordance with the assumptions of thematic analysis (Braun, Clarke, 2006), all publications collected as part of a systematic literature review were read many times to be sure of the correctness of coding. Next, line-by-line coding was performed, referring to assigning codes to each line of data (Glinka, Czakon, 2021).

To determine the state of knowledge and future directions of research on crowdsourcing in science, codes related to its *sine quo non* conditions were used, such as initiator, virtual community, process, and technology. This approach results from the previous findings of other researchers who conducted a systematic review of the literature on crowdsourcing in science (Karachiwalla, Pinkow, 2021). In relation to the identified definitions of crowdsourcing in science and its benefits, the following stages of the research process were adopted as codes: conceptual, empirical, and those related to the analysis of empirical data. In turn, the coding of crowdsourcing in science processes was based on crowdsourcing processes per se, such as preparation, initiation, generation, implementation, and verification (Ghezzi et al., 2018). However, to code the challenges in managing a crowdsourcing in science initiative, its individual stages were taken into account. This approach resulted from the recommendations of other researchers regarding the approach to crowdsourcing in science through the prism of its suitability for conducting scientific research (Shank, 2016).

2.1 Definitions and Features of Crowdsourcing in Science

Crowdsourcing in science is a term that first appeared with the demands to involve the broadly understood community in the creation of scientific knowledge (Buecheler et al., 2010). Although the first publication dedicated to crowdsourcing in science appeared over a decade ago, it is still considered to be "an emerging tool to improve the process of collecting, processing and analysing research data in many fields" (Law et al., 2017). However, it should be noted that there are variations in what is considered crowdsourcing in science. The difficulties associated with defining crowdsourcing are compounded by terminological boundaries that go beyond the concept of crowdsourcing. Moreover, it is not possible to directly transfer the findings of researchers in the field of crowdsourcing per se to the achievements of crowdsourcing in science. This is primarily due to the fact that the conceptual history of crowdsourcing in science is different from business crowdsourcing. Crowdsourcing per se mainly focuses on providing innovative solutions to organizational problems, creating new products or services, collecting user opinions about the brand, as well as creating and capturing value (Tucci et al., 2018). However, crowdsourcing in science is a kind of bridge between the democratization of science and a business origin and is connected, among others, with open innovation in science and co-creation of scientific knowledge (Beck et al., 2022).

In the existing body of work, crowdsourcing in science is defined in different ways (Lenart-Gansiniec et al., 2022). A review of the existing definitions of crowdsourcing in science shows that researchers mainly perceive it through the prism of potential benefits that can be obtained by the initiator. Due to the diversity of perspectives and definitions of crowdsourcing in science, it was considered necessary to organize the existing findings to establish the understanding of this concept. Terminological confusion may lead to researchers adopting incorrect theoretical assumptions and the risk of multiplying concepts and creating unnecessary scientific categories. The introduction of terminological order and clarification of existing concepts is important from the point of view of creating new and expanding existing knowledge. It should be noted that the purpose of this subchapter is not to provide a definition of crowdsourcing, but to present various approaches to understanding crowdsourcing in science and to organize them, taking into account the categories proposed by the author. Moreover, its various approaches were also indicated depending on the disciplines/field of science. This approach seems important due to the interdisciplinary nature of crowdsourcing in science.

A total of 43 definitions were identified in 76 publications collected as part of the systematic literature review. The analysis of the identified definitions indicates that crowdsourcing in science is certainly a heterogeneous concept (Karachiwalla, Pinkow, 2021; Wazny, 2017). Each representative of the field/discipline of science provides their own understanding, which makes it difficult to adopt a single position. Moreover, researchers often do not clearly indicate in their definitions how they understand the concept of crowdsourcing in science and refer to its benefits.

The identified definitions are presented below, taking into account the stages of the research process. They were quoted explicitly. As indicated, the definitions of crowdsourcing in science are related to its potential benefits, therefore its importance was also highlighted during the presentation of the definition. Due to the assumptions made when conducting a systematic literature review and the interdisciplinary nature of the concept of crowdsourcing in science, the fields/disciplines of science represented by the authors of those definitions were included in the tabular presentation of individual definitions. Interestingly, most definitions were provided by representatives of management and quality sciences (13 definitions). It should be noted, however, that despite this intensity, three were provided by the same team of scientists.

In accordance with the adopted deductive approach to coding the collected definitions, the following four topics were identified during the conceptual stage of conducting scientific research: access to resources, involvement, outsourcing research tasks to a virtual community, and the production model. As part of the empirical stage of the research process, one topic was identified: commissioning research tasks. In turn, as part of the stage related to data analysis and publication of results, one topic was also identified: resource exploitation. Their order results from the frequency of occurrence in individual definitions. For presentation purposes, individual definitions are presented in tabular form. In individual definitions, distinguishing features indicating the specificity of a given topic are marked in bold. The identified definitions, along with the potential importance of crowdsourcing in science, are presented below.

As part of the first stage of the research process, i.e. the conceptual stage, a total of 33 definitions of crowdsourcing in science were identified. The largest number of definitions was provided by representatives of management and quality sciences (11 definitions). They are as follows: social communication and media sciences (7 definitions); psychology (4 definitions); medical and health sciences (4 definitions); computer science (3 definitions); on Earth and the environment (3 definitions); and civil engineering, geodesy, and transport (1 definition). Most often, it is considered as access to resources (16 definitions), then involvement (13 definitions), and production model (4 definitions).

From the perspective of the conceptual stage of the research process, crowdsourcing in science is understood as an activity that allows access to a large amount of various and specialized (Beck et al., 2022) intangible or other resources necessary to conduct scientific research and in the possession of other researchers and/or members of society. In this way, crowdsourcing in science was most often understood by representatives of management and quality sciences (6 definitions), less often by researchers representing civil engineering, geodesy, and transport (1 definition) (Table 2.1).

The identified definitions indicate that crowdsourcing in science can be understood through the prism of the involvement of a broadly understood virtual community that is interested in participating in the creation of scientific knowledge (Table 2.2). In this way, crowdsourcing in science was most often understood by representatives of social communication and media sciences (4 definitions), management and quality sciences (4 definitions), and less frequently by researchers representing medical and health sciences (1 definition) and psychology (1 definition) and civil engineering, surveying, and transport (1 definition). The last category of definition, within the conceptual stage of conducting scientific research, crowdsourcing in science is understood as a production model of a

Table 2.1 Crowdsourcing in science as access to resources

Author/ authors	Definitions	Discipline/field of science
Mason, Suri (2012, p. 1)	Access to a **large, stable, and diverse pool of topics**, low cost of conducting experiments, and faster transitions between developing theory and performing experiments.	Psychology (social sciences)
Cullina et al. (2014, p. 2)	The crowd **may have limited or sufficient expertise** to perform the required research tasks.	Management and quality sciences (social sciences)
Schildhauer, Voss (2014, p. 255)	The main tool for accelerating the process of finding solutions to a given problem (not only scientific) by **incorporating external knowledge**, and specifically by including scientists and researchers in previously closed and now open systems of innovation processes.	Management and quality sciences (social sciences)
Michel et al. (2015, p. 2)	Including authors from the crowd can **provide valuable knowledge and resources** for developing complex scientific questions.	Management and quality sciences (social sciences)
Edgar et al. (2016, p. 2)	The researcher has inexpensive **access to a geographically and demographically diverse group of participants** from whom information can be systematically collected in a short period of time.	Psychology (social sciences)
Law et al. (2017, p. 1545)	Efforts that involve large numbers of people in a network to **help collect and process data**, which differ from the small team-like interactions that are now common in research settings.	Computer science (exact and natural sciences)
Majima (2017, p. 1)	Researchers in the behavioural and social sciences (such as psychology, linguistics, economics, and political science) have begun **collecting data** from surveys and online experiments with participants recruited from the online labour market.	Psychology (social sciences)
Curtis (2018, p. 5)	Scientists have **access (via the Internet) to many thousands of potential resources** held by participants in their projects and are able to achieve more than previously thought possible.	Medical sciences (medical and health sciences)
Sheehan (2018, p. 4)	A practice in which researchers can connect directly and **collect data** from a global pool of respondents.	Social communication and media sciences (social sciences)
Stritch et al. (2017, p. 490)	Thanks to the ubiquity of the Internet, researchers can **obtain data** from a platform – i.e. crowds of people participating in an online community or online platforms.	Management and quality sciences (social sciences)

(*Continued*)

Table 2.1 (Continued)

Author/ authors	Definitions	Discipline/field of science
Eklund et al. (2019, p. 1)	A digital process used to **solicit information, ideas and solicit input, creativity**, etc. from large online crowds.	Computer science (exact and natural sciences)
Hilton, Azzam (2019, p. 575)	**Gaining access to the knowledge** of hundreds of potential stakeholders via the Internet.	Medical sciences (medical and health sciences)
Lukyanenko et al. (2020, p. 964)	Projects typically end when the **desired data or services are crowdsourced**.	Computer science (exact and natural sciences)
Parrick, Chapman (2020, p. 173)	**Accessing large amounts of resources** at a reduced cost or offering financial incentives for solutions rather than paying for time spent developing solutions.	Medical sciences (medical and health sciences)
Franzoni et al. (2022, p. 276)	This may involve, among other things, **a greater diversity of knowledge input**, specialist knowledge resulting from specific experiences, as well as knowledge of existing problems and solutions.	Management and quality sciences (social sciences)
Beck et al. (2022, p. 2)	Very effective in a related innovation context where the researcher can have **access to specialist knowledge.**	Management and quality sciences (social sciences)

Source: own Own elaboration based on a literature review

Table 2.2 Engagement-driven crowdsourcing in science

Author/authors	Definitions	Discipline/field of science
Petersen (2013, p. 2)	Combined with the Internet, where **large numbers of self-selected people can be engaged** with minimal effort.	Social communication and media sciences (social sciences)
Del Savio et al. (2016, p. 3)	It can **facilitate and deepen engagement** between citizens and scientists.	Medical sciences (medical and health sciences)
Levy, Germonprez (2017, p. 29)	**It engages the crowd** actively (...) or passively (...) in a phenomenological exploration of the nature of user-generated content and may engage the crowd in contests, fundraisers, problem solving, and digital and physical product development.	Social communication and media sciences (social sciences)

(*Continued*)

Table 2.2 (Continued)

Author/authors	Definitions	Discipline/field of science
Stewart et al. (2017, p. 736)	Human intelligence tasks such as transcription, data set development, validation, and **engaging in** human factors research.	Psychology (social sciences)
Correia et al. (2018, p. 134)	It can improve the quality, cost, and speed of a research project **while engaging large sections of society and creating new science**.	Social communication and media sciences (social sciences)
Doyle et al. (2018, p. 1)	**It engages amateur volunteers** as co-creators of real scientific projects.	Social communication and media sciences (social sciences)
Hecker et al. (2018, p. 129–130)	**Engaging citizens** in activities such as data collection and annotation is a way to harness their distributed intelligence ("citizens as translators"), while enabling them to contribute to problem definition and data analysis leads to participatory science projects.	Earth and environmental sciences (exact and natural sciences)
Scheliga et al. (2018, p. 517)	The concept of acquiring services, ideas, or content by **engaging a large group of people**, usually from online communities.	Management and quality sciences (social sciences)
Houghton et al. (2019, p. 2)	Such research is typically driven by a basic science case (i.e. the need to process data that is too abundant for a professional scientist to work through alone and too rich or complex for algorithmic approaches) and represents the **involvement** of these individuals.	Civil engineering, surveying and transport (engineering and technical sciences)
Shanley et al. (2019, p. 1)	A methodology that **engages a large group of people** through an open invitation to solve a common task or problem, individually or collectively.	Earth and environmental sciences (exact and natural sciences)
Beck et al. (2021, p. 3)	Direct **participation by members of the public** in scientific research projects in response to an open call for comments.	Management and quality sciences (social sciences)
Beck et al. (2021, p. 9)	**Businesses, non-governmental organizations, and individual citizens were engaged** to submit "researchable" questions as part of a pioneering public consultation process.	Management and quality sciences (social sciences)
Lenart-Gansiniec et al. (2022, p. 20)	Online collaboration in which researchers **engage a group of people** with diverse knowledge and skills, via an open invitation to the Internet and/or online platforms, to undertake a specific research task or set of tasks.	Management and quality sciences (social sciences)

Source: Own elaboration based on a literature review.

Table 2.3 Crowdsourcing in science as a production model

Author/authors	Definitions	Discipline/field of science
Wiggins (2010, p. 337)	**A set of distributed production models** that use an open invitation to participate from a large, undefined network of people.	Social communication and media sciences (social sciences)
Wiggins, Crowstron (2011, p. 1)	A set of distributed **production models** that call for participation from a large, undefined network of people.	Social communication and media sciences (social sciences)
Franzoni, Sauermann (2022, p.1)	**Participation in the project is open** to a broad base of potential contributors, and intermediate inputs, such as data or problem-solving algorithms, are openly shared.	Management and quality sciences (social sciences)
Newman (2014, p. 105)	It uses **collective intelligence** (…), where some computational and analytical tasks can be performed in isolation by individual people rather than by groups that may or may not interact socially.	Earth and environmental sciences (exact and natural sciences)

Source: Own elaboration based on a literature review.

distributed, open nature, and based on collective intelligence (Table 2.3). In this way, crowdsourcing in science was most often understood by representatives of social communication and media sciences (2 definitions), less frequently by researchers representing management and quality sciences (1 definition), and earth and environmental sciences (1 definition). In this approach, the potential of crowdsourcing in science as a production model results from the participation of a large group of people with unique and diverse skills and knowledge in the value co-creation process. Thanks to interactions between these people, value can be created in both a tangible and social sense, which one person cannot provide (Beck et al., 2022).

A kind of supplement to the categories of definitions related to access to resources, but also the delegation of various tasks to a virtual community, is the consideration of crowdsourcing in science from the perspective of their exploitation (Table 2.4). There are 8 definitions that treat crowdsourcing in science as commissioning research tasks. In this way, crowdsourcing in science was most often understood by representatives of psychology (2 definitions), management and quality sciences (2 definitions), computer science (2 definitions), less often

Table 2.4 Crowdsourcing in science as outsourcing research tasks

Author/authors	Definitions	Discipline/field of science
Behrend et al. (2011, p. 801)	Paid recruitment of an online, freelance global workforce **to work on a specific task or set of tasks.**	Psychology (social sciences)
Pan, Blevis (2011, p. 1)	A new paradigm of online learning and collaboration in which "crowds" of people can collaborate and **perform specific tasks** (...) collaboration in three different contexts, namely academia, entrepreneurship and social values.	Computer science (exact and natural sciences)
Williams (2013, p. 31)	An organizing research entity that **outsources research tasks** that the entity itself would not be able to accomplish to large groups of people of its own choosing (laymen and experts).	Management and quality sciences (social sciences)
Wechsler (2014, p. 2)	**Directing research activities** to a broad target group that has expert knowledge and special skills in order to solve scientifically relevant problems and issues.	Earth and environmental sciences (exact and natural sciences)
Vaish et al. (2018, p. 829)	**A technique that coordinates open research** through an iterative cycle of open input, synchronous collaboration, and peer review.	Computer science (exact and natural sciences)
Watson, Floridi (2018, p. 758)	This process shows new and unusual ways in which **amateurs, experts, and digital technologies come together to create a coherent socio-technical system in projects.**	Psychology (social sciences)
Bassi et al. (2019, p. 8)	They require **an open call** that clearly identifies the skills, interests, and experience of participants best suited for the research.	Medical sciences (medical and health sciences)
Wang, Yu (2019, p. 2)	**A new way of conducting modern scientific research** (…), which is the result of technological development and the popularization of the Internet.	Management and quality sciences (social sciences)

Source: Own elaboration based on a literature review.

by researchers representing medical sciences (1 definition), and earth and environmental sciences (1 definition).

The last category of the definition of crowdsourcing in science is data analysis (2 definitions) (Table 2.5). In this way, crowdsourcing in science was most often understood by representatives of psychology (1 definition) and civil engineering, surveying, and transport (1 definition). In this approach, crowdsourcing

Table 2.5 Crowdsourcing in science as resource exploitation

Author/authors	Definitions	Discipline/field of science
Nov et al. (2010, p. 6)	An approach **to using resources** contributed by a large number of geographically dispersed people.	Civil engineering, surveying and transport (engineering and technical sciences)
Uhlmann et al. (2019, pp. 711–712)	The approaches aim to **maximize the use of available resources**, diversify inputs, enable high learning, and increase transparency and reliability.	Psychology (social sciences)

Source: Own elaboration based on a literature review.

in science is oriented towards maximizing (Ulhmann et al., 2019) the use of resources (Nov et al., 2010; Ulhmann et al., 2019), which allows for the improvement and acceleration of the use of intangible resources, in particular, their processing, visualization, and integration.

As already indicated, crowdsourcing in science is not a homogeneous concept, which is confirmed not only by the analysed definitions but also by its following distinguishing features, considered to be its *sine qua non* conditions or *differentia specifica* (Estellés-Arolas, González-Ladrón-de-Guevara, 2012), such as initiator, virtual community, process and technology. They are presented below, taking into account their inclusion in the definitions identified and presented above:

1 The initiator is recognized as a research entity, researchers, and scientists. He or she is responsible for preparing, initiating, generating, verifying, and implementing, i.e. all activities (sub-processes) that the crowdsourcing in science process includes.
2 Virtual community understood as online communities, crowd, independent global workforce, large, indeterminate, scattered, geographically diverse and demographically, a group of self-selected people, contributors, laypeople and experts, members of the public, amateur volunteers, scientists, researchers, citizens, potential stakeholders and enterprises, non-governmental organizations.
3 A process recognized as a specific iterative, digital activity recognized as: work order, action referral, coordination, connecting and creating, online learning and collaboration, conducting scientific research, engagement, share, maximization, contribution diversification, use of available resources, access, inclusion, collection, sourcing, and prospecting. These activities are addressed to virtual communities as an open invitation. As part of crowdsourcing in science, specific tasks of varying degrees of complexity are transferred to members of

the virtual community. These may be simple tasks (microtasks), complex tasks (macrotasks), or complicated (sophisticated) tasks.

- Simple tasks (microtasks) refer to tasks that do not require cooperation with other people. These are simple tasks that a member of the virtual community can complete in a few or a dozen or so minutes. These are usually work related to tagging or sorting content.
- Complex tasks (macrotasks) refer to tasks that require cooperation with other people, specific knowledge and skills, and a lot of commitment and time. These are usually tasks related to solving scientific problems or providing opinions on a scientific publication.
- Complicated tasks (sophisticated) refer to work requiring cooperation with others, high commitment, time, creativity and innovation. These are usually works involving posing research questions, research hypotheses, or jointly writing scientific publications.

4 Technology is understood as a digital, online platform that has specific functionalities enabling the initiator to communicate with members of the virtual community, including giving them tasks to perform.

Considering the above, regardless of the adopted perspective of the field/discipline of science, the specificity of crowdsourcing in science, its diversity, and polymorphism make it seem reasonable to look at this concept with a high level of granularity. This leads to the identification of concepts that are often used interchangeably in the literature – which may be incorrect and overly simplistic. The subsequent section will therefore cover this issue.

2.2 Crowdsourcing in Science on the Background of Related Concepts

The multiplicity of definitions indicated in the previous chapter, but also the diversity of approaches to crowdsourcing in science, is undoubtedly intensified by the diversity of concepts, which results from the differences between representatives of individual fields/disciplines of science signalled in the previous chapter. The literature emphasizes the alternating use of the following concepts alongside crowdsourcing in science: citizen science (Sprinks et al., 2017; Doyle et al., 2018; Lukyanenko et al., 2020; Mäkipää et al., 2020), online citizen science (Doyle et al., 2018; Houghton et al., 2019), crowd science (Sauermann, Franzoni, 2015; Franzoni et al., 2022), crowd research (Vaish et al., 2018) and open innovation in science (Beck et al., 2022).

Taking into account the above considerations, from the point of view of the diversity of perceptions of crowdsourcing in science, it is necessary to introduce terminological order. Differentiating features were used as distinguishing features, which also constitute *sine qua non* conditions, such as initiator, virtual community, process, and technology (Table 2.6).

Table 2.6 Crowdsourcing in science and related concepts

Differentiating criteria		Differentiating features	Crowdsourcing in science	Related concepts				
				Citizen science	Online citizen science	*Crowd science*	*Crowd research*	Open innovation in science
Initiator		Researcher	✓	✓	✓	✓	✓	✓
Virtual community		People from outside the scientific community	✓	✓	✓	✓	✓	
		Members of the scientific community	✓				✓	
Process	Participation in the project	Open	✓	✓	✓	✓	✓	✓
		Closed	✓					
	Data sharing	Open	✓			✓	✓	✓
		Closed	✓	✓	✓			
	Difficulty level of the task	Simple	✓	✓	✓	✓		
		Complex	✓				✓	✓
Technology		Platform	✓		✓	✓	✓	✓

Source: Own elaboration.

Based on the review of related concepts, it is possible to note the differences and similarities with crowdsourcing in science, which are discussed below.

Citizen science is defined as "the engagement of the general public in scientific research activities when citizens actively contribute to science through their intellectual effort or knowledge or through their tools and resources" (Den Broeder et al., 2018, p. 506). It therefore refers to the inclusion of members of the public in a research task or tasks and partnerships between scientists and society in scientific research (Mäkipää et al., 2020). As noted above, in citizen science, non-scientist volunteers may participate in a variety of research tasks, including collecting resources, formulating research questions, analysing data, and disseminating results. Citizen science is also about the participation of members of society in scientific research and a way to use their skills and passion to seek answers to universal questions about the world and its works (Eitzel et al., 2017).

In the context of the conceptual distinction in relation to citizen science and crowdsourcing in science, two positions appear in the literature. The former indicates that these are different concepts, and it is inappropriate to treat them synonymously. For example, Levy and Germonprez (2017, p. 29) argue that "crowdsourcing is not rooted in citizen interference in the scientific process". As indicated by Eitzel et al. (2017), it is inappropriate to consider citizen science as crowdsourcing and vice versa. What distinguishes them is primarily the involved stakeholders: in citizen science, these are people from outside the scientific community, while in crowdsourcing in science – in addition to volunteers from society, these are also people from the scientific community.

The latter indicates the possibility of combining crowdsourcing in science with citizen science. This is due to the similarities of both concepts. Thus, like citizen science, crowdsourcing in science refers to online collaboration focused on acquiring intangible resources from a large group of people (Eitzel et al., 2017). Some claim that crowdsourcing in science is one of the types of citizen science (Vachelard et al., 2016), because it refers to research cooperation between scientists and volunteers (Eklund et al., 2019).

There are voices that crowdsourcing in science is a form of citizen science (Scheliga et al., 2018). In turn, Ciasullo et al. (2022) considered crowdsourcing in science as one of the approaches to citizen science. In another perspective, crowdsourcing in science represents the lowest level of participation and engagement in citizen science projects (Haklay, 2013), while citizen science is on the same ladder but at the highest level. In turn, Lukyanenko et al. (2020, p. 963) suggested that "citizen science uses crowdsourcing as a work organization strategy".

Considering the above, the author is of the opinion that it is unjustified to treat citizen science and crowdsourcing in science synonymously. This is due to several reasons:

1. Crowdsourcing in science refers to the inclusion of a virtual community in the performance of a research task or tasks, where community members may include both other researchers and people from outside the scientific community. However, in citizen science, only volunteers – people from outside the scientific community undertake scientific work in cooperation with or under the supervision of professional scientists and scientific institutions.
2. Citizen science has a strong tradition in open science, conservation and biodiversity, and crowdsourcing in science is linked to value co-creation and open innovation.
3. Unlike crowdsourcing in science, participants in projects based on citizen science are not interested in receiving remuneration in exchange for the tasks they perform. With regard to crowdsourcing in science, there is a possibility of financial motivation, at least due to the fact that it is one of the manifestations of the "gig economy".
4. Citizen science projects do not require dedicated online platforms as is the case with crowdsourcing in science.

To sum up, we cannot equate crowdsourcing in science with citizen science, as they come from a different conceptual framework and involve a different group of stakeholders involved in the implementation of individual research tasks.

Online citizen science brings citizen science to the Internet, making it easier for professional scientists to connect with and engage in research with people outside the scientific community (Aristeidou, Herodotou, 2020).

In the literature, online citizen science is combined with crowdsourcing in science (Wiggins, 2010), which is due to similar reasons for the creation of both concepts. In particular, we are talking about the development of "Web 2.0" technology, the expansion of open science and Science 3.0. However, taking into account the specificity of online citizen science and crowdsourcing in science, the author is of the opinion that they cannot be considered to be identical concepts. What they have in common is access to a broadly understood virtual community via information and communication technologies. However, an important differentiating aspect is the way in which tasks are performed: in online citizen science, we are talking about volunteers performing a research task in cooperation or under the supervision of professional scientists and scientific institutions. In turn, in crowdsourcing in science, the stakeholders are other researchers and people from outside the scientific community. Finally, crowdsourcing in science does not focus only on simple tasks, as is the case with online citizen science. In the case of crowdsourcing in science, members of the virtual community can simultaneously perform many more tasks that are more complex. Thus, crowdsourcing in science and online citizen science are separate concepts.

Crowd science refers to open participation of all interested people in a scientific project. However, in addition to handing over the task, the initiator openly provides input and intermediate data, such as data sets or problem-solving algorithms (Franzoni, Sauermann, 2022). Tasks directed by the initiator are characterized by low complexity and are usually based on performing work on a set of data provided by him or her. In particular, these may include tagging, verifying, or describing scientific data (Bonney et al., 2016; Dickel, Franzen, 2016).

The literature postulates that crowd science is more similar to crowdsourcing in science than to citizen science (Franzoni et al., 2022). This is supported by the fact that the tasks are addressed only to other researchers, and not to people from outside the scientific community. Therefore, this seems to be the only part common to crowdsourcing in science. Other researchers point out that crowd science is not related to crowdsourcing in science, but rather is a form of citizen science (Scheliga et al., 2018), which results from the ways of motivating the virtual community. In crowd science, volunteers are not paid like in the case of citizen science.

Taking into account the above, the author is of the opinion that crowd science and crowdsourcing in science come from different conceptual circles and cannot be considered identical concepts. In particular, crowd science is closer to open science, due to the openness of input and intermediate data, but also the way of motivating Internet users. Therefore, crowdsourcing in science and crowd science are separate concepts. However, their common features allow crowd science to be considered one of the types of crowdsourcing in science (Lenart-Gansiniec, 2022). In particular, this concerns the participation of people from the scientific community in the implementation of research tasks.

Crowd research refers to the cooperation of various stakeholders during the implementation of research tasks. The basis here is open access, cooperation, exchange of views, brainstorming on various aspects related to the research process and information and communication technology. Work on the task is based on a project approach, where members of the virtual community work in parallel on a separate part of a large task. Additionally, in addition to exchanging ideas and regular meetings, members of the virtual community become some sort of reviewers based on the idea of the so-called peer review. More specifically, they communicate their assessment of the work of other teams by awarding them points.

Diversity of knowledge and skills is of great importance in crowd research, but tasks are usually directed to people from outside the scientific community. In this sense, this is one of the features that distinguishes crowd research from crowdsourcing in science, but connects it with citizen science, online citizen science and crowd science. The literature indicates that crowd research is one of the crowdsourcing techniques (Vaish et al., 2018). In particular, it is emphasized that crowd research is based on the coordinated work of a large group of people and a decentralized scoring system to recognize the contribution to the implementation of tasks. These features actually demonstrate the closeness of crowd research to crowdsourcing in science. An additional distinguishing feature is project work and the division of larger tasks into smaller parts. In this context, crowd research can be combined with crowdsourcing in science. In citizen science, online citizen science or crowd science – specific tasks are performed without the need to divide them into smaller parts. Taking into account the above, the author believes that the specificity of crowd research places it next to crowdsourcing in science. It should also be noted that the concept of "crowd research" was introduced by Vaish et al. (2018) and there were no extensive findings in this regard in the literature. The author agrees with the popularisers of the concept of crowd research (Vaish et al., 2018) that it is one of the techniques of crowdsourcing in science.

Open innovation in science (Beck et al., 2020) refers to the process of intentionally enabling, initiating, and managing incoming, outgoing, and related knowledge flows and collaboration across organizational and disciplinary boundaries in all stages of the scientific research process. These include formulating research questions, conceptualization, collecting, processing and analysing data, and writing publications.

Open innovation in science involves only academic scientists and non-academic organizations (Perkmann et al., 2013). This is what differentiates open innovation in science from crowdsourcing in science, because in the latter, not only people from outside the scientific community but also other scientists can be involved in tasks. Hence, it cannot be considered that open innovation in science is synonymous with crowdsourcing in science. Despite the reported discrepancies, there is a connection between crowdsourcing in science and open innovation in practice, which results from several reasons:

1 Open innovation in science focuses on openness and cooperation in the creation of scientific knowledge and includes purposefully managed knowledge

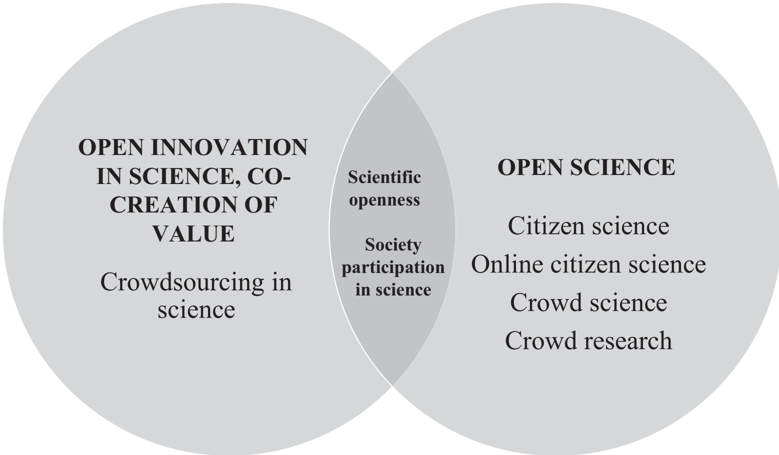
flows across organizational and sectoral boundaries. They also include the creation of innovative solutions taking into account incoming and outgoing processes and connections related to the flow of knowledge. Researchers share data and work on complex tasks (Beck et al., 2020). As in open innovations in science, openness, cooperation, and access to knowledge are also important in crowdsourcing in science (Schildhauer, Voss, 2014).

2 Open innovation in science and crowdsourcing in science are examples of the same open innovation paradigm because they share the use of complementary, diverse knowledge. However, what distinguishes crowdsourcing in science from open innovations in science are knowledge flows focused on the internal use of external knowledge obtained from stakeholders and the external use of knowledge through the sale of patents or licenses. In the case of crowdsourcing in science, flows are less important than in the case of open innovations in science, but cooperation and communication with members of the virtual community invited to carry out a specific task are more important.

3 Open innovation in science is oriented towards increasing the organization's innovative capabilities (Chesbrough, 2003). However, crowdsourcing per se has much greater potential opportunities focused on, among others, solving organizational problems, increasing transparency and openness, improving business processes, shaping competitive advantage, collecting valuable and difficult to obtain data, information and knowledge, their mapping, integration of distributed external competences (Chanal, Caron-Fasan, 2008), organizational learning (Lenart-Gansiniec, 2019), and knowledge management (Lenart-Gansiniec, 2018).

To sum up, the author believes that crowdsourcing in science and open innovation in science are not synonymous concepts. Crowdsourcing in science is a practice of open innovation in science (Beck et al., 2020).

The analysis of the differentiating features of related concepts lets us identify what connects and differentiates crowdsourcing in science from individual concepts (Figure 2.1). Generally, according to the author, the concepts discussed above are connected by scientific openness and public participation in science (Bonhoure et al., 2019; Ciasullo et al., 2022). This is part of the hallmarks of the democratization of science. In a word, it is important to involve various entities in undertaking various tasks, which increases the potential to develop a solution not only faster but also with greater value and quality (than in the case of independent action) (Hill et al., 2020). However, in the case of crowdsourcing in science, democratization of science refers to the active participation of scientists and/or people from outside the scientific community in the creation of scientific knowledge. However, in the case of citizen science, online citizen science, crowd science and crowd research – this refers to undertaking of tasks by people from outside the scientific community.



Source: own elaboration.

Figure 2.1 Crowdsourcing in science and other related concepts.

Moreover, what differentiates crowdsourcing in science from citizen science, online citizen science, crowd science and crowd research is the umbrella concept. The author believes that in the case of crowdsourcing in science, the superior concept involves open innovation in science and value co-creation. In relation to citizen science, online citizen science, crowd science, and crowd research, the umbrella concept is open science (Figure 2.1).

2.3 Advantage of Crowdsourcing in Science

As part of the first stage of the research process, i.e. the conceptual stage, crowdsourcing in science may prove useful when deciding on future research directions (Uhlmann et al., 2019), because the virtual community has the ability to take a multi-aspect view (Cooper et al., 2010). The result of this may be obtaining ideas for scientific research (Schlagwein, Daneshgar, 2014; Krivosheev et al., 2017; Brasseur et al., 2019; Uhlmann et al., 2019), identifying cognitive gaps (Beck et al., 2020), and formulating research purpose and research hypotheses (Parrick, Chapman, 2020). In this approach, the literature indicates that crowdsourcing in science can be used to improve existing knowledge and search for new solutions in order to reduce the limitations of existing research. In this approach, the potential of crowdsourcing in science as a production model results from the participation of a large group of people with unique and diverse skills and knowledge in the value co-creation process.

Due to the potential of crowdsourcing in science, it can be an activity enabling the inclusion of a large group (Law et al., 2017; Scheliga et al., 2018) of self-selecting stakeholders (Petersen, 2013), who represent both the scientific community and representatives of society (Doyle et al., 2018; Beck et al., 2022). Thanks to the involvement of a large group of people, it can contribute to increasing the transparency and credibility of scientific knowledge. All this means that crowdsourcing in science turns out to be crucial in the context of increasing the scale and impact of scientific research, the inclusiveness and democratization of science, and the acceleration of scientific discoveries (Edgar et al., 2016; Uhlmann et al., 2019).

In relation to the second stage of the research process, conducting research, crowdsourcing in science allows the recruitment of people interested in taking part in the implementation of the following research tasks: developing methods of data management, modification, improving existing research paradigms, improving research design, improving experimental protocols, designing survey questionnaires, establishing methods of data acquisition, and validating research tools. In addition, crowdsourcing in science may prove useful for conducting experiments, monitoring, improving the measurement of latent constructs, and testing scientific evidence (Williams, 2013).

The literature indicates that crowdsourcing in science may prove useful for the broadly understood analysis of collected research material, in particular, the translation of texts, audio and video materials (Sauermann, Franzoni, 2015), content analysis (Benoit et al., 2016; Budak et al., 2016), coding (Sauermann, Franzoni, 2015; Mazumdar et al., 2017), transcription (Schlagwein, Daneshgar, 2014; Law et al., 2017; Mazumdar et al., 2017), categorizing, cataloguing, contextualizing, and mapping the collected data.

In relation to the last stage of the research process related to the analysis of collected empirical material, crowdsourcing in science contributes to improving the replication of unpublished and published scientific research results (Uhlmann et al., 2019), i.e. re-conducting research while maintaining the same research conditions, which is guarantee of impartiality and ignores the researcher's subjective assessments. In this approach, according to Schweinsberg et al. (2017), a significant portion of unpublished and published research results are difficult to reproduce in independent laboratories, while crowdsourcing in science ensures that published results are reliable before they are widely disseminated.

Crowdsourcing in science may prove useful for performing peer review (Uhlmann et al., 2019), which amounts to "expert assessment of material submitted for publication" (Olson, 1990, p. 356). Some researchers refer to the use of crowdsourcing for reviewing as "readersourcing" (Mizzaro, 2012). Mizzaro (2012) stated that "readersourcing" is an independent, external, non-profit, and academic/scientific enterprise that enables the assessment of the quality of scientific literature and scientists, as well as providing critical comments on a given publication or its draft.

Finally, crowdsourcing in science may prove useful for editing various scientific texts (Schlagwein, Daneshgar, 2014) and jointly writing a publication (Uhlmann et al., 2019). According to Uhlmann et al. (2019), including various stakeholder groups in joint writing or editing enables the identification of possible errors in the resulting text and the creation of high-quality publications with comprehensive implications for practitioners.

Bibliography

Aguinis H., Lawal S.O. (2013), ELancing: A review and research agenda for bridging the science-practice gap, *Human Resource Management Review*, 23(1), 6–17.

Aristeidou M., Scanlon E., Sharples M. (2017), *Science learning in online communities of scientific investigations: Evidence and suggestions*, American Educational Research Association Annual Conference, http://oro.open.ac.uk/49563/.

Bassi H., Lee C., Misener L., Johnson A. (2019), Exploring the characteristics of crowdsourcing: An online observational study, *Journal of Information Science*, 46(3), 1–2.

Bassi H., Misener L., Johnson A.M. (2020), Crowdsourcing for research: Perspectives from a Delphi panel, *SAGE Open*, 10(4), 21582440209.

Beck S., Bergenholtz C., Bogers M., Brasseur T.-M., Conradsen M.L., Di Marco D., Distel A.P., Dobusch L., Dörler D., Effert A., Fecher B., Filiou D., Frederiksen L., Gillier T., Grimpe C., Gruber M., Haeussler C., Heigl F., Hoisl K., Hyslop K., Kokshagina O., LaFlamme M., Lawson C., Lifshitz-Assaf H., Lukas W., Nordberg M., Norn M.T., Poetz M., Ponti M., Pruschak G., Priego L.P., Radziwon A., Rafner J., Romanova G., Ruser A., Sauermann H., Shah S.K., Sherson J.F., Suess-Reyes J., Tucci C.L., Tuertscher P., Vedel J.B., Velden T., Verganti R., Wareham J., Wiggins A., Xu S.M. (2020), The open innovation in science research field: A collaborative conceptualisation approach, *Industry and Innovation*, 29(2), 136–185, https://www.tandfonline.com/doi/full/10.1080/13662716.2020.1792274.

Beck S., Brasseur T.-M., Poetz M., Sauermann H. (2022), Crowdsourcing research questions in science, *Research Policy*, 51(4), 104491.

Behrend T.S., Sharek D.J., Meade A.W., Wiebe E.N. (2011), The viability of crowdsourcing for survey research, *Behavior Research Methods*, 43, 800–813.

Benoit K., Conway D., Lauderdale B.E., Laver M., Mikhaylov S. (2016), Crowd-sourced text analysis: Reproducible and agile production of political data, *American Political Science Review*, 110(2), 278–295.

Bonhoure I., Cigarini A., Vicens J., Perelló J. (2019), Citizen social science in practice: A critical analysis of a mental health community-based project, https://doi.org/10.31235/osf.io/63aj7.

Bonney R., Phillips T.B., Ballard H.L., Enck J.W. (2016), Can citizen science enhance public understanding of science?, *Public Understanding of Science*, 25(1), 2–16.

Bramer W.M., Rethlefsen M.L., Mast F., Kleijnen J. (2018), Evaluation of a new method for librarian-mediated literature searches for systematic reviews, *Research Synthesis Methods*, 9(4), 510–520.

Braun V., Clarke V. (2006), Using thematic analysis in psychology, *Qualitative Research in Psychology*, 3(2), 77–101.

Bucheler T., Sieg J.H. (2011), Understanding science 2.0: Crowdsourcing and open innovation in the scientific method, *Procedia Computer Science*, 7, 327–329.

Buecheler T., Sieg J., Füchslin R., Pfeifer R. (2010), *Crowdsourcing, open innovation and collective intelligence in the scientific method: A research agenda and operational framework*, Artificial Life XII – Twelfth International Conference on the Synthesis and Simulation of Living Systems, http://ecas.issuelab.org/resources/29661/29661.pdf.

Burgelman J.C., Osimo D., Bogdanowicz M. (2010), Science 2.0 (change will happen….), *First Monday*, 15(7), https://firstmonday.org/ojs/index.php/fm/article/view/2961/2573.

Chanal V., Caron-Fasan M.L. (2008), *How to invent a new business model based on crowdsourcing: The Crowdspirit® case*, Conférence de l'Association Internationale de Management Stratégique, Sophia-Antipolis, France, 1–27.

Chesbrough H. (2003), The logic of open innovation: Managing intellectual property, *California Management Review*", 45(3), 33–58.

Ciasullo M.V., Carli M., Lim W.M., Palumbo R. (2022), An open innovation approach to co-produce scientific knowledge: An examination of citizen science in the healthcare ecosystem, *European Journal of Innovation Management*, 25(6), 365–392.

Cooper A.K., Coetzee S., Kourie D., 2010, Perceptions of virtual globes, volunteered geographical information and spatial data infrastructures, *Geomatica*, 64(1), 73–88.

Corbin J.M., Strauss A. (1990), Grounded theory research: Procedures, canons, and evaluative criteria, *Qualitative Sociology*, 13(1), 3–21.

Correia A., Schneider D., Fonseca B., Paredes H. (2018), *Crowdsourcing and massively collaborative science: A systematic literature review and mapping study*, International Conference On Collaboration And Technology, Springer, Cham, 133–154.

Cullina E., Conboy K., Morgan L. (2014), *Crowdsourcing and crowdfunding mechanisms for scientific research funding agencies – a preliminary entity categorisation matrix*, IPP2014: Crowdsourcing for Politics and Policy, Oxford, https://mural.maynoothuniversity.ie/6687/7/LM-Crowdsourcing.pdf.

Curtis V. (2018), *Online citizen science and the widening of academia: Distributed engagement with research and knowledge production*. Springer, Cham.

Del Savio L., Prainsack B., Buyx A. (2016), Crowdsourcing the Human Gut. Is crowdsourcing also 'citizen science'?, *Journal of Science Communication*, 15(3), 1–17.

Den Broeder L., Devilee J., Van Oers H., Schuit A.J., Wagemakers A. (2018), Citizen science for public health, *Health Promotion International*, 33(3), 505–514.

Dickel S., Franzen M. (2016), The „Problem of Extension" revisited: New modes of digital participation in science, *Journal of Science Communication*, 15(1), 1–15.

Djenontin I.N.S., Meadow A.M. (2018), The art of co-production of knowledge in environmental sciences and management: Lessons from international practice, *Environmental Management*, 61(6), 885–903.

Doyle C., Li Y., Luczak-Roesch M., Anderson D., Glasson B., Boucher M., Brieseman C., Christenson D., Coton M. (2018), What is online citizen science anyway? An educational perspective, https://arxiv.org/abs/1805.00441.

Edgar J., Murphy J., Keating M. (2016), *Comparing traditional and crowdsourcing methods for pretesting survey questions*. SAGE Open, https://journals.sagepub.com/doi/10.1177/2158244016671770.

Eitzel M.V., Cappadonna J.L., Santos-Lang C., Duerr R.E., Virapongse A., West S.E., Kyba C.C.M., Bowser A., Cooper C.B., Sforzi A., Metcalfe A.N., Harris E.S., Thiel M., Haklay M., Ponciano L., Roche J., Ceccaroni L., Shilling F.M., Dörler D., Heigl F., Kiessling T., Davis B.Y., Jiang Q. (2017), Citizen science terminology matters: Exploring key terms, *Citizen Science: Theory and Practice*, 2(1), 1–20.

Eklund L., Stamm I., Liebermann W. (2019), The crowd in crowdsourcing: Crowdsourcing as a pragmatic research method, *First Monday*, 24(1), 1–14.

Estellés-Arolas E., González-Ladrón-de-Guevara F. (2012), Towards an integrated crowdsourcing definition, *Journal of Information Science*, 38(2), 189–200.

Franzoni C., Poetz M., Sauermann H. (2022), Crowds, citizens, and science: A multi-dimensional framework and agenda for future research, *Industry and Innovation*, 29(2), 251–284.

Gasparyan A.Y., Ayvazyan L., Kitas G.D. (2013), Multidisciplinary bibliographic databases, *Journal of Korean Medical Science*, 28(9), 1270–1275.

Ghezzi A., Gabelloni D., Martini A., Natalicchio A. (2018), Crowdsourcing: A review and suggestions for future research, *International Journal of Management Reviews*, 20(2), 343–363.

Glinka B., Czakon W. (2021), *Podstawy badań jakościowych*. Polskie Wydawnictwo Ekonomiczne, Warszawa.

Hecker S., Bonney R., Haklay M., Hölker F., Hofer H., Goebel C., Gold M., Makuch Z., Ponti M., Richter A., Robinson L., Iglesias J.R., Owen R., Peltola T., Sforzi A., Shirk J., Vogel J., Vohland K., Witt T., Bonn A., (2018), Innovation in citizen science–perspectives on science-policy advances, *Citizen Science: Theory and Practice*, 3(1), 1–14.

Hill R., Walsh F.J., Davies J., Sparrow A., Mooney M., Wise R.M., Tengö M. (2020), Knowledge co-production for Indigenous adaptation pathways: Transform post-colonial articulation complexes to empower local decision-making, *Global Environmental Change*, 65, 102161.

Hilton L.G., Azzam T. (2019), Crowdsourcing qualitative thematic analysis, *American Journal of Evaluation*, 40(4), 575–589.

Houghton R., Sprinks J., Wardlaw J., Bamford S., Marsh S. (2019), A sociotechnical system approach to virtual citizen science: An application of BS ISO 27500:2016, *Journal of Science Communication*, 18(1), 1–25.

Karachiwalla R., Pinkow F. (2021), Understanding crowdsourcing projects: A review on the key design elements of a crowdsourcing initiative, *Creativity and Innovation Management*, 30(3), 563–584.

Krivosheev E., Caforio V., Benatallah B., Casati F. (2017), *Crowdsourcing paper screening in systematic literature reviews*, Proceedings of the Fifth Conference on Human Computation and Crowdsourcing, https://www.aaai.org/ocs/index.php/HCOMP/HCOMP17/paper/view/15921/15268.

Law E., Gajos K.Z., Wiggins A., Gray M.L., Williams A. (2017), *Crowdsourcing as a tool for research: Implications of uncertainty*, Proceedings ACM Conference on Computer Supported Cooperative Work and Social Computing, https://www.eecs.harvard.edu/~kgajos/papers/2017/law17-crowdsourcing.pdf.

Lenart-Gansiniec R. (2018), Selected crowdsourcing paradoxes: A literature review, *Przedsiębiorczość i Zarządzanie*, 19(9.3), 407–421.

Lenart-Gansiniec R. (2019), *Organizacyjne uczenie się w organizacjach publicznych. Perspektywa crowdsourcingu*. Wydawnictwo Naukowe PWN, Warszawa.

Lenart-Gansiniec R. (2021), The effect of crowdsourcing on organizational learning: Evidence from local governments, *Government Information Quarterly*, 38(3), 101593.

Lenart-Gansiniec R. (2022), Toward a typology development of crowdsourcing in science, *Journal of Information* Science. https://journals.sagepub.com/doi/abs/10.1177/01655515221118045

Lenart-Gansiniec R., Czakon W., Sułkowski Ł., Pocek J. (2022), Understanding crowdsourcing in science, *Review of Managerial Science*, 17(8), 2797–2830, https://doi.org/10.1007/s11846-022-00602-z.

Levy M., Germonprez M. (2017), The potential for citizen science in information systems research, *Communications of the Association for Information Systems*, 40, 22–39.

Lukyanenko R., Parsons J., Wiersma Y.F., Maddah M. (2019), Expecting the unexpected: Effects of data collection design choices on the quality of crowdsourced user-generated content, *MIS Quarterly*, 43(2), 1–12.

Lukyanenko R., Wiggins A., Rosser H.K. (2020), Citizen science: An information quality research frontier, *Information Systems Frontiers*, 22(4), 961–983.

Majima Y., Nishiyama K., Nishihara A., Hata R. (2017), Conducting online behavioral research using crowdsourcing services in Japan, *Frontiers in Psychology*, 8, 236403, https://www.frontiersin.org/articles/10.3389/fpsyg.2017.00378/full.

Mäkipää J.-P., Dang D., Mäenpää T., Pasanen T. (2020), *Citizen science in information systems research: Evidence from a systematic literature review*, Proceedings of the 53rd Hawaii International Conference on System Sciences, https://scholarspace.manoa.hawaii.edu/bitstream/10125/64311/0460.pdf.

Mason W., Suri S. (2012), Conducting behavioral research on Amazon's Mechanical Turk, *Behavior Research Methods*, 44, 1–23.

Mazumdar S., Wrigley S., Ciravegna F. (2017), Citizen science and crowdsourcing for earth observations: An analysis of stakeholder opinions on the present and future, *Remote Sensing*, 9(1), 1–21.

Michel F., Gil Y., Ratnakar V., Hauder M. (2015), A virtual crowdsourcing community for open collaboration in science processes, https://www.isi.edu/~gil/papers/michel-etal-amcis15.pdf.

Mizzaro S. (2012), Readersourcing - A manifesto, *Journal of the American Society for Information Science and Technology*, 63(8), 1666–1672.

Newman G. (2014), Citizen cyberscience - new directions and opportunities for human computation, *Human Computation*, 1(2), 103–109.

Nov O., Araz O., Anderson D. (2010), *Crowdsourcing for science: Understanding and enhancing SciSourcing contribution*, Workshop on the Changing Dynamics of Scientific Collaborations, https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.682.6141&rep=rep1&type=pdf.

Olson C.M. (1990), Peer review of the biomedical literature, *American Journal of Emergency Medicine*, 8(4), 356–358.

Pan Y., Blevis E. (2011), *A survey of crowdsourcing as a means of collaboration and the implications of crowdsourcing for interaction design*, International Conference on Collaboration Technologies and Systems, https://ieeexplore.ieee.org/abstract/document/5928716.

Parrick R., Chapman B. (2020), Working the crowd for forensic research: A review of contributor motivation and recruitment strategies used in crowdsourcing and crowdfunding for scientific research, *Forensic Science International: Synergy*, 30(2), 173–182.

Perkmann M., Tartari V., McKelvey M., Autio E., Broström A., D'Este P., Fini R., Geuna A., Grimaldi R., Hughes A., Krabel S., Kitson M., Llerena P., Lissoni F., Salter A.,

Sobrero M. (2013), Academic engagement and commercialisation: A review of the literature on university–industry relations, *Research Policy*, 42(2), 423–442.
Petersen S. (2013), *Crowdsourcing in design research - potentials & limitations*, Proceedings of the 19th International Conference on Engineering Design, Design Processes, Seoul, Korea, https://www.designsociety.org/download-publication/34839/Crowdsourcing+in+design+research+-+Potentials+%26+limitations.
Petticrew M., Roberts H. (2008), *Systematic reviews in the social sciences: A practical guide*. John Wiley & Sons, Malden, Oxford.
Reed J., Rodriguez W., Rickhoff A. (2012), *A framework for defining and describing key design features of virtual citizen science pro*, Proceedings of the 2012 iConference, https://dl.acm.org/doi/abs/10.1145/2132176.2132314.
Rouse A. (2010), *A preliminary taxonomy of crowdsourcing*, ACIS Proceedings, Paper 76, http://aisel.aisnet.org/acis2010/76.
Sauermann H., Franzoni C. (2015), Crowd science user contribution patterns and their implications, *Proceedings of the National Academy of Sciences of the United States of America*, 112(3), 679–684.
Scheliga K., Friesike S., Puschmann C., Fecher B. (2018), Setting up crowd science projects, *Public Understanding of Science*, 27(5), 515–534.
Schenk E., Guittard C. (2011), Towards a characterization of crowdsourcing practices, *Journal of Innovation Economics*, 7(1), 93–107.
Schildhauer T., Voss H. (2014), Open innovation and crowdsourcing in the sciences, In: Bartling S., Friesike S. (eds.), *Opening science*, Springer, Cham, 255–269.
Schlagwein D., Bjorn-Andersen N. (2014), Organizational learning with crowdsourcing: The revelatory case of LEGO, *Journal of the Association for Information Systems*, 15(11), 3.
Schlagwein D., Daneshgar F. (2014), *User requirements of a crowdsourcing platform for researchers: Findings from a series of focus groups*, Proceedings - Pacific Asia Conference on Information Systems, https://aisel.aisnet.org/pacis2014/195/.
Schweinsberg M., Madan N., Vianello M., Sommer S.A., Jordan J., Tierney W., Awtrey E., Zhu L.L., Diermeier D., Heinze J.E., Srinivasan M., Tannenbaum D., Bivolaru E., Dana J., Davis-Stober C.P., du Plessis C., Gronau Q.F., Hafenbrack A.C., Liao E.Y., Ly A., Marsman M., Murase T., Qureshi I., Schaerer M., Thornley N., Tworek C.M., Wagnmakers E.-J., Wong L., Anderson T., Bauman C.W., Bedwell W.L., Brescoll V., Canavan A., Chandler J.J., Cheries E., Cheryan S., Cheung F., Cimpian A., Clark M.A., Cordon D., Cushman F., Ditto P.H., Donahue T., Frick S.E., Gamez-Djokic M., Hofstein Grady R., Graham J., Gu J., Hahn A., Hanson B.E., Hartwich N.J., Hein K., Inbar Y., Jiang L., Kellogg T., Kennedy D.M., Legate N., Luoma T.P., Maibuecher H., Meindl P., Miles J., Mislin A., Molden D.C., Motyl M., Newman G., Ngo H.H., Packham H., Ramsay P.S., Ray J.L., Sackett A.M., Sellier A.-L., Sokolova T., Sowden W., Storage D., Sun X., Van Bavel J.J., Washburn A.N., Wei C., Wetter E., Wilson C.T., Darroux S.-C., Uhlmann E.L. (2017), The pipeline project: Pre-publication independent replications of a single laboratory's research pipeline, *Journal of Experimental Social Psychology*, 66, 55–67.
Shank D.B. (2016), Using crowdsourcing websites for sociological research: The case of Amazon Mechanical Turk, *American Sociologist*, 47(1), 47–55.
Shanley L.A., Parker A., Schade S., Bonn A. (2019), Policy perspectives on citizen science and crowdsourcing, *Citizen Science: Theory and Practice*, 4(1), 1–30.

Sheehan K.B. (2018), Crowdsourcing research: Data collection with Amazon's Mechanical Turk, *Communication Monographs*, 85(1), 140–156.

Sprinks J., Wardlaw J., Houghton R., Bamford S., Morley J. (2017), Task workflow design and its impact on performance and volunteers' subjective preference in Virtual Citizen Science, *International Journal of Human-Computer Studies*, 104, 50–63.

Stewart N., Chandler J., Paolacci G. (2017), Crowdsourcing samples in cognitive science, *Trends in Cognitive Sciences*, 21(10), 736–748.

Tucci C.L., Afuah A., Viscusi G. (ed.). (2018), *Creating and capturing value through crowdsourcing*. Oxford University Press, Oxford.

Uhlmann E.L., Ebersole C.R., Chartier C.R., Chartier C.R., Errington T.M., Kidwell M.C., Lai C.K., McCarthy R.J., Riegelman A., Silberzahn R., Nosek B.A. (2019), Scientific utopia III: Crowdsourcing science, *Perspectives on Psychological Science*, 14(5), 711–733.

Vachelard J., Gambarra-Soares T., Augustini G., Riul P., Maracaja-Coutinho V. (2016), A Guide to scientific crowdfunding, *PLoS Biol*, 14(2), e1002373.

Vaish R., Goyal S., Saberi A., Goel S. (2018), *Creating crowdsourced research talks at scale*, Proceedings of the World Wide Web Conference, https://dl.acm.org/doi/10.1145/3178876.3186031.

Wang G., Yu L. (2019), Differential game analysis of scientific crowdsourcing on knowledge transfer, *Sustainability*, 11(10), 1–16.

Watson D., Floridi L. (2018), Crowdsourced science: Sociotechnical epistemology in the e-research paradigm, *Synthese*, 195(2), 741–764.

Wazny K. (2017), Crowdsourcing ten years, A review. *Journal of Global Health*, 7(2), 020602.

Webster J., Watson R.T. (2002), Analyzing the past to prepare for the future: Writing a literature review, *MIS Quarterly*, 26(2), xiii–xxiii.

Wechsler D. (2014), Crowdsourcing as a method of transdisciplinary research. Tapping the full potential of participants, *Futures*, 60, 14–22.

Wiggins A. (2010), *Crowdsourcing science: Organizing virtual participation in knowledge production*, Proceedings of the International ACM SIGGROUP Conference on Supporting Group Work, https://experts.nebraska.edu/en/publications/crowdsourcing-science-organizing-virtual-participation-in-knowled.

Wiggins A., Crowston K. (2011), *From conservation to crowdsourcing: A typology of citizen science*, Proceedings 44th Hawaii International Conference on Systems Sciences (HICSS), Kauai.

Williams C. (2013), Crowdsourcing research: A methodology for investigating state crime, *State Crime Journal*, 2(1), 30–51.

3 Effective Management of Crowdsourcing in Science

Crowdsourcing in science is based on an online collaborative process. Thus, crowdsourcing in science consists of a sequence of specific, subsequent stages, requiring various activities that ultimately allow to achieve a specific result. In practice, the essence of those activities is determined by the specificity of crowdsourcing in science, where the basis is the "wisdom of the crowd", which comes down to the fact that "in the right conditions, groups turn out to be extremely intelligent and are often wiser than their most brilliant members" (Surowiecki, 2010, p. 15). Benefits from the wisdom of the crowd are possible to achieve under certain conditions including multiplicity, diversity of opinions, independence of group members, decentralization of tasks, and their aggregation. Without those circumstances, the "crowd", i.e. the virtual community, will not only be uninterested in completing tasks, but may also exhibit opportunistic behaviour.

The literature suggests that coordinated crowdsourcing processes can not only contribute to generating better results (Thuan et al., 2017), but also to carrying out a crowdsourcing initiative more efficiently and cheaper (Tranquillini et al., 2015). A necessary condition for implementing a crowdsourcing in science initiative is repeatable management mechanisms at every stage of such an initiative, in particular: simultaneous coordination of hundreds or even thousands of interactions with independent and geographically dispersed co-creators. Such mechanisms enable initiators to more effectively and continuously use the crowdsourcing platform to implement crowdsourcing projects focused on creating scientific knowledge. However, coordination alone is insufficient, as other activities are necessary, including planning, initiation, evaluation, and implementation of solutions provided by the virtual community. Finally, a poorly selected crowdsourcing platform may contribute to the low quality of ideas generated by the crowd and the crowd's reluctance to participate in crowdsourcing. Parameters such as reliability, range, capacity and storage, efficiency, security, comprehensiveness, types and methods of available interaction, bandwidth, working time, response time, and types of administrator rights are also important.

Taking into account the above considerations, the aim of this chapter is to discuss effective management of crowdsourcing in science. First, the processes

DOI: 10.4324/9781003482253-4

of crowdsourcing in science are recognized and characterized, and an original model of crowdsourcing in science is suggested from a process perspective. Then, the challenges of managing a crowdsourcing in science initiative are presented. Finally, the most frequently used crowdsourcing platform by researchers, Amazon Mechanical Turk, is presented.

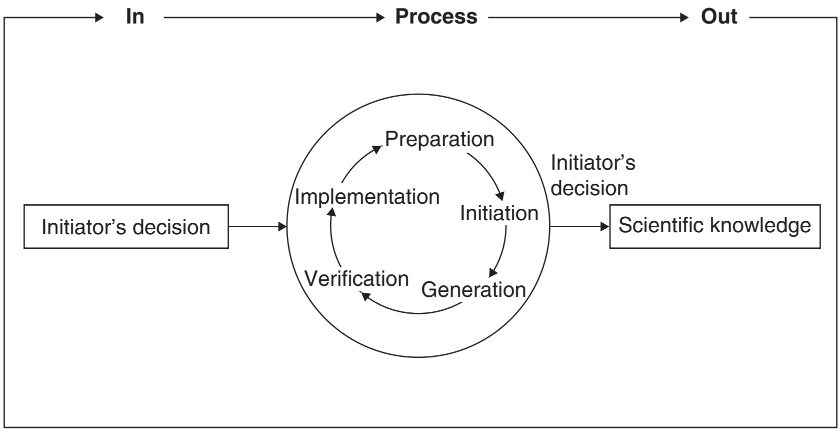
3.1 Crowdsourcing in Science: Step by Step

The specificity of crowdsourcing in science and its processual nature (Thuan, 2019) mean that it requires the initiator to take specific actions that ultimately lead to achieving the assumed goals. To recognize and illustrate them as well as the existing relationships between them, an original process model of crowdsourcing in science is proposed. The starting point for developing the model is the recommendations contained in the literature on the subject regarding building a conceptual framework (Jabareen, 2009), which "present key factors, constructs or variables and assume relationships between them" (Miles, Huberman, 1994, p. 440). The proposed model is based on five consecutive processes: preparation, initiation, generation, verification, and implementation. This model assumes cyclicality and repeatability of individual processes (Figure 3.1).

According to the proposed process model of crowdsourcing in science, each identified process consists of individual subprocesses related to activities that should be performed by the initiators. As it can be seen in the figure above, all processes refer to systematic, repeatable activities that ultimately lead to the achievement of a purposeful result in the form of creating scientific knowledge. Generally speaking, it is worth noting that the starting point in this model is the initiator's decision about the willingness or necessity to use crowdsourcing in science. However, this decision is not automatic, as it is a consequence of the needs of the initiator and other subjective factors. Generally, the initiator should start by "deciding whether a crowdsourcing approach is suitable for solving their internal problem(s)" (Muhdi et al., 2011, p. 322). Then, after making their decision on crowdsourcing, the initiator starts designing, which means making a number of decisions regarding the course of the scientific initiative. Next, they proceed to configuration of crowdsourcing in science, which comes down to the materialization of the project on the crowdsourcing platform. And at the last stage, the initiator also decides whether the solutions received from the virtual community will be used in practice and translate into scientific knowledge. Individual crowdsourcing in science processes is discussed below, along with specific activities within a given process.

3.1.1 Stage 1. Preparation

According to the proposed model (Figure 3.1), the crowdsourcing in science process is launched after the researcher makes a decision aimed at determining



Source: Own elaboration.

Figure 3.1 A process model of crowdsourcing in science.

"whether the crowdsourcing approach is suitable for solving (...) the problem(s)" (Muhdi et al., 2011, p. 322). This decision comes down to the initiator's assessment of the adequacy of crowdsourcing for a specific research task or tasks. The possibilities of using crowdsourcing in science in the context of creating scientific knowledge are endless, including, in terms of, identifying research directions (Krivosheev et al., 2017; Beck et al., 2020; Beck et al., 2022), selecting a research approach (Doan et al., 2011; Uhlmann et al., 2019), formulating a plan research (Schlagwein, Daneshgar, 2014; Beck et al., 2019), data analysis (Benoit et al., 2016; Crequit et al., 2018), and presentation of research results (Uhlmann et al., 2019).

After making the decision to use crowdsourcing, at the planning stage, the researcher performs a number of activities that are necessary to launch the initiative. Generally, the purpose of the preparation stage is to transform conceptual ideas about crowdsourcing tasks into a specific description, i.e. an invitation that will be addressed to members of virtual communities. However, before this happens, the initiator undertakes the following activities: designating the task, its specification, detailing and decomposition, defining the morphology of the virtual community, ways of motivating it, selecting a crowdsourcing platform, method of assessing and verifying tasks, and developing a schedule/time frame for the initiative. These will be introduced below.

Task assignment is related to the formulation of the task(s) that the researcher plans to convey to the virtual community. They should be consistent with the SMART principle, i.e. specific, measurable, achievable, relevant, and time-bound. It is indicated that an error made at this stage may increase the likelihood of obtaining low-quality results (Thuan et al., 2016).

Task specification is related to specifying the scope of the problem planned to be transferred to the virtual community, which comes down to specifying the task that will be directed to the virtual community. These may be tasks characterized by: (1) high specialization addressed to a selected group of people or (2) low specialization, open and addressed to an undefined group of people. Selecting tasks that are highly specialized may limit the diversity of the responses received. In turn, the second choice, i.e. tasks with low specialization, may contribute to discovering new knowledge and obtaining many creative answers, but this requires greater effort from the initiator related to the need to evaluate a heterogeneous pool of solutions.

Detailing the task is related to the researcher's decision on the complexity of the problem that will be addressed to the virtual community. The degree of complexity is determined by aspects, such as the difficulty of the knowledge search process, the requirements for knowledge, skills, and competences of members of the virtual community necessary to perform the task. In terms of the level of complexity, tasks can be divided into simple, moderate, and complex/advanced. Simple tasks do not require the cooperation of many people, detailed, advanced knowledge or work from the virtual community. For example, these may include work related to data analysis or processing, such as translation, tagging, visualization, coding, transcription, categorization, cataloguing, or mapping.

However, moderate tasks require the involvement of a larger number of people who can cooperate with each other. For example, these may include collecting data, monitoring, solving research dilemmas, or deciding on further research directions. Such tasks require more time from the virtual community but also specific knowledge and skills. Finally, complex/advanced tasks refer to those that require a high degree of creativity from the virtual community. Such tasks include identifying research gaps, formulating research problems and questions, research objectives, and research hypotheses.

Designing a crowdsourcing in science initiative requires decomposing the task, which comes down to dividing it into parts. This allows the researcher to direct tasks to smaller groups of the virtual community, which enables more efficient control over the work and increases the chance of access to various knowledge and skills resources. In the case of tasks with a greater degree of complexity, decomposition should take into account the possibility of cooperation and interaction between individual subgroups of the virtual community. The lack of this interaction may lead to uneven work and solutions with varying degrees of detail.

Determining the morphology of a virtual community comes down to determining the number of people participating in the crowdsourcing initiative. Additionally, such a choice is related to the initiator's determination of the requirements for the virtual community. What is expected of Internet users is determined by the type and complexity of the task. For example, creative tasks require large resources of various knowledge, creativity, and skills but also cooperation and knowledge sharing. However, simple tasks do not require cooperation or large amounts of knowledge and skills.

The choice of ways to motivate the virtual community is related to identifying motivators that can encourage Internet users to participate in the initiative. Despite various motives of virtual communities, it should be noted that tasks requiring creativity and significant commitment attract Internet users interested in developing knowledge and skills (Pee et al., 2018).

Internet users' motivation also depends on how the researcher constructs the task (Zhen et al., 2021; Martinez, 2017). Please note that some platforms (e.g. Amazon Mechanical Turk) assume payment of salaries to accounts established in the United States or India. In other cases, members of the virtual community carrying out tasks receive gift vouchers branded by Amazon. Another issue is ensuring sufficient protection of intellectual property, which is also important in the context of motivating the virtual community (Barends, de Vries, 2019; Saravanos et al., 2021).

Researchers can create their own crowdsourcing platform or use platforms provided by third parties. Developing your own crowdsourcing platform is certainly costly and time-consuming. However, the researcher's use of existing crowdsourcing platforms may pose a limitation in the form of its flexibility and adaptation to their individual needs (Schlagwein, Daneshgar, 2014). But the universality of such platforms facilitates the process of formulating a problem description, then sending it to the virtual community, selecting the collected solutions and providing feedback. In addition, the researcher can obtain help from the organization operating the crowdsourcing platform, in particular, in the context of intellectual property management and ongoing tracking of ideas or solutions to a scientific problem.

Regardless of what solution the initiator chooses, optimally the crowdsourcing platform should have the following functionalities (Schlagwein, Daneshgar, 2014): the ability to recruit participants to perform a research task/tasks, obtain funds for scientific research, and obtain consultations on research ideas.

At the stage of preparing a crowdsourcing in science initiative, it is important to develop a quality control method, and more specifically, to develop procedures for assessing and verifying the responses obtained from virtual communities. It also comes down to proposing criteria and requirements for solutions to tasks sent by the virtual community. They constitute a kind of guide for people planning to work within a given crowdsourcing initiative – in particular in the context of the expectations set for the virtual community and the methods of assessing and verifying the responses obtained. The arrangements regarding intellectual property are also important here, including the nature of the initiator's response to incidents of copyright infringement. Additionally, the literature suggests that initiators, in addition to developing their own requirements, may use, among others, reCAPTCHA or other protocols (Hauser et al., 2019) to capture and then discard community-generated data virtually.

Another issue at the stage of preparing a crowdsourcing in science initiative is for the initiator to establish a detailed schedule according to which the virtual community will carry out tasks and send answers and solutions. The time frame should take into account the potential responsiveness of Internet users. For example, Muhdi et al. (2011) find that most solutions appear within the first four weeks of announcing a crowdsourcing initiative. However, we cannot forget that tasks with a higher degree of complexity require greater commitment and creativity – hence it should be assumed that Internet users may need more time. Moreover, the longer the duration of a crowdsourcing initiative, the greater the likelihood of obtaining better quality solutions (Chen et al., 2011). However, there are situations where they complete tasks at the end of the required date – for fear of plagiarism by others. However, again there may be some risk that Internet users will start to be inspired by other people's solutions, and the researcher will obtain very similar ideas that may even infringe the intellectual property of other people. Ultimately, it seems reasonable to say that the duration of a crowdsourcing initiative depends on the difficulty and complexity of the task.

And finally, the last issue at the preparation stage refers to development of an open invitation by the initiator (Wiggins, Crowstron, 2011; Mason, Suri, 2012; Sauermann, Stephan, 2013; Franzoni, Sauermann, 2014; Eklund et al., 2019; Law et al., 2017; Schrögel, Kolleck, 2019;). It usually takes the form of a one-line note, supported by a short explanation of the research task (Petersen, 2013) and a request to solve a specific problem (Saez-Rodriguez et al., 2016).

3.1.2 Stage 2. Initiation

The next stage, initiation, focuses on activities aimed at clarifying the earlier (during the preparatory phase) arrangements for cooperation with the virtual community. At this stage, the initiator's activities should also be focused on developing methods of communication and risk management.

Cooperation with a virtual community means primarily communicating via a crowdsourcing platform. This requires the initiator to provide constant feedback to the communities. Many authors emphasize that this is a key element that determines the quality of solutions received from the virtual community (Blohm et al., 2013; Chan et al., 2021). At the beginning of the initiative, one-way and multi-directional communication is more appropriate, while during the initiative – two-way communication (Schäfer et al., 2017).

Counteracting potential risks (e.g. infringement of intellectual property, reluctance of Internet users to complete tasks or abandonment of tasks by members of the virtual community during their implementation) may be facilitated by clearly defining the problem, including detailed requirements regarding the expected solutions and directing inquiries to a specific group of the virtual community. Another issue is the protection of intellectual property – the initiator may consider including confidentiality agreements during and after the crowdsourcing initiative.

Such an agreement may include the following approaches to intellectual property protection (de Beer et al., 2017): (1) higher level: the initiator acquires intellectual property rights to the developed solutions; (2) lower level: idea submitters retain exclusive rights, but they may be granted to third parties (Mazzola et al., 2018). The complexity of the task determines the choice of copyright approach. Thus, tasks of higher complexity may be covered by a higher level of protection. Similarly, simple tasks that do not require specialized knowledge and skills from virtual communities may be covered by a lower level of protection.

3.1.3 Stage 3.Generating

After the initiator determines and clarifies the requirements for members of the virtual community – in the first and second stages, the initiator starts a crowdsourcing in science initiative. This automatically triggers the next stage of the initiative. It is related to generating, which comes down to coordinating the work of members of the virtual community. As part of a crowdsourcing in science initiative, the researcher may receive a very large number of solutions/ideas, but it may also turn out that the virtual community is not interested in taking part in the initiative. The initiator should be prepared for those two eventualities – by determining ways to transform the received solutions into valuable information or by providing additional incentives to Internet users. Therefore, there is a need to develop, at the preparation and initiation stage, criteria for assessing the feasibility of the reported solutions received from virtual communities. It is also important to establish specific indicators that will allow the initiator to keep track of whether the solutions obtained are consistent with previously assumed expectations (Ford et al., 2017). Based on previously developed criteria, at the generating stage, the initiator encourages the virtual community to act and answers any questions they may have regarding the assigned research task.

3.1.4 Stage 4. Verification

The generating stage, after the completion of the crowdsourcing in science initiative, moves into the evaluation phase, where the initiator, based on previously established criteria, performs verification. Therefore, taking into account the previous criteria, the submitted solutions are assessed in terms of the accuracy of the answers and expected results. Incorrect or low-quality data are also removed (Barger et al., 2011; Behrend et al., 2011; Kittur et al., 2008; Zhu, Carterette, 2010).

3.1.5 Stage 5. Implementation

The final stage is implementation, which comes down to accepting or rejecting the obtained data. However, crowdsourcing per se requires informing Internet users about the results of the selection and implementation of the idea/solution. This last element is important because members of the virtual community may feel discouraged from further cooperation when they see that their efforts have not been used. However, crowdsourcing in science does not require informing members of the virtual community about the implementation of ideas. What is important in crowdsourcing in science, at the implementation stage, is settlement, also financial (if the crowdsourcing platform requires it) and acceptance of solutions that meet the selection or evaluation criteria previously adopted by the initiator.

Taking the above into account, it should be stated that the most important role in a crowdsourcing in science initiative is played by the initiator. They are responsible for starting and running their projects. Moreover, the decision they make regarding whether to use crowdsourcing in science or not is complex and multi-threaded. At the preparation stage, crowdsourcing in science requires reflection on the part of the initiator, not only towards designing an initiative that allows for the generation of reliable data and results and the creation of scientific knowledge. In addition, it is important to reflect on methodological rigor, the desired quality and quantity of input, the expected time, and the required commitment and effort.

3.2 Challenges of Managing Crowdsourcing in Science

The literature, apart from the potential benefits, also points to challenges in managing a crowdsourcing in science initiative. They result, among others, from the paradox of openness (Foege et al., 2019), the nature of crowdsourcing full of paradoxes (Lenart-Gansiniec, 2021) and the paradoxes of creating knowledge using crowdsourcing (Boons et al., 2013). Moreover, crowdsourcing is "easy to develop and easy to break" (Zhao, Zhu, 2014, p. 428). For example, crowdsourcing in science can help academics collect knowledge or innovative ideas for scientific research, but their excess may make it difficult to process and transform them into scientific knowledge.

Organized but also conscious management of a crowdsourcing in science initiative is important not only for its success but also for ensuring the quality of the possible solutions. Unfortunately, as examples of the use of crowdsourcing per se by organizations show, the lack of management of the initiative not only ends in its failure, drain of resources, or excess costs but also in the loss of reputation, image, and trust of the virtual community (Lenart-Gansiniec, 2021). Moreover, members of virtual communities are beginning to treat the crowdsourcing platform as a place where they can criticize the entire initiative and, also, discredit the initiator.

As research develops, the literature draws attention to the challenges of crowdsourcing in science. Taking into account the nature of crowdsourcing in science, the author proposed their division, taking into account its individual crowdsourcing in science processes, such as preparation, initiation, generation, verification, and implementation.

3.2.1 Challenges at the Preparation Stage

The first challenge of crowdsourcing in science at the stage related to the preparation of a crowdsourcing in science initiative is related to the potential threat of improper assessment by the initiator-researcher whether a specific research task can be transferred to the virtual community. If a researcher directs an inappropriate task to Internet users, it may turn out during the initiative that the virtual community will not have sufficient knowledge and skills or research experience and understanding of research processes (Bassi et al., 2019, 2020). Subsequently, this may contribute to the failure of the crowdsourcing in science initiative because the virtual community may become discouraged and abandon the task. This may also be intensified by an incorrectly formulated invitation, which may contribute to the initiator obtaining solutions to tasks that are not in line with his or her expectations.

Another challenge is the functional aspects of existing crowdsourcing platforms. For example, Schlagwein and Daneshgar (2014) state that most scientific research based on crowdsourcing is carried out on one, the most popular crowdsourcing platform, i.e. Amazon Mechanical Turk (e.g. Kittur et al. al., 2008; Paolacci et al., 2010; Mason, Suri, 2012; Aguinis, Lawal, 2013; Crump et al., 2013). However, originally this platform was dedicated to business organizations. It was not meant for conducting scientific research. Previous research draws attention to potential difficulties related to the use of its functionality and operation (Sheehan, 2018).

Another challenge relates to improper planning of ways to motivate the virtual community. The literature indicates that a large number of participants does not guarantee that researchers will obtain optimal results (Schildhauer, Voss, 2014). As Franzoni and Sauermann (2014) point out, most members of the virtual community involved in a crowdsourcing in science initiative make only small and infrequent contributions and often stop their work immediately after joining the initiative. As Aguinis et al. point out (2021) this occurs in more than 30% of tasks on average. In particular, the literature draws attention to the variety of motives that guide Internet users when engaging in a crowdsourcing in science initiative. Additionally, crowdsourcing in science fits into the so-called "gig economy", where work on crowdsourcing platforms is often the main source of income for members of the virtual community (Hitlin, 2016). There is therefore a risk that Internet users may undertake too many tasks at the same time in order to maximize profit. Additionally, there may be some selectivity observed while choosing virtual tasks by community members among those that require less commitment and bring greater earning potential. It may also happen that one Internet user will have several alternative accounts on the platform from which he or she will log in multiple times and perform the same task.

It should be noted that the open nature of crowdsourcing in science means that the initiator is uncertain as to who is actually participating in the crowdsourcing initiative. There may also be uncertainty about the resources owned by the virtual community. In addition, members of the virtual community may provide false data when registering on the platform, which may mislead the initiator as to information about the respondents' demographics – the most common misstatements concern income, education, age, gender, and family status. As Aguinis et al. point out (2021), the mentioned anonymity may increase the carelessness of virtual communities in carrying out tasks.

In addition to the already highlighted challenges resulting from the specificity of the crowdsourcing in science process, Aguinis et al. (2021), based on a scoping review of the literature taken from 15 journals publishing articles using the MTurk platform to create scientific knowledge, pointed to the potential insufficient preparation of the members of the virtual community by the initiator to perform the task. This intensifies the following challenges, such as self-selection error, inability to verify the knowledge of English by members of the virtual community, threat of work automation and lack of credibility of the initiator. Of those mentioned above, the most important challenge seems to be self-selection bias, which refers to the subjective selection of tasks by members of the virtual community that are personally interesting to them or are socially desirable, e.g. for financial reasons. Therefore, there may be a risk that tasks rated by Internet users as unattractive for various reasons may not find contractors – despite the offered remuneration.

Moreover, most crowdsourcing platforms have descriptions prepared in English, which implies that the initiator must also prepare the tasks in this language. However, those platforms do not have functionalities that enable checking language proficiency of virtual community members. Hence, tasks may be undertaken by people who do not know English in general or their language competencies will result in tasks being performed intuitively, without being fully understood.

3.2.2 Challenges at the Initiation Stage

During the initiation stage, challenges may arise due to insufficient development of ways for the initiator to communicate with members of the virtual community. As Franzoni and Sauermann (2014) point out, this may increase the risk of the initiator having difficulty accessing the potential of Internet users and abandoning the task. Moreover, the findings of other researchers confirm that insufficient development of a specific plan for carrying out a crowdsourcing initiative (Muhdi et al., 2011) may contribute to its failure (Karachiwalla, Pinkow, 2021). Another challenge relates to insufficient delegation activities, which may lead to the initiator obtaining information overload and increase the difficulty of integrating the contributions of a larger number of participants. In this approach, the lack of definition of tasks by the initiator may generate additional risk in the form of low involvement of Internet users (Aristeidou et al., 2017) and loss of control over the work of the virtual community.

In line with the specificity of crowdsourcing in science, the virtual community involved in a crowdsourcing in science initiative consists of both people with specialized knowledge and research experience, but also people who come from outside the scientific community. The initiator is not sure about the minimum level of knowledge or skills. The assumption that Internet users have sufficient knowledge and skills may result in having to deal with those who are motivated by profit, and who perform tasks automatically and thoughtlessly. This way, the initiator will obtain incorrect or low-quality solutions. Additionally, the challenge is posed by the insufficient representativeness of the group. For example, on the Amazon Mechanical Turk crowdsourcing platform, the majority of registered Internet users are students living in the United States and India (Chandler, Shapiro, 2016).

Moreover, delegating a specific task to a virtual community to be performed without prior training poses the challenge of obtaining diverse results in violation of methodological rigor, which undermines the standards of scientific research. This leads to excessive burden on the initiator, as it may be necessary to conduct training for boarders introducing the specificity of the task to be performed (Bassi et al., 2019).

Moreover, in crowdsourcing tasks, the initiator provides Internet users with data, which is then processed, evaluated, or commented on by them. This implies some concern about unauthorized copying, processing, and use of data without the knowledge of the initiator, which may lead to intellectual property infringement. In addition, there may be doubts about the copyright of the data processed by the virtual community and the results of the crowdsourcing in science initiative. Additionally, members of a virtual community may believe that the content and data they create or provide should not be accessible or used by others.

3.2.3 Challenges at the Generating Stage

As part of generating a crowdsourcing in science initiative, i.e. during it, further challenges may arise. They are related to the potential behaviours of members of the virtual community and the passive attitude of the initiator.

Another challenge is offered by the anonymity of the virtual community – which results from the fact that Internet users registering on a crowdsourcing platform may provide false data. This makes it difficult to verify demographic data (Crump et al., 2013). As Ford (2017, p. 156) points out,

> particularly noteworthy among MTurk respondents is the presence of chasers and fraudsters, whose proper control is difficult and time-consuming. Chasers are those who rush through questions, paying too little attention to the

> questions being asked, creating incorrect or misleading data; and scammers are those who lie or misrepresent themselves in order to complete surveys and make money. MTurk respondents do not earn very much, which further forces participants to complete as many surveys as possible to earn enough money for their efforts.

The literature indicates that there may be a challenge related to creation of specific communities of Internet users performing tasks on the platform. They can share experiences on how to manipulate and deceive work automation during a crowdsourcing in science initiative. Various abuses from the virtual community can be noted in the form of the use of artificial intelligence (e.g. bots) or other software that have the potential to automatically perform several or a dozen tasks simultaneously on behalf of the Internet user. An example of such a scam was widely reported in Wired magazine ("A bot panic HITs Amazon Mechanical Turk").

In addition, there may be a situation when an Internet user wants to obtain information about a problem that concerns them regarding a current initiative. Incorrect interactions or their lack, as well as insufficient feedback mechanisms (Uhlmann et al., 2019) may contribute to discouragement of Internet users, weakening their commitment and abandoning the task. Finally, another challenge of crowdsourcing in science may be erroneous data provided by Internet users. These errors may result from performing many different tasks at the same time, distraction, inattention (Chandler et al., 2014), social bias (Behrend et al., 2011), which has a negative impact on the correctness of task performance (Crump et al., 2013).

3.2.4 Challenges at the Verification Stage

A virtual community joining a crowdsourcing in science initiative is guided by various motives: from entertainment, through cooperation, to learning. This requires a compromise between the need for an entertaining initiative to attract those interested in participating and making their participation in tasks more attractive (Eickhoff et al., 2014) and maintaining methodological rigor. Additionally, the open nature of crowdsourcing in science poses the challenge of uncertainty about who is participating in the task, which inherently leads to uncertainty about the composition of the crowd. Hence, there may be concern about the quality of the results of the work of the virtual community. Moreover, another challenge is the limited ability to verify the age of members of the virtual community – which poses a significant threat in the case of experiments carried out using crowdsourcing in science (Barchard, Williams, 2008).

While crowdsourcing platforms have numerous verification mechanisms, too stringent controls on the quality of work during it may contribute to virtual communities abandoning work (Vannette, 2017). The literature provides answers in terms of comparing the quality of research conducted in traditional and crowdsourcing ways. For example, Behrend et al. (2011) claim that there are no significant differences between non-crowdsourcing respondents and MTurk participants. They found that compared to survey research, in those conducted using crowdsourcing, the percentage of resignations from participation in tasks is similar. The same remark also applies to the answers obtained. However, as stated by Keith et al. (2017), crowdsourcing platforms can be viewed as a work management system in which researchers monitor, manage, and respond to the work of Internet users to ensure the quality of results. Another recommendation is to include members of the virtual community who have achieved a high acceptance rate in previous tasks on the platforms (*Human Intelligence Task*; ≥95%; Peer et al., 2017).

3.2.5 Challenges at the Implementation Stage

Internet users are more willing to participate in tasks that they consider credible, which is related to their perception of the reputation, identity, and experience of the initiator. Therefore, if in the opinion of the virtual community the initiator is not credible, has so far assessed the completed tasks in a biased way, did not provide feedback during the task implementation or formulated the invitation, instructions and expectations in an incomprehensible way, then it may turn out that Internet users will not take up his or her tasks and will not be open to cooperation in the future. Therefore, Internet users may boycott subsequent invitations, and what is more, they may also pass on negative opinions about the initiator to other members of the virtual community. There are already many forums and websites where Internet users share information about initiators (Mason, Suri, 2012), e.g. Turkopticon or Turker Nation.

3.3 Platform for Crowdsourcing in Science: Amazon Mechanical Turk

An online platform in the form of a website or online application allows researchers to access various resources, transfer research task(s), and interact with the crowd (Corbett, Cochrane, 2019). Crowdsourcing platforms act as orchestrators and intermediaries in relations and communication between the crowd and the initiator (more details: Estellés-Arolas, González-Ladrón-de-Guevara, 2012).

The literature indicates two types of dedicated scientific platforms, i.e.: (1) self-service and (2) intermediary.

- Self-service platforms, such as Prolific, MTurk, MTurk Toolkit, provide researchers with the ability to control and administer sample collection.
- Intermediary platforms are automated in nature, as sample collection and administration are performed on behalf of researchers. Such platforms include, for example, Qualtrics Panels.

In addition, researchers have the opportunity to access many different platforms enabling them to obtain materials, obtain feedback, or establish cooperation with other researchers – Academia.edu and ResearchGate. There are also platforms for individual communication and knowledge exchange such as MySpace, Facebook, and LinkedIn.

Although there are many crowdsourcing platforms, Amazon's Mechanical Turk (MTurk) (http://www.mturk.com) is by far the most widely used platform for social science research (Paolacci, Chandler, 2014). MTurk is a universal platform, easy to use, with comprehensive applications at all stages of the research process: conceptual, empirical, and data analysis. MTurk provides recruitment of employee-participants to perform tasks called Human Intelligence Tasks (HIT). HITs are often short, repetitive and have a small scope of work.

Currently, over 750,000 people are registered on the platform and are involved in various projects or are willing to participate. About 80% of them live in the United States and are under 50 years old, while 51% have a college degree. Researchers can also use this platform to recruit volunteers to complete surveys, participate in experiments and conduct content analyses. One of the main reasons why MTurk is attractive to researchers is its ability to collect data quickly. For example, a survey that requires 300 respondents can be completed in a matter of hours. Additionally, the MTurk respondent pool is also much more diverse than the typical student sample. Additionally, data collection costs are typically lower than those charged on other crowdsourcing platforms. For example, on Opinion Outpost you pay a respondent $5 to complete a 10-minute survey, while on MTurk the same survey costs $1.

Using the MTurk platform to complete a task or research tasks is simple. After registering on MTurk, researchers publish their research projects (referred to on the platform as Human Intelligence Task "HIT"), indicating how many staff are needed to complete the task (e.g. 300 people to analyse abstracts). Then, researchers can determine what qualifications the project participants should have and where they should come from. Employees who meet the qualifications then complete the HIT within a time period specified by the researcher (e.g. within three hours) and are often paid for their work within hours or days of completion. Payments for completed tasks are transferred directly from the researcher's account to the account of research participants. Additionally, the MTurk platform allows researchers to connect to online surveys or experiments hosted on platforms such as Qualtrics and Survey Monkey. For an additional fee, researchers can precisely determine the profile of a potential research participant, e.g. age, employment status, gender, income, education, or marital status). MTurk offers researchers an additional TurkPrime service that allows them to automatically enable and disable people involved in the work and notify them about the creation of HIT. Additionally, TurkPrime allows researchers to divide their work into microtasks, which allows them to speed up work on individual research tasks.

Generally, crowdsourcing platforms allow for the relatively inexpensive and rapid recruitment of respondents from representative and diverse populations (Horton et al., 2011). They allow you to create online content; collect, process, and analyse research data; acquire participants for surveys, experiments, expert panels, focused group interviews, statistical analyses, and transcriptions; generate research questions or hypotheses, research and project proposals; test research at an early stage; review publications, and disseminate research results (Beck et al., 2022).

Of course, despite the advantages, using platforms to conduct scientific research has its limitations. The first limitation refers to the motivation of potential respondents. As examples show, participant dropout rates can be high. In one study, scientists delegated to respondents using a crowdsourcing platform the task of extracting data from abstracts. Out of 20 people involved in the work, only 8 completed the task. The second limitation and challenge for researchers is familiarizing participants with the instructions, project schedule, and task details. Simply posting a task description on the platform may not be sufficient, as each potential respondent may interpret it in a completely different way. Third, there is a need to implement processes on platforms that guarantee and verify that the activities commissioned by them meet the high-quality standards required in scientific research. This is due to the fact that scientific research using platforms may be subject to unauthorized automation using bots. Hence, it is necessary for the researcher to use hidden control or qualification tests, where researchers can prevent "clicking" through survey questionnaires. The initial assessment and selection of participants who have the qualifications or competencies required by the researcher are also important.

Bibliography

Aguinis H., Lawal S.O. (2013), ELancing: A review and research agenda for bridging the science-practice gap, *Human Resource Management Review*, 23(1), 6–17.

Aguinis H., Villamor I., Ramani R.S. (2021), MTurk research: Review and recommendations, *Journal of Management*, 47(4), 823–837.

Aristeidou M., Scanlon E., Sharples M. (2017), *Science learning in online communities of scientific investigations: evidence and suggestions*, American Educational Research Association Annual Conference, http://oro.open.ac.uk/49563/.

Barchard K., Williams J. (2008), Practical advice for conducting ethical online experiments and questionnaires for United States psychologists, *Behavior Research Methods*, 40(4), 1111–1128.

Barends A.J., de Vries R.E. (2019), Noncompliant responding: Comparing exclusion criteria in MTurk personality research to improve data quality, *Personality and Individual Differences*, 143, 84–89.

Barger P., Behrend T.S., Sharek D.J., Sinar E.F. (2011), IO and the crowd: Frequently asked questions about using Mechanical Turk for research, *The Industrial-Organizational Psychologist*, 49, 11–17.

Bassi H., Lee C., Misener L., Johnson A. (2019), Exploring the characteristics of crowdsourcing: An online observational study, *Journal of Information Science*, 46(3), 1–2.

Bassi H., Misener L., Johnson A.M. (2020), Crowdsourcing for research: Perspectives from a Delphi panel, *SAGE Open*, 10(4), 21582440209.

Beck S., Bergenholtz C., Bogers M., Brasseur T.-M., Conradsen M.L., Di Marco D., Distel A.P., Dobusch L., Dörler D., Effert A., Fecher B., Filiou D., Frederiksen L., Gillier T., Grimpe C., Gruber M., Haeussler C., Heigl F., Hoisl K., Hyslop K., Kokshagina O., LaFlamme M., Lawson C., Lifshitz-Assaf H., Lukas W., Nordberg M., Norn M.T., Poetz M., Ponti M., Pruschak G., Priego L.P., Radziwon A., Rafner J., Romanova G., Ruser A., Sauermann H., Shah S.K., Sherson J.F., Suess-Reyes J., Tucci C.L., Tuertscher P., Vedel J.B., Velden T., Verganti R., Wareham J., Wiggins A., Xu S.M. (2022), The open innovation in science research field: A collaborative conceptualisation approach, *Industry and Innovation*, https://www.tandfonline.com/doi/full/10.1080/13662716.2020.1792274.

Beck S., Mahdad M., Beukel K., Poetz M. (2019), The value of scientific knowledge dissemination for scientists - a value capture perspective, *Publications*, 7(3), 1–23.

Behrend T.S., Sharek D.J., Meade A.W., Wiebe E.N. (2011), The viability of crowdsourcing for survey research, *Behavior Research Methods*, 43, 800–813.

Benoit K., Conway D., Lauderdale B.E., Laver M., Mikhaylov S. (2016), Crowd-sourced text analysis: Reproducible and agile production of political data, *American Political Science Review*, 110(2), 278–295.

Blohm I., Leimeister J.M., Krcmar H. (2013), Crowdsourcing: how to benefit from (too) many great ideas, *MIS Quarterly Executive*, 12(4), 199–211.

Chan K.W., Li S.Y., Ni J., Zhu J.J. (2021), What feedback matters? The role of experience in motivating crowdsourcing innovation, *Production and Operations Management*, 30(1), 103–126.

Chandler J., Mueller P., Paolacci G. (2014), Nonnaïveté among Amazon Mechanical Turk workers: Consequences and solutions for behavioral researchers, *Behavior Research Methods*, 46(1), 112–130.

Chandler J., Shapiro D. (2016), Conducting clinical research using crowdsourced convenience samples, *Annual Review of Clinical Psychology*, 12(1), 53–81.

Chen J.J., Menezes N.J., Bradley A.D., North T. (2011), Opportunities for crowdsourcing research on Amazon Mechanical Turk, *Interfaces*, 5(3), 1–4.

Crequit P., Mansouri G., Benchoufi M., Vivot A., Ravaud P. (2018), Mapping of crowdsourcing in health systematic review, *Journal of Medical Internet Research*, 20(5), 1–22.

Crump M.J., McDonnell J.V., Gureckis T.M. (2013), Evaluating Amazon's Mechanical Turk as a tool for experimental behavioral research, *PLoS One*, 8(3), 1–18.

De Beer J., McCarthy I.P., Soliman A., Treen E. (2017), Click here to agree: Managing intellectual property when crowdsourcing solutions, *Business Horizons*, 60(2), 207–217.

Doan A., Ramakrishnan R., Halevy A.Y. (2011), Crowdsourcing systems on the world-wide web, *Communications of the ACM*, 54(4), 86–96.

Eickhoff C., Harris C.G., de Vries A.P., Srinivasan P. (2014), *Quality through flow and immersion: Gamifying crowdsourced relevance assessments*, Proceedings of the 35th International ACM SIGIR Conference on Research and Development in Information Retrieval, https://dl.acm.org/doi/10.1145/2348283.2348400.

Eklund L., Stamm I., Liebermann W. (2019), The crowd in crowdsourcing: Crowdsourcing as a pragmatic research method, *First Monday*, 24(1), 1–14.

Estellés-Arolas E., González-Ladrón-de-Guevara F. (2012), Towards an integrated crowdsourcing definition, *Journal of Information Science*, 38(2), 189–200.

Ford J.B. (2017), Amazon's Mechanical Turk: A comment, *Journal of Advertising*, 46(1), 156–158.

Franzoni C., Sauermann H. (2014), Crowd science: The organization of scientific research in open collaborative projects, *Research Policy*, 43(1), 1–20.

Hauser D., Paolacci G., Chandler J. (2019), Common concerns with MTurk as a participant pool: Evidence and solutions, In: Kardes F., Herr P.M., Schwarz N. (eds.), *Handbook of research methods in consumer psychology*, Routledge, Routledge, London, New York¸ pp. 319–337.

Hedges M., Dunn S. (2018), *Academic crowdsourcing in the humanities: Crowds, communities and co-production*. Elsevier, Cambridge.

Hitlin P. (2016), *Research in the crowdsourcing age. A case study*, https://www.pewinternet.org/2016/07/11/research-in-the-crowdsourcing-age-a-case-study/.

Horton J.J., Rand D.G., Zeckhauser R.J. (2011), The online laboratory: Conducting experiments in a real labor market, *Experimental Economics*, 14(3), 399–425.

Jabareen Y. (2009), Building a conceptual framework: Philosophy, definitions, and procedure, *International Journal of Qualitative Methods*, 8(4), 49–62.

Karachiwalla R., Pinkow F. (2021), Understanding crowdsourcing projects: A review on the key design elements of a crowdsourcing initiative, *Creativity and Innovation Management*, 30(3), 563–584.

Keating M., Furberg R. (2013), *A methodological framework for crowdsourcing in research*, https://nces.ed.gov/FCSM/pdf/H1_Keating_2013FCSM_AC.pdf.

Keith M.G., Tay L., Harms P.D. (2017), Systems perspective of Amazon Mechanical Turk for organizational research: Review and recommendations, *Frontiers in Psychology*, 8, 1359.

Kittur A., Chi E.H., Suh B. (2008), *Crowdsourcing user studies with Mechanical Turk*, Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Florence, Italy, 453–456, https://dl.acm.org/doi/10.1145/1357054.1357127.

Krivosheev E., Caforio V., Benatallah B., Casati F. (2017), *Crowdsourcing paper screening in systematic literature reviews*, Proceedings of the Fifth Conference on Human Computation and Crowdsourcing, https://www.aaai.org/ocs/index.php/HCOMP/HCOMP17/paper/view/15921/15268.

Law E., Gajos K.Z., Wiggins A., Gray M.L., Williams A. (2017), *Crowdsourcing as a tool for research: Implications of uncertainty*, Proceedings ACM Conference on Computer Supported Cooperative Work and Social Computing, https://www.eecs.harvard.edu/~kgajos/papers/2017/law17-crowdsourcing.pdf.

Lenart-Gansiniec R. (2021), The effect of crowdsourcing on organizational learning: Evidence from local governments, *Government Information Quarterly*, 38(3), 101593.

Martinez M.G. (2017), Inspiring crowdsourcing communities to create novel solutions: Competition design and the mediating role of trust, *Technological Forecasting and Social Change*, 117, 296–304.

Mason W., Suri S. (2012), Conducting behavioral research on Amazon's Mechanical Turk, *Behavior Research Methods*, 44, 1–23.

Mazzola E., Acur N., Piazza M., Perrone G. (2018), To own or not to own? A study on the determinants and consequences of alternative intellectual property rights arrangements in crowdsourcing for innovation contests, *Journal of Product Innovation Management*, 35(6), 908–929.

Miles M., Huberman A. (1994), *Qualitative data analysis*. Sage, London.

Muhdi L., Daiber M., Friesike S., Boutellier R. (2011), The crowdsourcing process: An intermediary mediated idea generation approach in the early phase of innovation, *International Journal of Entrepreneurship and Innovation Management*, 14(4), 315–332.

Paolacci G., Chandler J. (2014), Inside the Turk: Understanding Mechanical Turk as a participant pool, *Current Directions in Psychological Science*, 23(3), 184–188.

Paolacci G., Chandler J., Ipeirotis P.G. (2010), Running experiments on Amazon Mechanical Turk, *Judgment and Decision Making*, 5(5), 411–419.

Pee L.G., Koh E., Goh M. (2018), Trait motivations of crowdsourcing and task choice: A distal-proximal perspective, *International Journal of Information Management*, 40, 28–41.

Peer E., Brandimarte L., Samat S., Acquisti A. (2017), Beyond the Turk: Alternative platforms for crowdsourcing behavioral research, *Journal of Experimental Social Psychology*, 70, 153–163.

Petersen S. (2013), *Crowdsourcing in design research - potentials & limitations*, Proceedings of the 19th International Conference on Engineering Design, Design Processes, Seoul, Korea, https://www.designsociety.org/download-publication/34839/Crowdsourcing+in+design+research+-+Potentials+%26+limitations.

Saez-Rodriguez J., Costello J.C., Friend S.H., Kellen M.R., Mangravite L., Meyer P., Norman T., Stolovitzky G. (2016), Crowdsourcing biomedical research: Leveraging communities as innovation engines, *Nature Reviews Genetics*, 17(8), 470–486.

Saravanos A., Zervoudaki S., Zheng D., Stott N., Hawryluk B., Delfino D. (2021), *The hidden cost of using Amazon Mechanical Turk for research*, International Conference on Human-Computer Interaction, Springer, Cham, pp. 147–164.

Sauermann H., Stephan P. (2013), Conflicting logics? A multidimensional view of industrial and academic science, *Organization Science*, 24(3), 889–909.

Schäfer S., Antons D., Lüttgens D., Piller F., Salge T.O. (2017), Talk to your crowd: Principles for effective communication in crowdsourcing. A few key principles for communicating with solvers can help contest sponsors maintain and grow their base of participants, *Research-Technology Management*, 60(4), 33–42.

Schildhauer T., Voss H. (2014), Open innovation and crowdsourcing in the sciences, In: Bartling S., Friesike S. (eds.), *Opening science*, Springer, Cham, 255–269.

Schlagwein D., Daneshgar F. (2014), *User requirements of a crowdsourcing platform for researchers: Findings from a series of focus groups*, Proceedings - Pacific Asia Conference on Information Systems, https://aisel.aisnet.org/pacis2014/195/.

Schrögel P., Kolleck A. (2019), The many faces of participation in science: Literature review and proposal for a three-dimensional framework, *Science & Technology Studies*, 32(2), 77–99.

Sheehan K.B. (2018), Crowdsourcing research: Data collection with Amazon's Mechanical Turk, *Communication Monographs*, 85(1), 140–156.

Surowiecki J. (2010), *Mądrość tłumu: większość ma rację w ekonomii, biznesie i polityce*. Wydawnictwo Helion, Gliwice.

Thuan N.H. (2019), Business process crowdsourcing: Building blocks, In: Thuan N.H., *Business process crowdsourcing*, Springer, Cham, 11–38.

Thuan N.H., Antunes P., Johnstone D. (2016), *Pilot experiments on a designed crowdsourcing decision tool*, 20th International Conference on Computer Supported Cooperative Work in Design, Nanchang, 601–606.

Thuan N.H., Antunes P., Johnstone D. (2017), A process model for establishing business process crowdsourcing, *Australasian Journal of Information Systems*, 21, 1–21.

Tranquillini S., Daniel F., Kucherbaev P., Casati F. (2015), Modelling, enacting, and integrating custom crowdsourcing processes, *ACM Transactions on the Web*, 9(2), 1–43.

Uhlmann E.L., Ebersole C.R., Chartier C.R., Chartier C.R., Errington T.M., Kidwell M.C., Lai C.K., McCarthy R.J., Riegelman A., Silberzahn R., Nosek B.A. (2019), Scientific utopia III: Crowdsourcing science, *Perspectives on Psychological Science*, 14(5), 711–733.

Vannette D. (2017), *Using attention checks in your surveys may harm data quality*, https://www.qualtrics.com/blog/using-attention-checks-in-your-surveys-may-harm-data-quality.

Wiggins A., Crowston K. (2011), *From conservation to crowdsourcing: A typology of citizen science*, Proceedings 44th Hawaii International Conference on Systems Sciences (HICSS), Kauai.

Zhen L., Wu Y., Wang S., Yi W. (2021), Crowdsourcing mode evaluation for parcel delivery service platforms, *International Journal of Production Economics*, 235, 108067.

Zhu D., Carterette B. (2010), *An analysis of assessor behavior in crowdsourced preference judgments*, Presented at the SIGIR 2010 Workshop on Crowdsourcing for Search Evaluations, Geneva, Switzerland, 17–20.

4 The Road to Successful Crowdsourcing in Science

Crowdsourcing in science, although etymologically derived from crowdsourcing per se, is a part of the progressive democratization of science, its inclusiveness, responsiveness, openness, and technicization. Crowdsourcing in science refers to online cooperation in the creation of scientific knowledge involving both people from and outside the academic environment. Its versatility means that it can be considered, among other things, a tool or a way to create online content; communicate between teachers and people outside the scientific community, as well as formulate innovative research questions, hypotheses, research proposals, collect, process, and analyse research data; and solve problems arising while writing an article or conducting research and disseminating results, recruiting participants for surveys, studies, experiments, focus groups, performing statistical analyses, transcriptions, testing research at an early stage, and reviewers of the concept of a research project or article.

Although the nature of crowdsourcing per se has been widely discussed in the literature over the last 16 years (Howe, 2006), research on crowdsourcing in science is developing much slower, and the topic itself has not penetrated the mainstream (Beck et al., 2022). So far, the issues of morphology and factors motivating the virtual community and the functionality of crowdsourcing platforms have been the subject of the most extensive attention. One of them in particular, Amazon Mechanical Turk, has become almost the most studied platform, because analyses in this area cover practically every aspect of it. As a result, very little space has so far been devoted to one of the most important *since qua non* conditions of crowdsourcing in science, which is the initiator. Moreover, adopting a micro perspective, i.e. the initiator in research on crowdsourcing in science, as well as identifying the reasons for using it are recommended directions of research (Beck et al., 2022).

The aim of this chapter is to provide a road to successful crowdsourcing in science. The first part presents the essential competencies for crowdsourcing in science. The second part of the chapter illustrates researchers' attitude and perception. Then, in the third part of this chapter, managing people and human resources processes in the context of crowdsourcing in science is presented.

DOI: 10.4324/9781003482253-5

4.1 Essential Competencies for Crowdsourcing in Science

Due to its procedural nature, crowdsourcing in science poses a number of challenges to the initiator related to the organization of a scientific initiative. The challenges mentioned in the literature are related to, among others, the threat of automation of the work of virtual community members (Aguinis et al., 2021), their anonymity (Mason, Suri, 2012), or lack of involvement (Aristeidou et al., 2017). This means that the initiator who addresses Internet users must devote their resources, time, and attention. Using the "wait and see" approach may bring more negative consequences than benefits (Dahlander, Piezunka, 2014), including loss of Internet users' trust, control over their actions or abandonment of a task (Dahlander et al., 2019; Dahlander, Piezunka, 2020), and thus unnecessary time and financial outlays.

To summarize the findings regarding the challenges of crowdsourcing in science, it should be noted that transferring a task to a virtual community using crowdsourcing in science without precisely defining its purpose and feasibility of implementation may prolong the achievement of the expected results and increase the costs of performing individual research tasks. Moreover, the issue of directing these tasks to virtual communities in exchange for small fees or vouchers may turn out to be problematic, which is considered by some researchers to be exploitation (Callison-Burch, Dredze, 2010; Paolacci et al., 2010). All of this raises additional challenges for crowdsourcing in science. On the one hand, the initiator does not understand the motivation of the virtual community involved in crowdsourcing in science, because Internet users do not act only for one reason: it may be financial, but also altruistic or hedonistic reasons. On the other hand, Internet users may actually feel exploited, as shown by the research of Busarovs (2013, p. 11):

> one person (...) makes a profit by taking away some feature of another person for their own benefit (...) Exploitation (...) may occur in morally unpleasant forms without harming the interests of the exploiter and despite the exploited person's fully voluntary consent to exploitative behaviour.

Due to the fragmentary state of knowledge regarding the competences of the initiator of crowdsourcing in science, a general framework for the initiator's competences was proposed in the form of a conceptual model. This model constitutes the basis for further considerations regarding the desired competences of the initiator of crowdsourcing in science. Due to the fact that in the study of competencies, in order to provide a model, it is important to create clusters of competencies that categorize them (Patterson et al., 2000), this work adopts the proposals for modelling competencies that are most often used (Hafkesbrink, Schroll, 2014; Mulder, 2015). Based on competency modelling, the identified competencies were grouped into the following clusters: intrapersonal, interpersonal, and professional:

- Intrapersonal competences refer to a person's self-awareness of their capabilities and limitations. They are related to abilities that are helpful in coping with specific tasks and solving problems.
- Interpersonal competences refer to the ability to interact with others, establish cooperation, and communicate.
- Professional competences refer to the knowledge, skills, and attitudes that are necessary to implement a crowdsourcing in science initiative and will allow the initiator to meet the challenges related to the implementation and management of crowdsourcing in science.

The proposed conceptual model of the initiator's competences in the field of crowdsourcing in science adopts an integrated approach to various areas and levels of analysis of crowdsourcing in science, postulated in the literature on the subject (Franzoni et al., 2022). Therefore, during its development, some attention was paid to the specificity of each stage of the initiative, taking into account the tasks and challenges that the initiator may face (Table 4.1).

The proposed model can be used as a starting point for developing organizational support mechanisms in the field of training or other forms of development of knowledge and skills of research workers in the field of crowdsourcing in science. Organizing a crowdsourcing initiative, including a scientific one, poses a number of challenges. This means that the initiator must have certain competences specific to crowdsourcing in science.

At the preparation and initiation stage, both intrapersonal, interpersonal, and professional competences are necessary. In particular, divergent and lateral thinking skills are important, which is consistent with the previous findings of Hafkesbrink, Schroll (2014) and Podmetina et al. (2018) in terms of competencies of an open innovation specialist. These competencies are particularly important at the stage of preparing a crowdsourcing in science initiative, where the initiator determines the scope of the crowdsourcing task, determines the morphology and methods of motivation, selects a crowdsourcing platform, and develops methods of assessing and verifying tasks and a work schedule. At this stage, it is important that the initiator has the competence to see connections between seemingly distant areas, go beyond established patterns and see new opportunities in existing situations.

Taking into account the individual stages of a crowdsourcing in science initiative, the ability to carry out self-promotion becomes more important, especially during its initiation. As part of initiating, it is necessary to develop arrangements for communication with members of the virtual community (Aristeidou et al., 2017), but also to arouse trust among Internet users – because the lack of credibility of the initiator may lead to them not wanting to engage in a specific task (Aguinis et al., 2021).

Table 4.1 A conceptual model of competencies of the initiator of crowdsourcing in science

Competencies	**Initiative stages**				
	1	**2**	**3**	**4**	**5**
Intrapersonal					
Skills in analytical thinking				✓	
Skills in divergent thinking	✓				
Skills in lateral thinking	✓				
Skills in reflective thinking				✓	
Skills in dealing with criticism					✓
Self-promotion skills		✓			
Skills in dealing with failure					✓
Interpersonal					
Teamwork skills	✓				
Skills in work coordination			✓		
Multitasking			✓		
Professional					
Skills in storytelling	✓				
Skills in popularizing scientific knowledge	✓				
Skills in navigating in the Internet environment		✓			
Skills in promoting a crowdsourcing in science initiative		✓			
Skills in processing large data sets				✓	
Skills in the risk management					✓
Skills in the intellectual property management					✓

Explanations: 1 – preparation; 2 – initiating; 3 – generating; 4 – verification; 5 – implementation.

In the initial stages of a crowdsourcing in science initiative, teamwork skills are required from the initiator, which is consistent with the existing findings regarding the competences of an open innovation specialist (Chatenier et al., 2010; Hafkesbrink, Schroll, 2014; Podmetina et al., 2018). The entire crowdsourcing in science process is launched based on the decision of the initiator – a researcher. However, this decision is not automatic (Muhdi et al., 2011) and is related to the researcher's awareness of the need. The initiator then looks for the information indispensable while satisfying the need and then plans the course of the crowdsourcing in science initiative, including its specifics. At this stage, the initiator's competences related to the ability to work in a team are important, in particular, the ease of establishing contacts with others, communicating, adapting to new situations, motivating others to act, being focused on cooperation and making decisions.

At the stage of preparing any initiative of crowdsourcing in science, skills in the field of storytelling, popularization of knowledge and promotion of a crowdsourcing in science initiative are important, which in the literature on open innovation are recognized as media skills and content presentation (Podmetina et al., 2018). The initiator of crowdsourcing in science is responsible for developing an invitation addressed to members of the virtual community, but it should not only explain the purpose of the task and the initiator's expectations. It is important that it is written in such a way that it encourages members of the virtual community to choose a given initiative against the background of thousands of others (Wiggins, Crowstron, 2011; Mason, Suri, 2012; Sauermann, Stephan, 2013; Franzoni, Sauermann, 2014; Eklund et al., 2019; Law et al., 2017; Schrögel, Kolleck, 2019). Therefore, both storytelling and knowledge popularization skills may prove important from the point of view of the initiator of crowdsourcing in science.

Moreover, at the preparation stage, the ability to promote a crowdsourcing in science initiative is important. During this stage, the initiator, in addition to monitoring and motivating members of the virtual community, undertakes a number of activities related to providing feedback and advice (Ford et al., 2015). Therefore, competences in presenting the initiative to other Internet users using various promotional means, in particular, social media, are important. The initiator's skills in navigating the online environment may also be important, which is consistent with the findings regarding the competences of an open innovation specialist (Podmetina et al., 2018). This comes down not only to knowledge of the behaviour of members of the virtual community but also to their motivation (Crump et al., 2013; Ford, 2017; Uhlmann et al., 2019). Therefore, skills in using the crowdsourcing platform, as well as knowledge of the mechanisms regulating behaviour on the Internet are required.

At the stage of generating crowdsourcing in science, competences in the form of work coordination skills may be important, which is consistent with the findings of Du Chatenier et al. (2010) regarding the open innovation specialist. During the generation stage, a researcher may receive a very large number of solutions/ideas or Internet users will not be interested in participating in it (Ford et al., 2015). This requires the initiator to ensure coherence and continuity of the crowdsourcing in science initiative, modify it if necessary, and additionally motivate Internet users to act (Ford et al., 2015). Additionally, the competence related to multitasking is important, which fits into the existing findings in the field of open innovation competences (Hafkesbrink, Schroll, 2014; Podmetina et al., 2018). As already mentioned, at the generation stage, the initiator undertakes a number of activities related to coordinating the work of members of the virtual community, related to ongoing monitoring of their activities and behaviour on the platform, as well as inspiring or encouraging them to act (Ford et al., 2015). Therefore, the competence to undertake many activities at the same time is important.

Additionally, reflective thinking is also important, which allows for self-assessment on the part of the initiator and the recognition and elimination of one's own mistakes, as well as modification, if necessary, of the current way of engaging members of the virtual community, which is recommended in the literature (Behrend et al., 2011; Crump et al., 2013; Chandler et al., 2014). Therefore, it is necessary to constantly, reflectively observe the behaviour of members of the virtual community in order to eliminate potential threats, because this translates into the correctness of the task and the quality of the results obtained by the initiator (Crump et al., 2013).

At the stage of scientific verification, analytical and reflective thinking and the ability to process large data sets are important. This stage refers, among other things, to the assessment of incoming solutions in terms of meeting the criteria of response accuracy or expected results previously adopted by the initiator and the removal of low-quality data (Kittur et al., 2008; Barger et al., 2011; Behrend et al., 2011). All this requires the initiator to conduct a substantive analysis and assessment of a specific situation and work on large data sets (Hung, 2013).

The last stage of a crowdsourcing in science initiative (implementation) not only refers to the fact that the initiator accepts/rejects the solutions provided by members of the virtual community (Mason, Suri, 2012). The literature indicates that at this stage, Internet users may share negative opinions or comments about the initiator (Mason, Suri, 2011) posted on forums or websites such as Turkopticon or Turker Nation. Therefore, from this point of view, it is important for the initiator to be able to accept criticism, even non-constructive criticism. Additionally, members of the virtual community do not always perform tasks in accordance with the initiator's expectations, which may result, among others, from threats related to misunderstanding the invitation provided by the initiator, inattention, haste, or insufficient knowledge of English (Aguinis et al., 2021). Therefore, the ability to deal with failures is also important, which comes down to analysing mistakes, failures, drawing conclusions for the future, but also coming to terms with the time and possible costs incurred.

As previously mentioned, intellectual property management skills are important during the implementation phase. While this stage involves acceptance/rejection of the solutions sent by Internet users, the issue of intellectual property rights is also important (Mason, Suri, 2011). This is especially important in view of the so-called Arrow's information paradox (Arrow, 1962), where Internet users may feel exploited and appropriated by the initiator of the provided solution, while at the same time providing Internet users with information about its rejection (Keith et al., 2017). Hence, the initiator's professional competences in the field of intellectual property management seem to be important. Additionally, the competences to critically look at the solutions provided by Internet users and make decisions on their acceptance/rejection are valuable. In particular, conscientiousness, but also prudence in making decisions, is important, because if the assessment is not fair, but rather subjective, there may be a risk that Internet users will not undertake the initiator's tasks in the future (Mason, Suri, 2011). Therefore, the initiator's competence in risk management is important, in particular in minimizing or anticipating potential controversial situations.

4.2 Researchers' Attitude and Perception

The literature review shows that crowdsourcing in science is recommended for younger researchers starting their scientific careers. Uhlmann et al. (2019, p. 713) argue that "early career scientists from lesser-known institutions, underrepresented demographic groups, and countries where economic resources are scarce may never have a fair chance to compete". This is confirmed by the findings of Beck et al. (2020), who suggest that older researchers are more sceptical about involving the public in research tasks. In a different approach, Linek et al. (2017) suggest that senior researchers are more likely to engage in collaborative practices. Other researchers indicate that age is inversely related to research productivity and acceptance of new ideas, with older researchers being less active and more sceptical of a variety of alternative ways of creating scientific knowledge (Davis et al., 2011).

The literature indicates that experience may be important in the context of crowdsourcing in science, in particular measured by the scientific degree/title (Beck et al., 2022). There are voices that higher-ranking scientists have less time to use modern solutions to conduct scientific research because the solutions in question are time-consuming. There is also a decrease in the motivation of full professors to reach for technological innovations, which results from the lack of need to formally build scientific achievements in the context of scientific advancement (Kyvik, Olsen, 2008; Abramo et al., 2016).

There may be discrepancies as to whether a specific discipline or field of science represented by a scientist is more suitable for crowdsourcing in science. The bibliometric analysis conducted by the author (Lenart-Gansiniec, 2020) shows that representatives of virtually all disciplines use crowdsourcing in science. Authors of publications in which crowdsourcing in science is used include representatives of social sciences (psychology, e.g. *Austrialian Journal of Psychology*; political science, e.g. *Political Analysis*; communication and media, e.g. *JCOM Journal of Science Communication*, *Communication Monographs*, *ASLIB Journal of Information Management*; economics and management, e.g. *Experimental Economics*, *Journal of Consumer*, *Research Public Management Journal*), medicine and health (e.g. *PLoS One*, *American Journal of Preventive Medicine*), biological (e.g. *American Biology Teacher*), chemistry (e.g. *Chemical Engineering News*), physics (astronomy, e.g. *Science & Astronomy*), or humanities (e.g. history and archaeology, e.g. *IOS Press Content Library*).

There are voices that representatives of certain fields or disciplines of science are more predisposed to use crowdsourcing in science. As stated by Beck et al. (2020, p. 19) in particular, "applied sciences and parts of the social sciences such as economics and management studies" are more susceptible to crowdsourcing in science.

There is much evidence in the scientific literature of the relationship between the personality and behaviour of research workers, in particular, in the field of ethics (Giluk et al., 2015), knowledge sharing (Pratama et al., 2022), and scientific productivity (Mitręga, 2016; Wieczorek et al, 2021), cognitive skills (Rahman et al., 2018), and data sharing (Linek et al., 2017).

The literature also suggests that there is a connection between personality traits (included in the so-called "the Big Five" model) and crowdsourcing in science (Beck et al., 2022). In the so-called "the Big Five" model basic personality traits are openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism (McCrae, Costa, 2008).

Despite the importance of personality traits in the context of crowdsourcing in science, the literature findings in this area are inconsistent. It is emphasized that people with a high level of openness to experience are more willing to consider new ideas and unconventional values in their scientific work (Beck et al., 2022). Moreover, these people have a positive attitude towards learning new things and are willing to engage in learning (Barrick, Mount, 1991). Others, however, believe that it is not openness to new experiences, but extraversion that is the most important dimension in the context of crowdsourcing in science. For example, Koole et al. (2001) find out that a low level of extraversion contributes to openness to new things and the willingness to cooperate with others. This is surprising, because people with a high level of extraversion are characterized by positive feelings towards new experiences and like this type of behaviour because it allows them to focus attention on themselves (Ashton et al., 2002).

Other researchers believe that a high level of agreeableness may be important for crowdsourcing in science because people with such traits are trusting, understanding, helpful, willing to cooperate, compassionate, kind, and avoid conflicts (Gerber et al., 2011).

Researchers do not agree on the importance of the high-level "neuroticism" dimension for crowdsourcing in science. It is pointed out that neurotic people are characterized by low emotional stability, which means that they can give up at any time in new situations and with an uncertain outcome (Barlow et al., 2014). Moreover, a high level of neuroticism is associated with a low tendency to establish cooperation with unknown people. Conversely, a person who scores low on neuroticism does not exhibit extreme emotional reactions (Burger, 2013).

Other findings show that people with a high level of conscientiousness are reluctant to try new things, and the scope of tasks performed by these people does not go beyond standard professional duties (Alford, Hibbing, 2007). However, conscientious people are people for whom it is important to follow conservative and traditional values and do what is expected of them (Liao, Chuang, 2004). This is related to an internal sense of respect for the interests of the organization and group norms, which makes a person more willing to reach for unconventional solutions. However, there are also opinions in the literature that cooperative behaviour occurs in people with a low level of conscientiousness (Kurzban, Houser, 2001).

In addition to the features included in "the Big Five" model, individual innovativeness is recognized in the literature as a key predictor of the adoption of a new solution (Agarwal, Prasad, 1998; Cowart et al., 2008). It refers to the extent to which predispositions reflect a person's tendency to look for something new (Hirschman, 1980), experimenting with various novelties regardless of the communicated experiences of others (Watchravesringkan et al., 2010). It is also an individual's tendency to try new initiatives in their professional work (Agarwal, Prasad, 1998). It is based on the assumption that when individuals are sufficiently innovative, they see novelties that "bring" some utility (Ngafeeson, Sun, 2015). Individually innovative people like doing something new and looking for challenges that will broaden and deepen their sense of meaning in life. Their innovative nature makes it easier for them to try new technologies for their personal curiosity.

Moreover, individual innovativeness is also associated with a person's opinion about whether a particular activity is unique, which brings excitement and interest and a willingness to try it (Nov, Ye, 2008). Finally, people who are innovative are often active seekers of information about new ideas (Agarwal, Prasad, 1999), advocates, and ambassadors of new ideas (Rogers, 2003). For example, Rogers (1983) argues that an individual's propensity to innovate determines acceptance or rejection of new technology. A study by San Martín and Herrero (2012) reveals that personal innovativeness positively moderates the relationship between performance expectancy and behavioural intention. Additionally, Ke et al. (2012) find a moderating effect of individual innovativeness on the relationship between perceived usefulness and behavioural intention to use an online system. Similar conclusions are reached by Thakur and Srivastava (2014) who find that individual innovativeness is related to personal attitudes towards risk-taking propensity in relation to decisions regarding the use of technology. People who are innovative need little encouragement to reach for new things, and after trying them, they are willing to help others and show them how to use it in their professional work.

In addition to the features centred around "the Big Five" model, as well as individual innovativeness, some researchers claim that scientific productivity increases the researcher's openness to new things and his or her willingness to use crowdsourcing in science (Wagner et al., 2018). Broadly speaking, scientific productivity refers to the ability of scientists and is a key indicator of scientific activity. In colloquial terms, productivity is understood as "producing a lot, giving good results, efficient, fruitful, useful" (Skorupka et al., 1968, p. 631). In turn, from a praxeological perspective, productivity refers to economy (Pszczołowski, 1978). As Mitręga (2016, p. 25) points out that "most often, activities undertaken by a scientist are valued in quantitative terms (e.g. points for publications, hours of classes completed), then they are valued and weighed".

The importance of scientific productivity in the context of the competences of the initiators of crowdsourcing in science may be analysed from two perspectives. It is said that crowdsourcing in science can increase scientific productivity. Researchers confirm that the recognition and adoption of open research practices increase not only public access to academic literature, but also scientific productivity (Björk et al., 2014; Levin et al., 2016). In turn, Beck and her colleagues (2020) find that scientific productivity is significantly related to behavioural intentions oriented towards entrepreneurial and innovative activities. In turn, Ding and Choi (2011) argue that publication achievements, patent experience, co-authorship, and networking are positively related to the openness of scientific workers to including the public in scientific research.

Some respondents point to the Matthew effect, according to which there is a self-reinforcing dynamic of academic success. As Merton (1968, p. 56) points out, "the Matthew effect may serve to highlight the contributions to science of established scientists and reduce the visibility of the contributions of lesser-known authors". Additionally, the Matthew effect is associated with the denial of meritocracy (Allison et al., 1982) – which means that scientific successes are cumulative (Clauset et al., 2015; Bol et al., 2018). In this approach, it is emphasized that outstanding researchers with strong scientific achievements are characterized by a greater tendency to reach for new solutions, especially those that will give them a greater opportunity to engage in involving society in scientific research (Ulhmann et al., 2019).

Generally, the literature indicates that the intention to use crowdsourcing in science is not dependent on organizational motivation systems (Beck et al., 2022), i.e. external motivation. Therefore, including crowdsourcing in science in the system of evaluating academics' work or financing will not motivate academics to engage in crowdsourcing in science. What prompts scientists to use crowdsourcing in science is the scientist's increase in the status quo in the scientific community, confirmation of professional identity and scientific recognition (Beck et al., 2022).

The above findings are part of the sense of belonging to a professional group. In this sense, belonging is essential in establishing and maintaining strong relationships with others, staying motivated, and achieving success in one's career. Some researchers indicate that a sense of belonging in higher education is promoted by social connections with colleagues and other researchers (Watson et al., 2010), which is related to effort, attention, self-esteem, and persistence (Ulmanen et al., 2016). Finally, a sense of belonging is associated with the desire to be appreciated, included, and accepted by the professional environment (Goodenow, Grady, 1993). Therefore, recognition obtained not only in the native scientific unit but also recognition in the scientific community is the basis for the success of a scientist (Bergeron, Liang, 2007). Academics' use of crowdsourcing is conditioned by the possibility of obtaining approval in the international scientific community (Beck et al., 2022).

Attitude involves a person's evaluation of a particular action or situation. It can be positive (supportive), negative (disapproval), or neutral (indifferent). In this approach, the attitude towards crowdsourcing in science can be defined as the openness, reluctance, or indifference of academic teachers to involve other researchers or people from outside the scientific community in the implementation of a research task or tasks. Attitudes may be ambivalent when a person manifests a positive attitude in one aspect and a negative attitude in another. For example, a person may think that crowdsourcing in science is unnecessary or even harmful but may change their attitude due to environmental pressure or fear of losing their job.

In turn, when a person adopts an attitude of resistance to crowdsourcing in science, they may hesitate to adopt a new solution for various reasons, including the lack of formal incentives, a personal desire to maintain the status quo, reluctance to unlearn the current ways of carrying out tasks, a sense of threat, and failure to recognize potential benefits, or applicability (Imran et al., 2016). In practice, when crowdsourcing in science is perceived by a given person as an activity that hinders rather than facilitates the creation of scientific knowledge, they may adopt an unfavourable attitude.

The literature suggests that some people may be aware of the benefits of "something new" but may also show a significant level of concern about possible threats or challenges (Sjöberg, 2002) – such an attitude is then associated with scepticism. Finally, there may be a situation where a person is enthusiastic about a particular activity but may be so concerned about the risks that they fail to recognize the potential benefits.

Of course, the above analysis definitely does not show the entire spectrum of possible attitudes towards crowdsourcing in science. However, the aim of this study is not to identify attitudes, but to determine whether attitude per se may be important for an academician's intention to use crowdsourcing in science. Based on the point of view of Beck et al. (2022), crowdsourcing in science involves human action, and it is the attitudes of researchers towards crowdsourcing in science that are key to intentions. In the light of the above considerations, a positive attitude of research workers towards crowdsourcing in science seems to be an important attribute of the desired competences of the initiator (Riesch, Potter, 2014). The specific attitude of an academic teacher towards crowdsourcing in science is the result of their beliefs, which is reflected in emotions, intentions, and intended behaviours.

Each behaviour is assessed as positive or negative (the emotional component of the attitude), or desirable (if it has mainly positive effects) or undesirable (if it is associated with mainly negative effects). Previous research reported varying indications of researchers' attitudes towards online collaborations and the involvement of a group of self-selected individuals in the creation of scientific knowledge. For example, Poliakoff and Weeb (2007) conducted research to identify reasons why academics engaged non-researchers to conduct research. The respondents in that study were academic teachers and doctoral students from science departments. A total of 851 academic teachers and 149 doctoral students were surveyed. Poliakoff and Weeb (2007) found that it was the positive attitude of the initiator that was important for including people from outside the scientific community in the creation of scientific knowledge. It should be emphasized that the findings of Poliakoff and Weeb (2007) focus on public engagement defined as scientific communication involving anyone outside the scientific community in scientific research. Hence, the obtained results cannot be directly transferred to crowdsourcing in science because the latter involves not only laypeople but also other researchers in cooperation.

Riesch and Potter (2014) conducted thirty semi-structured interviews with scientists and science communicators working on both regional and national science projects in the United Kingdom. Research by Riesch and Potter (2014) showed negative attitudes of respondents towards crowdsourcing in science. Despite reporting negative attitudes, Riesch and Potter (2014) also stated that involving the community in scientific work could improve the conduct of scientific research, but the willingness to use this type of solution depended on a positive assessment by researchers. This statement is declarative because researchers did not verify that thesis.

In another research, Schlagwein and Daneshgar (2014) organized a series of focus groups with 28 researchers from Asia and the Pacific. Most interviewees saw the potential of crowdsourcing in terms of access to various sources of knowledge and conducting scientific research (e.g. experiments, surveys, or interviews). One participant indicated that they turned to crowdsourcing to transcribe interviews. However, there were also negative attitudes towards crowdsourcing in science among respondents. The interlocutors declared that they resulted from the perceived shortcomings of existing crowdsourcing platforms and the lack of institutional regulations regarding the inclusion of the virtual community in scientific research.

Law and her colleagues (2017) conducted semi-structured interviews with 18 researchers from the sciences and humanities. The authors pointed out that crowdsourcing was not widely used by researchers and was rather an emerging tool to improve the conduct of scientific research. They also pointed to negative attitudes towards crowdsourcing in science. The attitudes resulted from the uncertainty reported by the interviewees regarding the delegation of tasks to the virtual community, data sharing, knowledge of the virtual community, the course of crowdsourcing, and the quality of the obtained data. Moreover, crowdsourcing was perceived by the respondents as something optional and carried out in their free time, and as an element supporting scientific research.

Beck and her colleagues (2022) reached similar findings. Researchers analysed data from two initiatives of crowdsourcing in science and signalled cautious attitudes among scientists towards its use. They emphasized that those attitudes resulted from the perception of crowdsourcing in science as excessively absorbing and requiring the involvement of significant resources to configure the project infrastructure and the need to recruit participants and evaluate applications. Such attitudes definitely do not make it easier to implement such initiatives.

The current findings regarding the importance of descriptive norms for the intention to involve members of society in conducting scientific research are clear (Poliakoff, Weeb, 2007; Beck et al., 2022). Generally, descriptive norms refer to a person's perception of the behaviour of others, which may constitute a model for imitation or adaptation. As a result, a person observes specific behavioural patterns of other people and tries to adapt to them. In this approach, information about how others behave can help make decisions easier and faster. Influenced by the behaviour of others, others may tend to follow the majority and actively perform the behaviour. However, the meaning of descriptive norms depends on the reference group. This is supported by the findings of Poliakoff and Weeb (2007) who state that scientists are more likely to participate in activities based on involving members of the public in research when their colleagues also do so. Finally, academics may turn to crowdsourcing in science because of the belief that it is a valuable norm in research communities. This is consistent with the findings of Zenk-Möltgen and Akdeniz (2018), who believe that only the openness of the scientific community can be a driving force for participatory activities, which is part of social influence, the desire to build trust in science and obtain feedback on the research conducted (Thursby et al., 2018).

The literature indicates that past behaviour may reinforce future behaviour (Ajzen, 2002). As confirmed by the findings of Poliakoff and Weeb (2007), a scientist who has had experience with involving other people in the creation of scientific knowledge will have such intention in the near future. Generally, this is related to the issue of trust in new solutions, the academic community, and people outside the scientific community. The literature indicates correlations between trust and the effect and efficiency of the entire crowdsourcing process. Successful crowdsourcing campaigns will typically be both attractive to potential participants and meet sufficient data quality standards. Thus, the intention to use crowdsourcing in science may depend on the initiator's trust in the knowledge, skills, or experience of the virtual community involved in a given project and the belief that a member of the virtual community will reliably perform given activities. The initiator may perceive it through the prism of their previous experience in similar situations, in particular, in terms of the personal involvement of academics in activities for the benefit of society, the sense of personal effectiveness and professional obligation, and the willingness to contribute to public debate.

Perceived behavioural control refers to a person's beliefs about the ease or difficulty of taking a given action. It should be emphasized that using crowdsourcing requires specific effort, including coordinating a very large group of people, undertaking promotional activities, and motivating members of the virtual community (Uhlmann et al., 2019). The literature indicates that despite the potential usefulness of crowdsourcing in science, initiators may not use it because they perceive it as difficult. In a word, due to the fact that the effort put into its use exceeds the performance benefits – the initiator may give up the desire to use crowdsourcing in science. In this context, research workers will identify and assess their expectations regarding its ease of use before using crowdsourcing in science. Moreover, even if a scientist decides to use crowdsourcing in science, if they encounter a certain level of difficulty, they may resign from it in the future (Uhlmann et al., 2019).

Perceived usefulness refers to the degree to which an individual believes and is sure that performing a specific action can improve their job performance. Thus, the decision to perform an action is based primarily on perceived benefits or the belief that needs will be met. In short, a person will be willing to perform an action if they believe that it will be useful at work and may bring benefits (Mukminin et al., 2020).

There is some belief in the literature that the intention to use crowdsourcing in science is related to the benefits that researchers will find in crowdsourcing (Mukminin et al., 2020). It is important to convince researchers that crowdsourcing will meet their needs. In particular, the following aspects are important: access to diverse knowledge and skills, increasing generalizability and reliability, reducing time burden, democratization of research and scientific openness (Ciasullo et al., 2021).

Similar conclusions were reached by Correia et al. (2020), who stated that the initiator's perception of its usefulness was important for the intention to use crowdsourcing in science. In particular, the potential opportunities of crowdsourcing in science in solving scientific problems, research design, and data collection and analysis are gaining importance. Additionally, the authors point to potential benefits related to increasing the diversity of perspectives, accelerating the conduct of scientific research, and improving its quality.

In turn, other researchers confirmed that academics' belief that using crowdsourcing in science should improve their work results was related to the intention to use it (Porter et al., 2020). Based on the results of three experiments conducted on the Amazon Mechnical Turk crowdsourcing platform, Porter et al. (2020) showed that improving transparency and reproducibility and accelerating the collection of large research data sets were important. Additionally, Porter et al. (2020) indicate that using crowdsourcing in science is perceived by academics as a more valuable opportunity to obtain data than more traditional ones.

Perceived risk, as another factor that is part of cognitive determinants, can be defined as an assessment, after collecting information, of the degree of threat, uncertainty, and negative consequences or outcomes associated with a specific behaviour (Mandrik, Bao, 2005). Previous findings by other researchers indicate an inverse relationship between perceived risk and intentions to perform a specific action. In this approach, people who have a high level of anxiety related to the use of new technology in conducting research attach less importance to its use. Generally, before a person decides to engage in any behaviour, they first assess the potential losses they may incur as a result.

Perceived effort refers to a person's perception of an action in terms of the time and energy required to undertake it. From the perspective of the effort incurred by a given person, it is related to the involvement in launching a crowdsourcing initiative, in particular promotion, description of the research project, motivation of the virtual community to take part in the initiative (Law et al., 2017). Thus, perceived time and effort spent may be important for academics' intentions to use crowdsourcing in science.

In relation to crowdsourcing in science, the literature points to social norms and normative pressure. Social norms refer to the belief that an important (from the individual's point of view) person or group of people will approve, and support a given behaviour. This leads to increased motivation and the willingness to take into account the views, opinions and judgments of others. For example, if co-workers or friends perceive a certain action as appropriate, then another person is more likely to perform it (Poliakoff, Webb, 2007). Previous research shows that subjective norm matters for behavioural intentions related to involving others in the creation of scientific knowledge. For example, in research conducted by Poliakoff and Weeb (2007), the importance of acceptance of specific behaviour by colleagues from one's home university was established. In another approach, Shirk et al. (2012) show that due to concerns about the negative perception of their colleagues, academics declared that they refrained from using crowdsourcing. Other researchers, Yoon and Kim (2017) conducted research among 2,193 social science faculty members and doctoral students at universities in the United States. The findings suggest that subjective norms matter in the context of behavioural intentions and the reuse of data provided by other scientists. In turn, Law et al. (2017) interviewed 18 researchers from the sciences, humanities, and social sciences. On their basis, they concluded that scientists are afraid to use crowdsourcing in science for fear of being negatively perceived by the scientific community.

In other research, Dudo and Besley (2016), examining 390 members of the American Association for the Advancement of Science, found that scientists who believed that their colleagues supported specific activities related to public involvement in scientific research showed greater activity in prioritizing such activities. According to Besley (2015), the reason for that state of affairs is so-called "the Sagan effect", which comes down to scientists' concerns about negative sanctions from the scientific community when members of the public are involved in the research process. This is confirmed by the findings of Ecklund et al. (2012), according to which disapproval from closest colleagues, mentors or managers, associated with "the Sagan effect", will contribute to a negative attitude towards all forms based on the involvement of members of society in the creation of scientific knowledge.

Perceived normative pressure refers to those patterns or norms that are established by organizations or the professional environment. Furthermore, normative pressure refers to legitimizing measures that result from collective expectations. In the literature, perceived normative pressure, as collective expectations, is considered a mechanism for regulating behaviour in a given community. It is set by, among others, the research community, local networks, and research institutions. Academics will adjust their behaviour in accordance with their beliefs, because they are aware that such actions are desirable or even required. In the context of intentions related to crowdsourcing in science, perceived normative pressure may contribute to academics following, accepting, and further implementing socially accepted behaviours in the scientific community in their scientific work. In this view, normative pressures presumably cause scientists to conform to norms in order to strengthen their professionalism and gain legitimacy for their way of working. This is supported by Kim and Adler (2015) who found that normative pressure played an important role in the intention to make decisions about sharing scientific data. The results of those studies show that scientists perform specific activities due to the desire to fit into generally accepted institutional norms, values, and expectations. Both Kim and Adler (2015) and Harper and Kim (2018) found that normative pressure was important in the context of intentions to reach for solutions enabling scientific openness.

4.3 Managing People and Human Resources Processes

In the context of human resources management in universities, the idea of the so-called "new managerialism" (Gewirtz, Ball, 2000) should be noted. It focuses on finding ways to improve the effectiveness of universities. In this approach, human resources management is considered the most essential and important for the university's results towards the implementation of the third mission oriented towards popularization, understanding of science by society, and its democratization. This fits into the new directions of research postulated in the literature regarding the identification of limitations, challenges, and barriers in the use of technology in higher education institutions, as well as its acceptance (Nguyen-Anh et al., 2022).

The literature indicates that organizational support can be considered at the individual and organizational levels. At the individual level, it is related to employees' beliefs that the organization values their contribution and cares about their overall well-being (Rhoades, Eisenberger, 2002). In this approach, if employees perceive that their organization values employees' contributions and provides them with opportunities to increase their professional potential, they feel obliged to reciprocate those favours through concern for the organization and willingness to perform specific actions. At the organizational level, organizational support is understood as the degree of organizational encouragement and resources regarding employees' work environment (Eisenberger et al., 1990).

The literature indicates that crowdsourcing initiatives for researchers usually take place on special platforms (Bassi et al., 2019). However, as Bassi et al.

(2020), Cuccolo et al. (2020), and Schlagwein, Daneshgar (2014) point out, the diversity of crowdsourcing platforms contributes to scientists signalling the need to obtain support from the organization. Bassi et al. (2020), based on the results of the Delphi study, prove that the use of crowdsourcing in scientific research may lead to various ethical dilemmas that scientists may face, including: representativeness of the sample, generalizability, quality of the obtained data or remuneration for members of the virtual community. This leads to research workers expecting support in creating quality assurance mechanisms in research projects.

In turn, according to Cuccolo et al. (2020), the help obtained by a researcher in starting a crowdsourcing initiative will contribute to reducing barriers and increasing openness and willingness to use crowdsourcing. These findings are confirmed, among others, by Behrend et al. (2011), who claim that there are no significant differences between non-crowdsourcing respondents and MTurk participants. They found that, compared to survey studies, in those conducted using crowdsourcing, the percentage of withdrawals from participation in the program was similar. The same remark also applies to the answers obtained. However, as stated by Keith et al. (2017), crowdsourcing platforms can be viewed as a work management system in which researchers monitor, manage, and respond to the work of Internet users to ensure the quality of work. Like any system, launching a research project using a crowdsourcing platform requires knowledge of functionality and operation from research workers.

In turn, Schlagwein and Daneshgar (2014) state that most crowdsourcing-based scientific research is conducted on the Amazon Mechanical Turk crowdsourcing platform. However, this platform was originally intended as a labour market platform, not for conducting scientific research. In addition to ethical dilemmas related to using crowdsourcing platforms such as Amazon Mechanical Turk (Pittman, Sheehan, 2016), previous research draws attention to potential difficulties related to the use of its functionality and operation (Sheehan, 2018). Schlagwein and Daneshgar (2014) state that existing crowdsourcing platforms are insufficient for research workers because they do not ensure data security, system availability and speed, and intuitive user interface layout. The authors will emphasize the need to develop a crowdsourcing platform dedicated only to research workers and university support in the form of a guide containing ready-made templates or pre-tests for research tasks.

It is therefore worth it for universities to provide research workers with examples of good practices in the use of crowdsourcing in science by researchers from other universities. This may embolden and encourage crowdsourcing in science, because a scientist will see that this way of creating scientific knowledge is approved, also internationally. However, before starting popularization or training in the field of crowdsourcing in science, it is necessary to diagnose and understand how scientific workers relate to this concept, in particular, what is their level of knowledge about crowdsourcing in science. In particular, awareness refers to research workers' understanding of the importance of crowdsourcing in science for the creation of scientific knowledge and their actions to implement research processes. Moreover, crowdsourcing in science may be perceived by scientific workers as an unnecessary activity due to the need to incur additional time expenditure, given the already high teaching, scientific, and organizational burdens.

The next step is to support the development of knowledge and competences of research workers in the field of crowdsourcing in science, which will enable the organization of an effective initiative. In particular, it is important to show how to organize such an initiative, how to ensure the quality of data, how to evaluate it and ensure methodological rigor and workflows of members of the virtual community. Moreover, in general, crowdsourcing in science is based on online collaboration. Without showing the potential benefits but also ways of mitigating possible risks arising from such cooperation, scientific workers may develop a lack of trust and reluctance to enter into such cooperation. There may also be a risk that research workers will only cooperate with people they already know and carry out research tasks together. But this support in the form of training cannot be coercive but should only be available to researchers interested in crowdsourcing in science.

A good solution may be to develop a guide to crowdsourcing platforms and their functionalities – following the example of foreign universities that publish such information on their websites. Such a guide should be interactive with the ability to quickly, intuitively search for terms of interest to the initiator or solutions to emerging problems. However, it is indicated that this may turn out to be insufficient if a researcher encounters technical difficulties during the initiative. Therefore, it is important that the university additionally provides access to technical assistance. It is also important that an employee interested in using crowdsourcing in science obtains the approval and support of their direct superiors.

It is worth noting that imposing or including crowdsourcing in science in employee evaluation systems from above will not only not encourage it, but on the contrary – it will be treated as another obligation that must be implemented. Which will increase the signalling of the challenge rather than eliminate it. In this perspective, support and commitment from the higher education institution employing the researcher is crucial to overcoming internal resistance to crowdsourcing in science by providing knowledge and skills in this area. However, it is not official procedures or orders, but support at every stage of the crowdsourcing initiative that is important from the point of view of scientific workers, as indicated by the respondents themselves. Sometimes too much pressure or official directives may turn out to be what makes it difficult, not easier, to use crowdsourcing in science. Moreover, recognizing crowdsourcing in science as one of the elements of employee evaluation does not constitute support for researchers, but rather a trigger for reluctance and resistance.

Bibliography

Abramo G., D'Angelo C.A., Murgia G. (2016), The combined effects of age and seniority on research performance of full professors, *Science and Public Policy*, 43(3), 301–319.

Agarwal R., Prasad J. (1998), A conceptual and operational definition of personal innovativeness in the domain of information technology, *Information Systems Research*, 9(2), 204–215.

Agarwal R., Prasad J. (1999), Are individual differences germane to the acceptance of new information technologies?, *Decision Sciences*, 30(2), 361–391.

Aguinis H., Villamor I., Ramani R.S. (2021), MTurk research: Review and recommendations, *Journal of Management*, 47(4), 823–837.

Alford J.R., Hibbing J.R. (2007), Personal, interpersonal, and political temperaments, *The ANNALS of the American Academy of Political and Social Science*, 614, 196–212.

Allison P.D. (1982), Discrete-time methods for the analysis of event histories, *Sociological Methodology*, 13, 61–98.

Aristeidou M., Scanlon E., Sharples M. (2017). *Science learning in online communities of scientific investigations: Evidence and suggestions*, American Educational Research Association Annual Conference, http://oro.open.ac.uk/49563/.

Arrow K.J. (1962), Economic welfare and the allocation of resources for invention, In: Nelson R.R. (ed.), *The rate and direction of inventive activity*, Princeton University Press, Princeton, 609–626.

Ashton M.C., Lee K., Paunonen S.V. (2002), What is the central feature of extraversion? Social attention versus reward sensitivity, *Journal of Personality and Social Psychology*, 83(1), 245–252.

Bandura A. (1986), The explanatory and predictive scope of self-efficacy theory, *Journal of Social and Clinical Psychology*, 4(3), 359.

Barger P., Behrend T.S., Sharek D.J., Sinar E.F. (2011). IO and the crowd: Frequently asked questions about using Mechanical Turk for research, *The Industrial-Organizational Psychologist*, 49, 11–17.

Barlow D.H., Ellard K.K., Sauer-Zavala S., Bullis J.R., Carl J.R. (2014), The origins of neuroticism, *Perspectives on Psychological Science*, 9(5), 481–496.

Barrick M.R., Mount M.K. (1991), The big five personality dimensions and job performance: A meta-analysis, *Personnel Psychology*, 44(1), 1–26.

Bassi H., Lee C., Misener L., Johnson A. (2019), Exploring the characteristics of crowdsourcing: An online observational study, *Journal of Information Science*, 46(3), 1–2.

Bassi H., Misener L., Johnson A.M. (2020), Crowdsourcing for research: Perspectives from a Delphi panel, *SAGE Open*, 10(4), 21582440209.

Beck S., Bergenholtz C., Bogers M., Brasseur T.-M., Conradsen M.L., Di Marco D., Distel A.P., Dobusch L., Dörler D., Effert A., Fecher B., Filiou D., Frederiksen L., Gillier T., Grimpe C., Gruber M., Haeussler C., Heigl F., Hoisl K., Hyslop K., Kokshagina O., LaFlamme M., Lawson C., Lifshitz-Assaf H., Lukas W., Nordberg M., Norn M.T., Poetz M., Ponti M., Pruschak G., Priego L.P., Radziwon A., Rafner J., Romanova G., Ruser A., Sauermann H., Shah S.K., Sherson J.F., Suess-Reyes J., Tucci C.L., Tuertscher P., Vedel J.B., Velden T., Verganti R., Wareham J., Wiggins A., Xu S.M. (2020), The open innovation in science research field: A collaborative conceptualisation approach, *Industry and Innovation*, 29(2), 136–185, https://www.tandfonline.com/doi/full/10.1080/13662716.2020.1792274.

Beck S., Brasseur T.-M., Poetz M., Sauermann H. (2022), Crowdsourcing research questions in science, *Research Policy*, 51(4), 104491.

Behrend T.S., Sharek D.J., Meade A.W., Wiebe E.N. (2011), The viability of crowdsourcing for survey research, *Behavior Research Methods*, 43, 800–813.

Bergeron D., Liang X.F. (2007), Thriving in the academy: A model of faculty career success, *Academy of Management Proceedings*, 2007(1), 1–6. doi:10.5465/ambpp.2007.26531855

Besley J.C. (2015), What do scientists think about the public and does it matter to their online engagement?, *Science and Public Policy*, 42(2), 201–214.

Björk B.C., Laakso M., Welling P., Paetau P. (2014), Anatomy of green open access, *Journal of the Association for Information Science and Technology*, 65(2), 237–250.

Bol T., de Vaan M., van de Rijt A. (2018), The Matthew effect in science funding, *Proceedings of the National Academy of Sciences*, 115(19), 4887–4890.

Burger J.M. (2013). *Desire for control: Personality, social and clinical perspectives*, Springer Science & Business Media, New York.

Busarovs A. (2013), Ethical aspects of crowdsourcing, or is it a modern form of exploitation, *International Journal of Economics and Business Administration*, I(1), 3–14.

Callison-Burch C., Dredze M. (2010), *Creating speech and language data with Amazon's Mechanical Turk*, Proceedings of the NAACL HLT 2010 Workshop on Creating Speech and Language Data with Amazon's Mechanical Turk, https://dl.acm.org/doi/10.5555/1866696.1866697.

Chandler J., Mueller P., Paolacci G. (2014), Nonnaïveté among Amazon Mechanical Turk workers: Consequences and solutions for behavioral researchers, *Behavior Research Methods*, 46(1), 112–130.

Chatenier E.D., Verstegen J.A., Biemans H.J., Mulder M., Omta O.S.F. (2010), Identification of competencies for professionals in open innovation teams, *R&D Management*, 40(3), 271–280.

Ciasullo M.V., Carli M., Lim W.M., Palumbo R. (2021), An open innovation approach to co-produce scientific knowledge: An examination of citizen science in the healthcare ecosystem, *European Journal of Innovation Management*, 25(6), 365–392.

Clauset A., Arbesman S., Larremore D.B. (2015), Systematic inequality and hierarchy in faculty hiring networks, *Science Advances*, 1(1), e1400005.

Correia A., Schneider D., Jameel S., Paredes H., Fonseca B. (2020), *Empirical investigation of the factors influencing researchers' adoption of crowsourcing and machine learning*, International Conference on Intelligent Systems Design and Applications, Springer, Cham, 1257–1270.

Cowart K.O., Fox G.L., Wilson A.E. (2008), A structural look at consumer innovativeness and self-congruence in new product purchases, *Psychology & Marketing*, 25(12), 1111–1130.

Crump M.J., McDonnell J.V., Gureckis T.M. (2013), Evaluating Amazon's Mechanical Turk as a tool for experimental behavioral research, *PLoS One*, 8(3), 1–18.

Cuccolo K., Irgens M.S., Zlokovic M.S., Grahe J., Edlund J.E. (2021), What crowdsourcing can offer to cross-cultural psychological science, *Cross-Cultural Research*, 55(1), 3–28.

Dahlander L., Jeppesen L.B., Piezunka H. (2019), How organizations manage crowds: Define, broadcast, attract, and select, In: *Managing inter-organizational collaborations: Process views*, Emerald Publishing Limited, Bingley, 239–270.

Dahlander L., Piezunka H. (2014), Open to suggestions: How organizations elicit suggestions through proactive and reactive attention, *Research Policy*, 43(5), 812–827.
Dahlander L., Piezunka H. (2020), Why crowdsourcing fails, *Journal of Organization Design*, 9(1), 1–9.
Davis L., Larsen M.T., Lotz P. (2011), Scientists' perspectives concerning the effects of university patenting on the conduct of academic research in the life sciences, *The Journal of Technology Transfer*, 36(1), 14–37.
Ding W., Choi E. (2011), Divergent paths to commercial science: A comparison of scientists' founding and advising activities, *Research Policy*, 40(1), 69–80.
Dudo A., Besley J.C. (2016), Scientists' prioritization of communication objectives for public engagement, *PLoS One*, 11(2), e0148867.
Ecklund E.H., James S.A., Lincoln A.E. (2012), How academic biologists and physicists view science outreach, *PLoS One,* 7(5), e36240.
Eisenberger R., Fasolo P., Davis-LaMastro V. (1990), Perceived organizational support and employee diligence, commitment, and innovation, *Journal of Applied Psychology*, 75(1), 51–59.
Eklund L., Stamm I., Liebermann W. (2019), The crowd in crowdsourcing: Crowdsourcing as a pragmatic research method, *First Monday*, 24(1), 1–14.
Ford R.C., Richard B., Ciuchta M.P. (2015), Crowdsourcing: A new way of employing non-employees?, *Business Horizons*, 58(4), 377–388.
Franzoni C., Poetz M., Sauermann H. (2022), Crowds, citizens, and science: A multi-dimensional framework and agenda for future research, *Industry and Innovation*, 29(2), 251–284.
Franzoni C., Sauermann H. (2014), Crowd science: The organization of scientific research in open collaborative projects, *Research Policy*, 43(1), 1–20.
Gerber A.S., Huber G.A., Doherty D., Dowling C.M., Raso C., Ha S.E. (2011), Personality traits and participation in political processes, *The Journal of Politics*, 73(3), 692–706.
Gewirtz S., Ball S. (2000), From Welfarism to New Managerialism: Shifting discourses of school headship in the education marketplace, *Discourse: Studies in the Cultural Politics of Education*, 21(3), 253–268.
Giluk T.L., Postlethwaite B.E. (2015), Big Five personality and academic dishonesty: A meta-analytic review, *Personality and Individual Differences*, 72, 59–67.
Goodenow C., Grady K.E. (1993), The relationship of school belonging and friends' values to academic motivation among urban adolescent students, *The Journal of Experimental Education*, 62(1), 60–71.
Hafkesbrink J., Schroll M. (2014), Ambidextrous organizational and individual competencies in open innovation: The dawn of a new research agenda, *Journal of Innovation Management*, 2(1), 9–46.
Harper L.M., Kim Y. (2018), Attitudinal, normative, and resource factors affecting psychologists' intentions to adopt an open data badge: An empirical analysis, *International Journal of Information Management*, 41, 23–32.
Hirschman E.C. (1980), Innovativeness, novelty seeking, and consumer creativity, *Journal of Consumer Research*, 7(3), 283–295.
Howe J. (2006), The rise of crowdsourcing, *Wired*, http://www.wired.com/wired/archive/14.06/crowds.html.
Hung N.Q.V., Tam N.T., Tran L.T., Aberer K. (2013), An evaluation of aggregation techniques in crowdsourcing, In: Lin X., Manolopoulos Y., Srivastava D., Huang G. (eds.),

Web information systems engineering, Lecture Notes in Computer Science, vol 8181. Springer, Berlin, Heidelberg, https://doi.org/10.1007/978-3-642-41154-0_1.

Imran M., Mitra P., Castillo C. (2016), *Twitter as a lifeline: Human-annotated twitter corpora for NLP of crisis-related messages*, https://arxiv.org/pdf/1605.05894.pdf.

Ke C.H., Sun H.M., Yang Y.C. (2012), Effects of user and system characteristics on perceived usefulness and perceived ease of use of the web-based classroom response system, *Turkish Online Journal of Educational Technology*, 11(3), 128–143.

Keith M.G., Tay L., Harms P.D. (2017), Systems perspective of Amazon Mechanical Turk for organizational research: Review and recommendations, *Frontiers in Psychology*, 8, 1359.

Kim Y., Adler M. (2015), Social scientists' data sharing behaviors: Investigating the roles of individual motivations, institutional pressures, and data repositories, *International Journal of Information Management*, 35(4), 408–418.

Kittur A., Chi E.H., Suh B. (2008), *Crowdsourcing user studies with Mechanical Turk*, Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Florence, Italy, 453–456, https://dl.acm.org/doi/10.1145/1357054.1357127.

Koole S.L., Jager W., van den Berg A.E., Vlek C.A., Hofstee W.K. (2001), On the social nature of personality: Effects of extraversion, agreeableness, and feedback about collective resource use on cooperation in a resource dilemma, *Personality and Social Psychology Bulletin*, 27(3), 289–301.

Kurzban R., Houser D. (2001), Individual differences in cooperation in a circular public goods game, *European Journal of Personality*, 15(1), 37–52.

Kyvik S., Olsen T. (2008), Does the aging of tenured academic staff affect the research performance of universities?, *Scientometrics*, 76(3), 439–455.

Law E., Gajos K.Z., Wiggins A., Gray M.L., Williams A. (2017), *Crowdsourcing as a tool for research: Implications of uncertainty*, Proceedings ACM Conference on Computer Supported Cooperative Work and Social Computing, https://www.eecs.harvard.edu/~kgajos/papers/2017/law17-crowdsourcing.pdf.

Lenart-Gansiniec R. (2020), *Crowdsourcing in science: A bibliometric analysis and a research agenda*, ISPIM Connects Global 2020: Celebrating the World of Innovation, https://ruj.uj.edu.pl/xmlui/bitstream/handle/item/269288/lenart-gansiniec_crowdsourcing_in_science_2020.pdf?sequence=1&isAllowed=y.

Levin N., Leonelli S., Weckowska D., Castle D., Dupré J. (2016), How do scientists define openness? Exploring the relationship between open science policies and research practice, *Bulletin of Science, Technology & Society*, 36(2), 128–141.

Liao H., Chuang A. (2004), A multilevel investigation of factors influencing employee service performance and customer outcomes, *Academy of Management Journal*, 47(1), 41–58.

Linek S.B., Fecher B., Friesike S., Hebing M. (2017), Data sharing as social dilemma: Influence of the researcher's personality, *PLoS One*, 12(8), e0183216.

Llorente C., Revuelta G., Carrió M., Porta M. (2019), Scientists 'opinions and attitudes towards citizens' understanding of science and their role in public engagement activities, *PLoS One*, 14 (1), e0224262.

Mandrik C.A., Bao Y. (2005), Exploring the concept and measurement of general risk aversion, *Advances in Consumer Research*, 32(4), 531–539.

Mason W., Suri S. (2012), Conducting behavioral research on Amazon's Mechanical Turk, *Behavior Research Methods*, 44, 1–23.

McCrae R.R., Costa P.T., Jr. (2008), The five-factor theory of personality, In: John O.P., Robins R.W., Pervin L.A. (eds.), *Handbook of personality: Theory and research*, New York, The Guilford Press, 159–181.

Merton R.K. (1968), *Social theory and social structure*. The Free Press, New York.

Mitręga M. (ed.) (2016), *Networking akademicki jako czynnik produktywności pracowników naukowych*. Uniwersytet Ekonomiczny w Katowicach, Katowice.

Muhdi L., Daiber M., Friesike S., Boutellier R. (2011), The crowdsourcing process: An intermediary mediated idea generation approach in the early phase of innovation, *International Journal of Entrepreneurship and Innovation Management*, 14(4), 315–332.

Mukminin A., Habibi A., Muhaimin M., Prasojo L.D. (2020), Exploring the drivers predicting behavioral intention to use m-learning management system: Partial least square structural equation model, *IEEE Access*, 8, 181356–181365.

Mulder M. (2015), *Professional competence in context. A conceptual study*, American Educational Research Association, Chicago.

Ngafeeson M.N., Sun J. (2015), The effects of technology innovativeness and system exposure on student acceptance of e-textbooks, *Journal of Information Technology Education: Research*, 14, 55.

Nguyen-Anh T., Nguyen A.T., Tran-Phuong C., Nguyen-Thi-Phuong A. (2022). Digital transformation in higher education from online learning perspective: A comparative study of Singapore and Vietnam, *Policy Futures in Education*, 21(4), https://doi.org/10.1177/14782103221124181.

Nov O., Ye C. (2008), Users' personality and perceived ease of use of digital libraries: The case for resistance to change, *Journal of the American Society for Information Science and Technology*, 59(5), 845–851.

Paolacci G., Chandler J., Ipeirotis P.G. (2010), Running experiments on Amazon Mechanical Turk, *Judgment and Decision Making*, 5(5), 411–419.

Patterson F., Ferguson E., Lane P., Farrell K., Martlew J., Wells A. (2000), A competency model for general practice: Implications for selection, training, and development, *British Journal of General Practice*, 50(452), 188–193.

Pittman M., Sheehan K. (2016), Amazon's Mechanical Turk a digital sweatshop? Transparency and accountability in crowdsourced online research, *Journal of Media Ethics*, 31(4), 260–262.

Podmetina D., Soderquist K.E., Petraite M., Teplov R. (2018), Developing a competency model for open innovation: From the individual to the organisational level, *Management Decision*, 56(6), 1306–1335.

Poliakoff E., Webb T.L. (2007), What factors predict scientists' intentions to participate in public engagement of science activities?, *Science Communication*, 29(2), 242–263.

Porter N.D., Verdery A.M., Gaddis S.M. (2020), Enhancing big data in the social sciences with crowdsourcing: Data augmentation practices, techniques, and opportunities, *PLoS One*, 15(6), e0233154.

Pratama A.R., Firmansyah F.M., Rahma F. (2022), Security awareness of single sign-on account in the academic community: The roles of demographics, privacy concerns, and Big-Five personality, *PeerJ Computer Science*, 8, e918.

Pszczołowski T. (1978), *Mała encyklopedia prakseologii i teorii organizacji*. Zakład Narodowy im. Ossolińskich, Wrocław-Warszawa-Kraków.

Rahman M.S., Mannan M., Hossain M.A., Zaman M.H., Hassan H. (2018), Tacit knowledge-sharing behavior among the academic staff: Trust, self-efficacy, motivation and Big Five personality traits embedded model, *International Journal of Educational Management*, 32(5), 761–782.

Rhoades L., Eisenberger R. (2002), Perceived organizational support: A review of the literature, *Journal of Applied Psychology*, 87(4), 698.

Riesch H., Potter C. (2014), Citizen science as seen by scientists: Methodological, epistemological and ethical dimensions, *Public Understanding of Science*, 23(1), 107–120.

Rogers E.M. (2003), *Diffusion of innovations* (5th ed.), Free Press, New York.

Rogers R.W. (1983), Cognitive and physiological processes in fear appeals and attitude change: A revised theory of protection motivation, In: Cacioppo J.R., Petty R.E. (eds.), *Socialpsychology: A sourcebook*, Guilford, New York, 153–177.

San Martín H., Herrero Á. (2012), Influence of the user's psychological factors on the online purchase intention in rural tourism: Integrating innovativeness to the UTAUT framework, *Tourism Management*, 33(2), 341–350.

Sauermann H., Stephan P. (2013), Conflicting logics? A multidimensional view of industrial and academic science, *Organization Science*, 24(3), 889–909.

Schlagwein D., Bjorn-Andersen N. (2014), Organizational learning with crowdsourcing: The revelatory case of LEGO, *Journal of the Association for Information Systems*, 15(11), 3.

Schrögel P., Kolleck A. (2019), The many faces of participation in science: Literature review and proposal for a three-dimensional framework, *Science & Technology Studies*, 32(2), 77–99.

Sheehan K.B. (2018), Crowdsourcing research: Data collection with Amazon's Mechanical Turk, *Communication Monographs*, 85(1), 140–156.

Shirk J.L., Ballard H.L., Wilderman C.C., Phillips T., Wiggins A., Jordan R., McCallie E., Minarchek M., Lewenstein B.V., Krasny M.E., Bonney R. (2012), Public participation in scientific research: A framework for deliberate design, *Ecology and Society*, 17(2), 1–20.

Sjöberg L. (2002), Attitudes toward technology and risk: Going beyond what is immediately given, *Policy Sciences*, 35(4), 379–400.

Skorupka S., Auderska H., Łempicka Z. (1968), *Mały słownik języka polskiego*. Wydawnictwo Państwowe Wydawnictwo Naukowe, Warszawa.

Thakur R., Srivastava M. (2014), Adoption readiness, personal innovativeness, perceived risk and usage intention across customer groups for mobile payment services in India, *Internet Research*, 24(3), 369–392.

Thursby J.G., Haeussler C., Thursby M.C., Jiang L. (2018), Prepublication disclosure of scientific results: Norms, competition, and commercial orientation, *Science Advances*, 4(5), 1–14.

Uhlmann E.L., Ebersole C.R., Chartier C.R., Chartier C.R., Errington T.M., Kidwell M.C., Lai C.K., McCarthy R.J., Riegelman A., Silberzahn R., Nosek B.A. (2019), Scientific utopia III: Crowdsourcing science, *Perspectives on Psychological Science*, 14(5), 711–733.

Ulmanen S., Soini T., Pietarinen J., Pyhältö K. (2016), The anatomy of adolescents' emotional engagement in schoolwork, *Social Psychology of Education*, 19(3), 587–606.

Wagner C.S., Whetsell T., Baas J., Jonkers K. (2018), Openness and impact of leading scientific countries, *Frontiers in Research Metrics and Analytics*, 3(10), 1–10.

Watchravesringkan K., Hodges N.N., Kim Y.H. (2010), Exploring consumers' adoption of highly technological fashion products: The role of extrinsic and intrinsic motivational factors, *Journal of Fashion Marketing and Management: An International Journal*, 14(2), 263–281.

Watson W.E., BarNir A., Pavur R. (2010), Elements influencing peer evaluation: An examination of individual characteristics, academic performance, and collaborative processes, *Journal of Applied Social Psychology*, 40(12), 2995–3019.

Wieczorek A.L., Mitręga M., Spáčil V. (2021), Dynamic academic networking concept and its links with English language skills and research productivity–non-Anglophone context, *PLoS One*, 16(2), e0245980, https://doi.org/10.1371/journal.pone.0245980.

Wiggins A., Crowston K. (2011), *From conservation to crowdsourcing: A typology of citizen science*, Proceedings 44th Hawaii International Conference on Systems Sciences (HICSS), Kauai.

Yoon A., Kim Y. (2017), Social scientists' data reuse behaviors: Exploring the roles of attitudinal beliefs, attitudes, norms, and data repositories, *Library & Information Science Research*, 39(3), 224–233.

Zenk-Möltgen W., Akdeniz E., Katsanidou A., Naßhove V., Balaban E. (2018), Factors influencing the data sharing behavior of researchers in sociology and political science, *Journal of Documentation*, 74(5), 1053–1073.

5 Challenge in the Development of Crowdsourcing in Science

The current findings in the field of crowdsourcing in science show that for over a decade, it has been recognized as a cognitively interesting and emerging concept (Buecheler et al., 2010), which is a response to the demands of both the democratization of science and its technicization (Cozma, Dimitrova, 2021). Supporters of crowdsourcing in science indicate that in the future it will constitute a complementary method of creating scientific knowledge (Kwoka, 2017). In opposition, critics of crowdsourcing in science emphasize that its further development intensifies many methodological and ethical challenges (Mortensen, Hughes, 2018). On the one hand, crowdsourcing in science fits into the demands of platformization of science, which increases questions about whether it will pose a threat to established ways of creating scientific knowledge (Bryson, 2016). On the other hand, virtual communities engaging in the implementation of tasks as part of crowdsourcing in science initiatives have different motivations and expectations. This determines the need to activate and encourage Internet users to participate in the task given by scientists (Kaufmann et al., 2011). A controversial issue is providing Internet users with stimuli encouraging them to carry out research tasks based on fun and entertainment. At the same time, concerns about methodological rigour are highlighted (Farrell, Sweeney, 2021). Finally, questions are raised about the future of crowdsourcing in science in the context of the development of other emerging technologies. It is increasingly emphasized that artificial intelligence is the future of scientific research (OECD Science, Technology and Innovation Outlook, 2018; Thiebes et al., 2021; UKRI, 2021; Xu et al., 2021). Another significant challenge for the creation of scientific knowledge is found in the development of other technologies (Feger et al., 2019), such as blockchain, augmented virtual reality, Metaverse, and artificial intelligence.

Taking into account the above considerations, the aim of this chapter is to discuss future directions and challenges in the development of crowdsourcing in science. The chapter presents the author's proposal for future directions of research on crowdsourcing in science. In addition to considerations on the future of crowdsourcing, the chapter presents potential scenarios for its development in the context of other technologies.

DOI: 10.4324/9781003482253-6

5.1 New Direction for Research on Crowdsourcing in Science

The growing interest of researchers in the issue of crowdsourcing in science allows us to assume that it will remain an interesting and rewarding area of scientific exploration for many years to come. This is confirmed by the growing methodological literature providing recommendations on best practices for researchers interested in using crowdsourcing in science (Berinsky et al., 2012; Casler et al., 2013; Paolacci, Chandler, 2014; Peer et al., 2017; Mortensen, Hughes, 2018).

However, the relatively rapid interest of researchers in crowdsourcing in science has resulted in knowledge about it being developed in an unstructured and somewhat dispersed manner. Of course, the literature provides recommendations as to the directions of future research on crowdsourcing in science, but practice is definitely ahead of theory and the need for a new look at its potential is constantly recognized. Therefore, based on the observations from the literature review and qualitative research conducted by the author, new, original directions for future research on crowdsourcing in science were proposed. At the same time, they have implications for future researchers.

Both the results of a systematic literature review and qualitative research allowed the conclusion that in the future, research on crowdsourcing in science should be interdisciplinary, transdisciplinary, and longitudinal in nature – depending on the issues and thematic scope of the research, which is detailed below. So far, crowdsourcing in science has attracted the interest of practitioners and researchers from various fields of science and scientific disciplines. This contributed to the creation of a kind of bubble because it was analysed only using a specific lens specific to the field of science and scientific discipline (Raasch et al., 2013). Therefore, the view on crowdsourcing in science has been narrowed. As stated by Eklund et al. (2019, p. 2) "the novelty of this research technique has not yet produced procedures and best practices, and more importantly, there is a lack of consensus – especially between disciplines – as to what this 'method' is, how to use it, and even after what to use it for". In this approach, even multidisciplinary research may turn out to be insufficient to resolve emerging scientific dilemmas in the area of crowdsourcing in science. Yes, there is value in collaboration between researchers from several different fields and scientific disciplines, but in multidisciplinary research each researcher works in their own context with little cross-disciplinary inspiration and shares information and results at the end of their research to support the overall combined findings.

5.1.1 Direction 1. Interdisciplinary Research

Interdisciplinary research, in principle, not only expands the possibilities for further evolution of each research field but is also necessary in relation to new research fields (Bonaccorsi, Vargas, 2010), such as crowdsourcing in science.

Moreover, interdisciplinary research not only allows for a better understanding of the evolution of a given concept, but also allows for the proposal of joint creation and recombination of knowledge within and between scientific disciplines. Additionally, it allows for integration in the scientific community in order to jointly solve problems and reduce the concentration on central problems (Darden, Maull, 1977).

An interdisciplinary approach is usually used when it is required to remove barriers resulting from the specificity of a given scientific discipline and to develop a consensus between disciplines to solve a complex or multi-faceted problem (Siedlok, Hibbert, 2014). Currently, interdisciplinary research on crowdsourcing in science is, according to the author, the "Holy Grail". Apart from declarations showing such a necessity, there is still little discussion about the development, methods of carrying out or examples of the application of an interdisciplinary approach in relation to crowdsourcing in science. Crowdsourcing in science itself is interdisciplinary in nature, as it combines both social and behavioural aspects. While scientists representing psychological sciences (Buhrmester et al., 2011) and sociological sciences (Beck et al., 2022) have explored crowdsourcing in science to varying degrees in recent years, the results they obtained were presented as independent. Therefore, it seems necessary not only to combine the achievements in the field of crowdsourcing in science provided by sociologists and psychologists, but also to include representatives of anthropology, political science, management, and economics in research cooperation – this will allow for a broader look at crowdsourcing in science. Below is the author's proposal of research directions in crowdsourcing in science that require an interdisciplinary approach.

The first proposed issue that requires interdisciplinary research is the crowdsourcing behaviour of academic teachers. This issue is certainly complex and multi-faceted. In this case, knowledge about crowdsourcing behaviour is provided by management and quality sciences (satisfaction with the activity performed), sociology (dynamics of behaviour), psychology (emotions, attitudes, perception, awareness), anthropology (values in relation to different organizational cultures), political science (division of power), and economics (rational explanations for behaviour). Analysing crowdsourcing behaviour related to scientific initiatives should therefore take into account the cultural context and the specificity of individual universities where research workers are employed. Taking into account the organizational context is important because, as shown by the research results indicated by the author, the opinion of colleagues and organizational support are important for the intention to crowdsource.

A broad approach to the crowdsourcing behaviour of academics should also take into account the aspect of power, conflicts, and competitions within universities. Crowdsourcing per se is perceived through the prism of control and coercion, which implies taking into account aspects of power and manipulation or other unethical behaviour on the part of both initiators and members of the virtual community in research on crowdsourcing behaviour (Moss et al., 2020). It is also important to take into account the publication strategies of academic workers in future research on crowdsourcing in science. The literature postulates that the competences, skills and reputation of a researcher influence not only research results (e.g. the number of publications and citations of the researcher), but also a person's tendency to include others in research (Mitręga, 2016).

Considering the above, the crowdsourcing behaviour of research workers may be a particularly promising direction for future interdisciplinary research. However, it should be remembered that interdisciplinary research has specific requirements, in particular, that "the integration of knowledge takes place not in the final phases of the cognitive process (preparation of empirical material, analysis), but in a continuous manner (...)" (Wierzchosławski, 1996, pp. 98–99). This requires the researcher to find a common language or a lens that allows for explaining behaviour in a wide range of contexts. According to the author, it may be the theory of planned behaviour, which is intensively used not only by representatives of management sciences but also psychology, medical and health sciences, or political sciences.

Dynamics of behaviour of virtual communities is another issue. Supporters of crowdsourcing per se emphasize the potential and value of the so-called "wisdom of crowds" and collective intelligence (Wexler, 2011), where "under the right conditions, groups turn out to be extremely intelligent and often wiser than the most brilliant of their members" (Surowiecki, 2010, p. 15). Others, however, signal that virtual communities are "crazy", which refers to situations where they can collectively make mistakes and even act in illogical and unpredictable ways (Mennis, 2006).

The literature also presents the threat of majority tyranny, which occurs when decisions made by the majority of a group do not take into account the needs of the minority. Therefore, the question arises about the strategies of virtual communities. This fits with calls in the literature for the reconfiguration of the virtual community (Wexler, 2011). Additionally, the proposed direction for future research is a response to the postulated shift from perceiving the virtual community as an irrational group threatening and disrupting social order towards an active and rational coalition or collective with its own norms and methods of operation oriented towards activity and commitment. All this drives the need to focus research attention on the mechanisms and games of collective intelligence. An interdisciplinary approach may be helpful here, as it will enable us to discover the behaviours and reactions of virtual communities as well as the factors causing their positive behaviour.

First, collaboration is an essential feature of scientific work (Wieczorek et al., 2021). Previous work linked the context of cooperation for creating scientific knowledge in connection with co-authored publications, implementation of scientific projects or, more broadly, scientific productivity (Mitręga, 2016; Wieczorek et al., 2021). However, although crowdsourcing in science refers to the process of online cooperation, a simple translation of the previous findings of other researchers in the field of scientific cooperation is, according to the author, not possible. First of all, because in scientific cooperation we have knowledge about who participates in it. In crowdsourcing in science, it is difficult to determine who ultimately participates in crowdsourcing in science initiatives. Some researchers believe that the virtual community participating in a crowdsourcing in science initiative consists mainly of representatives of America and India, as well as Europeans and representatives of Southeast Asia. Despite this, there is a cognitive and research gap in the current findings regarding whether the geographical location of virtual community members may influence their way of working and the quality of knowledge transferred. This is therefore the basis for proposing another direction for future research aimed at determining whether cultural differences among virtual community members may be important for the quality of their work and, therefore, the creation of scientific knowledge.

Second, crowdsourcing per se is based on diversity, which may contribute to the paradox of redundancy (Lenart-Gansiniec, 2018) and difficulties in capturing knowledge. The literature recognizes creation of scientific knowledge as a social product, but unpredictable, opportunistic interactions and behaviours of members of virtual communities may occur. In short, both the diversity of members of virtual communities and the multitude of potential interactions constitute a challenge and new directions for scientific considerations. Hence, attention is drawn to the need for interdisciplinary research taking into account the perspectives of psychology, sociology, and anthropology, which will be aimed at proposing a model for creating scientific knowledge using crowdsourcing in science. The literature provides models of knowledge creation through crowdsourcing per se, but they incorporate an organizational knowledge perspective. There were also attempts to use a model intended for analysing the organizational environment for scientific knowledge, but it only worked in the context of creating knowledge in international teams (Hautala, 2011).

Given the above, the challenge for future researchers is to provide a model for scientific knowledge creation that incorporates crowdsourcing in science. However, it should be remembered that adapting the knowledge developed by members of the virtual community to the requirements and expectations of the initiator involves strengthening it in social contexts and selectively combining it with existing base knowledge. And finally, the question of what actions of the initiator will be effective when creating scientific knowledge is as important as the answer to the question of how to integrate different knowledge.

As mentioned in the second chapter of this work, at the implementation stage the received solutions are integrated with the research process. This may contribute to the emergence of threats and risks related not only to the quality of data, but also to the initiator's reluctance to use knowledge obtained from outside. In this context, the researcher's individual absorption capacity seems important. However, this issue is ignored in mainstream research on crowdsourcing in science. Only Beck et al. (2022, pp. 148–149) stated that individual absorptive capacity is “the driving force for open and collaborative behaviour”. However, it seems that individual absorption capacity not only triggers the academician’s willingness to use crowdsourcing in science but also constitutes an important element in adopting solutions provided by members of the virtual community. Therefore, it is important to recognize the mechanisms of integration of the initiator’s base knowledge with the knowledge provided by the virtual community. Taking into account the above, it is suggested to seek an answer to the following question: what is the importance of the individual absorption capacity of an academic teacher for the creation of scientific knowledge using crowdsourcing in science?

Another issue in the context of future research directions on crowdsourcing in science is the fact that crowdsourcing per se contributes to organizational learning at all its levels (Schlagwein, Bjorn-Andersen, 2014; Lenart-Gansiniec, 2021). However, to the best of the author’s knowledge, there is no research on this aspect in the context of the individual learning level of academic teachers. Research of this kind could certainly dramatically increase the usefulness of crowdsourcing for academics, and the following research questions are suggested: What is the importance of crowdsourcing in science for academics’ learning?

In relation to crowdsourcing in science, the assumptions of the long tail theory are confirmed. This means that since members of the virtual community are guided by various motives, including the need for satisfaction, belonging to a team, or building their own reputation – this forces the initiator to coordinate and manage the entire initiative. The initiator is a kind of orchestrator inviting and encouraging the virtual community to work. Despite the importance of the need to manage a crowdsourcing initiative (Blohm et al., 2018), little attention has been paid to this topic in the existing literature, especially in the context of crowdsourcing in science. It seems important to take a broader approach to this issue and provide a model of the scientific maturity of the crowdsourcing initiative. Such a maturity model has already been proposed for public organizations (Lenart-Gansiniec, 2019), but it does not cover the specificity of a crowdsourcing in science initiative. Therefore, it seems necessary to develop a tool that will help initiators plan and then coordinate the initiative and determine the level and status of striving to achieve the assumed goal, i.e. creating scientific knowledge.

As stated in the previous chapters of the study, thanks to crowdsourcing, a researcher can gain access to a variety of knowledge and a lot of data. However, this diversity means that they may receive a large amount of data, which will require its aggregation. While the literature provides evidence on techniques for aggregating results in crowdsourcing per se (Hung, 2013), in the context of crowdsourcing in science there is a lack of information on how to perform this aggregation. Therefore, another research question is proposed: What are the techniques for aggregating knowledge obtained through crowdsourcing in science? Identifications in this area are important because there is a difference between data generated as part of a crowdsourcing initiative per se and scientific data (Beck et al., 2022).

Conducting interdisciplinary research entails several methodological challenges. First, interdisciplinary research generally serves as a means of scientifically investigating bimodal phenomena because it allows for synergy between two contrasting modes or forms. This entails the need to choose the scope of interdisciplinarity, which refers to the conceptual and cultural distance between the participating research fields. Besides, the so-called the "paradigmatic war" (Tobi, Kampen, 2018, p. 1210) conducted between representatives of social and behavioural sciences makes it even more difficult to conduct scientific research also on crowdsourcing in science. In a narrow approach to interdisciplinarity, interaction between scientific fields is not difficult in epistemological terms but may not yield many new assumptions. However, a broad approach to interdisciplinarity indicates crossing the boundaries of many distant disciplines. However, epistemological heterogeneity may make it difficult to integrate different methods and the resulting knowledge, as well as to interpret heterogeneous data. Additionally, "interdisciplinarity requires more than just complementarity" because it is necessary to use "new types of empirical approaches" as well as "integrated analyses" (Fiore et al., 2008, p. 254).

Second, the literature suggests that interdisciplinarity may be detrimental to the identity of a research field (Hjørland, 2013). This means that although interdisciplinary research can be applied to a variety of topics, one dominant perspective is recommended in the literature (White, Haas, 1975). This therefore intensifies new challenges for researchers dealing with the issue of crowdsourcing in science in the form of searching for the dominant perspective. According to the author of this book, cognitive psychology may be such a perspective for crowdsourcing in science, where the basis is focusing on the processes of perception, attention, thinking, and memory. This will not only allow us to understand the behaviour of members of virtual communities, but also to predict their capabilities and limitations in the implementation of various crowdsourcing tasks. Additionally, by adopting the perspective of cognitive psychology, it is possible to examine the nature of cognitive processes related to information processing – which is important in the case of designing a crowdsourcing task and determining its level of difficulty (Hettiachchi et al., 2019).

5.1.2 Direction 2. Transdisciplinary Research

Crowdsourcing in science is recognized in the literature as a method of transdisciplinary research (Wechsler, 2014). This research is focused on identifying real problems in order to proactively support actions or interventions that improve the way society functions. The research is based on the pursuit of crossing disciplinary boundaries, the inclusion of multidisciplinary and interdisciplinary academic research, the involvement of all social actors in conducting scientific research as participants in the process (Lawrence, 2004).

The complex and dynamic nature of crowdsourcing in science (Beck et al., 2022) makes it necessary for researchers to break out of disciplinary silos. However, in line with the idea of transdisciplinary research, crowdsourcing in science requires academic teachers involving members of virtual communities in various research tasks. All this may entail many unprecedented challenges, both methodological and ethical (Mortensen, Hughes, 2018). Recognizing them using a single disciplinary perspective does not provide a picture of a complex topic. Transdisciplinary research may enable entry into the indicated challenges, due to the promise of going beyond the academic domain and gaining access to practical knowledge, among others, coming from the virtual community.

The author believes that in the future, transdisciplinary research in the context of crowdsourcing in science will become recommended. However, we cannot forget that although they are helpful in meeting contemporary research challenges, they are associated with barriers and limitations, in particular: (1) crossing disciplinary boundaries, (2) overcoming differences between the expectations of management theorists and practitioners, (3) potential conflicts arising from the cooperation of partners with different expectations. Moreover, transdisciplinary research implies the need to combine and reconcile different expectations regarding the potential results of researchers' work: creating new scientific knowledge, social responsibility for the results of scientific research and designing recommendations for practice and decision-makers (Adelle et al., 2021). To conclude, in transdisciplinary research, academics should become initiators of change (Wittmayer, Schäpke, 2014).

Recommended directions for research on crowdsourcing in science using transdisciplinary research are presented below. In particular, they include ethical challenges (exploitation of members of the virtual community, issues of privacy, intellectual property) and methodological challenges (reliability and quality of crowdsourcing data). Additionally, future directions for transdisciplinary research may address the organizational and social determinants of crowdsourcing in science.

Problems related to the sense of exploitation of virtual community members are signalled by scientists using crowdsourcing (Pittman, Sheehan, 2016; Moss et al., 2020). The reported problem is intensified by the fact that crowdsourcing per se, including the scientific one, is part of the so-called "gig economy" (De Stefano, 2016). The literature leaves no doubt that employees working on crowdsourcing platforms are often treated as "commodities" (Aloisi, 2015) and their work is commodified (Bergvall-Kåreborn, Howcrof, 2014). Bezos, creator of the Amazon Mechanical Turk platform, said: "You've heard of software-as-a-service. Now this is human-as-a-service". Taking into account the above, the author of this work states that there is a need for a deeper research discussion on the issue of exploitation of the virtual community. This is important because, on the one hand, academic teachers, thanks to crowdsourcing, gain unlimited access to knowledge resources, but there may be a risk of treating members of the virtual community performing tasks as cheap labour. On the other hand, platform workers may experience a low sense of job security, life satisfaction (Shapiro et al., 2013), and a high level of anxiety (Arditte et al., 2016). All this means that they can perform work at their own discretion, even unreliably and chaotically.

Taking into account the above, transdisciplinary research focused on the issue of exploitation of virtual communities participating in crowdsourcing in science initiatives is perceived as promising. Due to the specific nature of such research, the inclusion of both scientists, gig workers, and decision-makers may prove helpful in finding optimal solutions that take into account the needs and expectations of each party.

Another future direction for transdisciplinary research on crowdsourcing in science is the issue of privacy in crowdsourcing in science. This is especially important because the specific nature of crowdsourcing per se and the fact that anonymous users participate in it increases concerns about privacy (Kandappu et al., 2015). One of the many incidents quoted below confirms the need to conduct research in this area involving both researchers, members of the virtual community and decision-makers. For example, in 2016, the Amazon Mechanical Turk platform was used to generate psychological profiles of Internet users without their knowledge (Davies, 2015). All this increases the need to conduct transdisciplinary research, taking into account the observations of both initiators and members of the virtual community and IT solution providers. It will then be possible to develop solutions that will be satisfactory for both parties.

Crowdsourcing in science provides access to unlimited and diverse knowledge. Despite the reported benefits, there may be threats related to intellectual property. This is due to several reasons. First, in crowdsourcing in science, members of the virtual community can gain access to information and a detailed description of the task, including ideas for scientific research. This is required by the guidelines for developing an invitation to perform a task, which is posted by the initiator on the crowdsourcing platform – the more detailed it is, the greater the probability of the initiator receiving solutions consistent with his expectations (Buhrmester et al., 2018). However, this may increase theft of research ideas.

Second, members of the virtual community engage in tasks and submit their ideas. This may also increase another threat of intellectual property infringement. In this approach, potential contractors may perform tasks only for financial reasons, which may potentially give rise to the temptation of unethical behaviour.

Third, members of the virtual community who start the task accept expectations of initiators, but also trust them (Keith et al., 2017). However, the threat of the so-called Arrow's information paradox (Arrow, 1962), which involves the potential risk of an academic appropriating the provided solution, without rewarding Internet users – under the pretext of the alleged unsuitability of the solution.

There are a lot of discussions in the literature about the risks and consequences of using crowdsourcing in science (Burnette et al., 2022). Although so far the authors have focused on legal issues and conditions mitigating emerging threats resulting from infringement of intellectual property rights by Internet users (Chen et al., 2011) – many aspects in this area have not been sufficiently recognized, which constitutes an invitation to for further research. In particular, it seems important to propose an approach to copyright management taking into account various types of crowdsourcing tasks, especially in relation to complex (sophisticated) tasks. This protection is important because complex tasks include, among others, requests to send ideas for scientific research or formulate research questions. It is therefore important to provide clear solutions that will protect the initiator's intellectual property and reduce the risk of data loss and theft. Moreover, solutions to the tasks rejected by the initiator remain in their possession, which may lead to potential copyright problems. According to the author, this aspect should also be recognized in future transdisciplinary research.

Another issue is related with the fear of virtual community members about the theft of personal and sensitive data, which may reduce the openness of Internet users to take part in a crowdsourcing in science initiative. The literature provides examples of theft of sensitive data, including credit card data (Lasecki et al., 2015). However, there may be practices from virtual communities in the form of phishing, spamming, stalking, harassment, malware, or other fraud (Xia, McKernan, 2020). For example, Internet users gathered around the MTurk signalled the platform providers that they were tricked into visiting fake websites installing malware that destroyed their computer equipment (Xia et al., 2017).

Bearing the above in mind, the following question may be asked: how to balance the tension between the open nature of crowdsourcing in science and the protection of the initiator's know-how? While the practice provides solutions in the form of platforms for reporting online abuses (e.g. Internet Eyes, LiveSafe), there are still no directives or guidelines on how the initiator and members of the virtual community can deal with privacy threats. Although press reports and information posted on the European Commission's website show that the European Union has noticed the need to regulate work on crowdsourcing platforms and has launched consultations on gig workers – this does not solve the need to take a comprehensive look at the issue of intellectual property (Xia et al., 2017, p. 19). Hence, transdisciplinary research may prove invaluable. According to the author, due to the multi-aspect nature of the work of the virtual community, there is some need to involve many non-scientific entities in research, including those from business, government, and society, in particular, the "gig worker" environment, which may result in the development of solutions that will be more useful in crowdsourcing practice.

Transdisciplinary research may prove helpful in identifying issues of reliability and quality of data provided by members of the virtual community involved in crowdsourcing in science initiatives. The focus of future research in this area stems from several reasons. First, as already mentioned, crowdsourcing platforms collect a huge amount of data that is transmitted by the initiator and received by Internet users – and vice versa (Paolacci, Chandler, 2014).

Second, there are differences in the recognition of the quality of data generated through crowdsourcing in science. Many researchers state that the results obtained through crowdsourcing in science are comparable in quality to those conducted using traditional methods (Behrend et al., 2011; Casler et al., 2013; Keith et al., 2017). However, there are voices that these results may not meet scientific standards (Riesch, Potter, 2014). The literature provides findings on the reasons for this state of affairs, such as insufficient knowledge of members of the online community, lack of skills in conducting scientific research (Wiggins, 2010), susceptibility to inattention (Chandler et al., 2014), bias (Antin, Shaw, 2012), and dishonesty (Peer et al., 2017).

Considering the above, transdisciplinary research in the context of data quality in crowdsourcing in science may contribute not only to understanding the tendency of virtual communities to violate work standards. The importance of preventing unethical behaviour in online communities is one of the most important issues, especially in the face of the scandal on the Amazon Mechanical Turk platform related to the use of bots to automate the completion of survey questionnaires (Kennedy et al., 2020). In addition to identifying tendencies of Internet users, the results of transdisciplinary research may prove useful in developing universal standards or procedures enabling academics to verify the quality of Internet users' work. It seems helpful to include not only scientists and members of the virtual community, but also managers of crowdsourcing platforms and decision-makers in this type of research.

Another proposed issue that requires transdisciplinary research refers to determinants of crowdsourcing in science, particularly including those of organizational and social nature. The literature postulates that regulations or internal procedures obliging research workers to use crowdsourcing in science may increase their reluctance to engage in such activities (Beck et al., 2022). Despite this, attempts to provide such regulations can be noted. One of them refers to the guidelines of the European Commission's Community Research and Development Information Service, EC's Strategy on the 3 O's: "Open Innovation/Open Science/Open to the World – a vision for Europe". Other regulations concerned open science (Dubinsky, 2014) and the demands for the entrepreneurial role of universities in society (Etzkowitz, Leydesdorff, 2000). This is consistent with the expectation that "scientific research will be oriented not only to the interests of the academic community, but also to the ways of working and living of people in society (...)" (Păunescu et al., 2022, p. 154).

In addition to the signalled regulatory intentions of crowdsourcing in science, it should be noted that the assessment of scientists' work results is focused on research, teaching and organizational areas – while cooperation or the inclusion of people from outside the scientific community in research are outside the assessment criteria. Given the current state of knowledge, it is difficult to clearly state whether there is a general need or justification for including collaborative practices, including crowdsourcing in science, in evaluation systems. Therefore, it is not known whether the regulations motivating scientists to use crowdsourcing in science should be internal to universities or obligatory – national or even international. Transdisciplinary research that involves various stakeholder groups may be helpful here – which will allow us to develop solutions that meet their needs and expectations.

Conducting transdisciplinary research poses several challenges. First, there may be difficulty in combining different perspectives (Tress et al., 2005). This is compounded by the fact that interaction between scientists and practitioners can prove difficult because they may use different terminology to refer to the same issues. Second, the integration of the obtained research results may pose a challenge that is difficult to overcome due to the variety of methods used in transdisciplinary research. This means that transdisciplinary research may be perceived as excessively time-consuming and difficult (Hering et al., 2012). The third challenge is to engage practitioners in research. Moreover, it is important to show practitioners that the research will bring measurable benefits to them. In this approach, although it is crucial in transdisciplinary research, it remains unclear what the role of individual people in the research project is.

5.1.3 Direction 3. Longitudinal Research

Longitudinal research refers to the repeated collection of research data from the same people/organizations over a certain period of time (Ruspini, 1999), which allows for the development of a processual approach to a given research problem. Moreover, the extended period of data collection and their repeatability using the same research instruments make it possible to create a multi-layered understanding of the organizational context and discover many new meanings. Additionally, specific time intervals allow for understanding the dynamics of organizational behaviour, which may change due to the emergence of new factors. Such research also allows for the measurement and analysis of patterns of change over time and the identification of the causes of the change process, the temporal sequencing of variables, repeated observations of those variables within cases or units, and the examination of the causal directions of changes in specific variables over time (Ployhart, Vandenberg, 2010).

As academics' perception of crowdsourcing in science may change along with their experience of using it (Sonderegger et al., 2012) it is valuable to focus on the dynamics of behaviour and the causes of temporal changes. The literature shows that in the earliest stages of introducing new solutions, users might make decisions that may differ from those related to continuation (Godoe, Johansen, 2012). Moreover, attitudes may vary as people gain experience using a given technology (Venkatesh, 2000). It is therefore important to capture the temporal nature of changes in beliefs, intentions of initiators, and therefore intentions and behaviours related to crowdsourcing in science. In general, it is important to understand academics' perception of crowdsourcing in science, taking into account the time factor. This may contribute to the identification of conditions that influence the change in the perception of crowdsourcing. In addition, it is important to recognize the behaviour of members of the virtual community, with particular emphasis on their retention during the crowdsourcing in science initiative. Below, the possibilities of conducting longitudinal research in relation to the intention to use crowdsourcing in science and the retention of virtual community members are discussed in detail.

While conducting cross-sectional studies is particularly suitable for estimating the frequency and differences related to behaviour, they do not allow for understanding how and why intentions or behaviours change in individual people. With respect to the causality of a given behaviour, cross-sectional studies may be insufficient to observe changes over time and test causal relationships. Identifying the determinants of behaviour may prove important in understanding the attitudes, perceptions, motivations, and experiences of academics with regard to crowdsourcing in science (Beck et al., 2022). It is therefore easy to disagree with the statement of Ployhart and Vandenberg (2010, p. 96), who believe that "the variables underlying the theory and their relationships are described in dynamic terms (...)". Additionally, conducting cross-sectional research in relation to the determinants of intentions for specific behaviours may cause the researcher to make a false assumption that intention, and then behaviour, is the result of a linear decision-making process (Oberfield, 2014, p. 778). Moreover, it may be wrong to assume a priori that decisions once made by scientists will not change. Behavioural intention, as the level of motivation to perform a given behaviour, is considered a causal and proximal mechanism influencing a specific behaviour. Intentions are susceptible to change, which further leads to changes in behaviour.

Identification of the determinants of the intention to use crowdsourcing in science should be conducted using longitudinal research due to the fact that the intention per se is recognized in the literature, taking into account many different theories originating from psychology (Kwon, Silva, 2020). The following theories may be given here: the theory of planned behaviour, the theory of social exchange, the theory of rational action, the theory of behavioural reasoning, and the theory of self-determination. This multiplicity of theories further intensifies the need for a multiple, iterative look at crowdsourcing in science.

The reason for conducting longitudinal research in relation to crowdsourcing in science is the fact that learning about current behaviour is possible by identifying past behaviour – which makes it possible to predict intentions. This state of affairs is supported by the findings of Poliakoff and Weeb (2007), who state that past behaviour can guide current and future behaviour because initiating and controlling processes become automatic. Unlike behaviours that are infrequent or performed in unstable or difficult situations, the influence of past behaviours on current behaviour is assumed to be mediated by intentions (Ouellette, Wood, 1998). However, it is not always possible to examine previous experiences, because in some countries crowdsourcing in science itself is new and research workers have no experience with its use. In this case, when examining the determinants of user intentions, it is important to study this phenomenon over a longer period of time and not only through the prism of a cross-sectional snapshot (Sonderegger et al., 2012).

The literature shows that the percentage of completed tasks by Internet users is on average 62.72% (Buhrmester et al., 2011; Shapiro et al., 2013; Schleider, Weisz, 2015). Moreover, crowdsourcing per se fits into the "90-9-1" rule, where 90% of online community members only observe, 9% participate from time to time, and 1% regularly (Wazny, 2017). Understanding the factors that influence retention in virtual communities is critical to the success of crowdsourcing in science initiatives (Keith et al., 2017). This is due to the fact that the virtual community is one of the important sine qua non conditions of crowdsourcing, including the scientific one (Lenart-Gansiniec et al., 2022). While retention in crowdsourcing per se remains an important but well-recognized topic (Mesgari et al., 2015), in relation to the scientific one it is still insufficiently explored. Due to the specificity of crowdsourcing in science and the different motivations of participating Internet users, retention may be dictated by other reasons. In the initiative announced by organizations, Internet users can work individually or together to create innovations, they can also vote, take part in competitions, or work on solutions to organizational problems. This has consequences related to the fact that at the beginning, Internet users starting the task have certain expectations in relation to their roles in the initiative, the duration of the task and the level of difficulty. When their expectations are violated due to discrepancies between expectations and actual tasks, role conflict and resignation are likely to occur.

Internet users' reasons for abandoning a task may be different at the beginning of a crowdsourcing in science initiative and during its realization (Auer et al., 2021). Additionally, according to Helson's (1947) acceptance level theory, Internet users may evaluate their current experiences in relation to previous experiences. This takes the perspective of a psychological contract because online communities engaged in crowdsourcing "are struggling with both economic instability and career instability (…)" (Liu et al., 2020, p. 2). Therefore, longitudinal research focused on identifying the attitudes and behaviours of Internet users involved in a crowdsourcing in science initiative would be interesting.

The use of longitudinal research poses several challenges. One of the most important is the measurement and analysis of hidden constructs (Ployhart, Vandenberg, 2010). Intentions may depend on various factors. All of this means that measures of the latent construct will not be equivalent across time periods.

In this case, the question arises about the optimal time interval – some changes develop slowly, which means that they may not be captured in repeated measurements performed at short intervals.

There is no consensus in the literature as to the intervals at which longitudinal studies should be conducted. Some claim that two periods are sufficient (Menard, 2002), others postulate several waves (Brænder, Andersen, 2013). Regardless, each choice entails specific consequences and may lead the researcher to an incorrect conclusion that there was an actual change in the variable between measurements, which may only be related to measurement error. In relation to management and quality sciences, research that takes into account three repeated observations is optimal (Ployhart, Vandenberg, 2010, p. 97).

Another challenge is to retain all respondents during longitudinal research, which is difficult in the case of research on the intention to use crowdsourcing in science by research workers. There may be situations in which a research participant advances academically or changes his or her place of employment. The question therefore arises as to whether such a participant may continue to respond in future studies. The literature recommends that in this case, "researchers need to consider how they define the panel (sample or population) of interest to provide guidance for dealing with both loss of the participants and new participants" (Stritch, 2017, p. 234).

Despite the potential limitations and challenges related to conducting longitudinal research in the context of crowdsourcing in science, such research allows to fit into the general challenge of the need to recognize dynamic issues, dependent on the time factor, using methods that allow discovering the conditions and motives of choices or behaviours (Stritch, 2017). Longitudinal research allows for testing complex phenomena that change quickly over time. Academic teachers' intentions to use crowdsourcing in science depend, among other things, on their attitudes, perceptions and motivations – and they are changing (Beck et al., 2022). Research on crowdsourcing in science from the perspective of initiators and virtual communities, taking into account time, will therefore allow for capturing hidden variables and thus may strengthen both management theory and practice.

5.2 The Future of Crowdsourcing in Science

Crowdsourcing in science enjoys constant and dynamic interest in both theory and practice (Rea et al., 2020). The latest Elsevier report (2022) showed that both the COVID-19 pandemic, but also technological progress, funding uncertainty and pressure to look for ways to accelerate scientific research while ensuring methodological rigour – increase the need to reorganize and search for complementary ways of conducting scientific research. The Elsevier report also points primarily to the important role of information and communication technologies in the creation of scientific knowledge.

However, in addition to enthusiastic and open positions that crowdsourcing in science will play an important role in the creation of scientific knowledge in the future, there are also predictions of its inevitable decline (Chmielewski, Kucker, 2020). The need to discuss its future is intensified by the criticism of crowdsourcing per se, questioning its ability to create scientific knowledge and reliability (Dahlander, Piezunka, 2020). Pessimistic views about crowdsourcing per se indicate that it is just a passing fad that brings more harm to the initiator than good (Aruguete et al., 2019). In addition, attention is paid to its cost and time consumption. With regard to crowdsourcing in science, concerns are increasingly raised in the literature about the ethical, methodological and fairness aspects of remunerating members of the virtual community for the work they perform (Rea et al., 2020). It is also signalled that excessive reliance on information and communication technology in the context of creating scientific knowledge reduces the ability to contribute to the development of science, while increasing the risks related to methodological rigour (Rea et al., 2020) and excessive workload of research workers. Research conducted by Schlagwein and Daneshgar (2014) leads to the conclusion that existing crowdsourcing platforms are insufficient for research workers because they do not ensure, among other things, data security, but also access to them, system speed, and an intuitive user interface layout. Schlagwein and Daneshgar (2014) will emphasize the need to develop a crowdsourcing platform dedicated only to research workers and university support in the form of ready-made templates or pre-tests for research tasks. However, Rea et al. (2020) analysed articles published between 2011 and 2019 in which scientists used crowdsourcing to collect research data and conducted interviews with Internet users gathered around crowdsourcing in science platforms. Findings by Rea et al. (2020) show that both employees and members of the virtual community point to the threats arising from crowdsourcing in science in the form of potential information asymmetry and power imbalance – which is also a threat to its future and further development.

Despite critical and sceptical voices about the future of crowdsourcing in science, its constant presence in scientific articles and monographs can be noted. Crowdsourcing in science has dedicated conferences and sessions at prestigious international scientific conferences, such as “Open Innovation in Science (OIS) Research Conference” and “International Open and User Innovation Conference”. Research on the issue of crowdsourcing is carried out in international, significant research centres, including Ludwig Boltzmann Gesellschaft Open Innovation in Science Center[1], Lab for Open Innovation in Science Einstein Center for Neurosciences Berlin.[2] Moreover, interest in crowdsourcing in science increased with the outbreak of the COVID-19 pandemic (Noel-Storr et al., 2022), where its potential for carrying out scientific research was noticed.

5.3 Crowdsourcing in Science Versus Fast-Changing Technology Development

It is widely assumed that digital technologies will be ubiquitous in institutions, societies and organizations, which is part of the "transformation", "paradigm shift", "fourth industrial revolution", and "platformization" (Opazo-Basáez et al., 2022). However, the continuous development of digital platforms is compounded not only by challenges in the context of crowdsourcing in science, but also by new opportunities for creating scientific knowledge. In particular, questions arise about potential scenarios for the development of crowdsourcing in science in the context of other technologies that appear on the market (Tran-Gia et al., 2013). The analysis of scientific and grey literature shows that crowdsourcing in science may go in the following directions in the future (given alphabetically): blockchain, digital storytelling, gamification, metaverse, artificial intelligence, and virtual reality. Below they are discussed and their potential for use in crowdsourcing in science is indicated. It should be noted that these observations are of an original nature and result from a look at the potential benefits of crowdsourcing in science and the evolution of crowdsourcing per se.

5.3.1 Blockchain

Blockchain is a distributed technology that involves transferring transactions to a network environment via interconnected computers. Computer systems allow, using tokens (e.g. bitcoins), to encrypt and verify records, called blocks. In this approach, each block contains a certain number of transactions, and each time a new transaction occurs, its record is added to the user's ledger. Blocks are connected using cryptography. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data. Blockchain provides distributed, decentralized storage, sharing, and use of data across multiple computers so that the record cannot be altered (Dutra et al., 2018). It also allows data to be verified for compliance with established requirements (Aleinikov et al., 2018; Novikov et al., 2018), which improves their transparency and security and prevents their manipulation (Sheldon, 2018).

According to the author, in the context of creating scientific knowledge, one of the possible applications of blockchain is the registration of research data using the blockchain. Thanks to cryptographic protection, the data will be secured without unauthorized access. Moreover, sharing data on the blockchain enables the creation of a research environment, which increases the chances of intensifying scientific cooperation. This can also improve the peer review process, as well as the verification of opinions and their permanent storage (Tenorio-Fornés et al., 2021).

Thanks to blockchain technology, ideas for hypotheses and scientific research can be submitted by the virtual community anonymously using the blockchain, which promotes innovation, but can also limit the repetition of ideas – because when the virtual community sees the submissions of others, it can be inspired by them or copy them (Liu et al., 2020). In a word, the specificity of blockchain can increase the transparency and openness of science and eliminate dishonesty, in particular data manipulation. And finally, blockchain can contribute to increasing the trust of members of the virtual community in the honest intentions of the initiators – because all data received and transmitted are encrypted and authorized thanks to blockchain technology. Researchers can post their ideas, research results or anything else on the blockchain system and thus prove their existence at a specific time.

Moreover, the specificity of blockchain means that virtual communities can be additionally motivated. As van Rossum (2017, p. 17) points out,

> researchers can publish their research and invite others to contribute and help. Anyone who does so receives virtual tokens for their contribution (...) These tokens can provide an incentive to increase the quality and speed of inflow (...) For example, each month it 'costs' a certain percentage of tokens to obtain feedback for publication.

Another benefit of using blockchain to create scientific knowledge is the ability for initiators to retain ownership of their work or acquired data through so-called "non-fungible assets". These are mechanisms for defining and storing elements such as copyrights, academic degrees, and certificates in the blockchain. All this makes blockchain technology a potential for increasing reproducibility in science (Kadadha et al., 2022).

The first attempts to use blockchain to create scientific knowledge can be noted. One example is the Scienceroot platform. It is a scientific ecosystem based on open access to blockchain that combines all functions required during the process of creating scientific knowledge – from financing, through research, to publishing. The second example can be provided by Pluto. It is a blockchain-based platform that facilitates decentralized scientific communication between researchers and people interested in participating in scientific research.

5.3.2 Digital Storytelling

Digital storytelling refers to telling of personal stories using information and communication technologies (Couldry, 2008). Digital storytelling combines narrative with digital audio and visual content in short films lasting 3 to 5 minutes (Lambert, Hessler, 2018). However, in those films the emphasis is not so much on the technical aspect, but rather on the combination of narrative, audio, and visual elements, because their goal is to stimulate, excite, and learn the audience (Martin et al., 2019). All this means that digital storytelling allows scientists to "become creative storytellers" (Robin, 2008, p. 222).

Digital storytelling is gaining importance in medicine, education, social services, international development, and media communication (de Jager et al., 2017). It provides organizations with the opportunity to reach potential recipients, but also to create an image, invite and engage the virtual community to co-create products or services, prototype, and implement solutions to current organizational problems (Pera, Viglia, 2016). Digital storytelling allows you to promote new business models and convince customers about new directions in the organization's development. Finally, it can encourage customers to share their experiences, which allows the organization to build long-term relationships and trust (de Jager et al., 2017).

Recently, it has been signalled that the potential of digital storytelling can be used in the context of scientific work, in particular, in the context of science popularization (Joubert et al., 2019). These opportunities result from the fact that digital storytelling is considered a manifestation of the democratization of science, legitimization, and scientific communication (Erdoğan, 2021). It also responds to the challenges related to the so-called social contract (Lubchenco, 1998), which involves meeting social needs through scientific research and communicating its results to the broadly understood community (Ettinger, 2020) and gaining their favour, arousing interest, commitment, and encouraging and persuading a given behaviour. This can raise awareness of science and build trust in it and scientists. Digital storytelling also has the potential to popularize scientific knowledge, increase visibility, and decolonize research (De Jager et al., 2017).

Over the last few years, digital storytelling has evolved from recorded short videos posted on websites to incorporating digital storytelling into crowdsourcing. With regard to organizations, it is emphasized that digital storytelling allows organizations to combine virtual reality with virtual experiences, and also stimulates sensory and behavioural experiences (Kim, Hall, 2020). Digital storytelling combined with crowdsourcing may prove helpful in organizing the so-called "roadshow" (a series of meetings), word-of-mouth marketing, establishing contact with stakeholders, and providing information about the heritage or history of the organization. As Davey and Benjaminsen (2012) point out, digital storytelling can be used not only to communicate research results to stakeholders, but also to collect data, especially qualitative data. Digital storytelling is also an essential element of a successful crowdfunding initiative (Omeragic, 2016).

Taking into account the evolution of digital storytelling, but also of crowdsourcing per se, it seems that the future direction of the development of crowdsourcing in science may be the inclusion of digital storytelling in scientific initiatives. This is due to several reasons. First, crowdsourcing in science has its limitations related to the initiator's communication of the expectations set for online communities. The initiator places an open invitation on the platform in the form of a written message, containing the specifics of the task. This form creates the risk that the message may be read and interpreted in different ways. The potential of digital storytelling makes it possible to transform text into personalized multimedia content containing visual, visual-spatial, and verbal elements. Integrating all three elements can make it easier to present the purpose of the crowdsourcing in science initiative and the expectations of the researcher. Internet users' failure to understand the expectations set for them by the initiator may contribute to the failure of a crowdsourcing in science initiative. Blohm et al. (2018) point out the need to post instructions explaining the requirements on the crowdsourcing platform. Such descriptions can be replaced by digital narratives.

Second, it is indisputable that digital narratives matter in scientific processes. The researcher's goal is not only to disseminate the results of scientific research in the academic environment, but also to communicate them to a wider audience (Dahlstrom, 2014), in line with the useful nature of science. When a scientist tells a story, the virtual community sees who invites them to perform the task, but also can observe personal reactions and emotions regarding a given scientific topic. Moreover, the issue of the virtual community's trust in the initiator is of indisputable importance (Lenart-Gansiniec, 2017), because violations occur related to the initiator's failure to fulfil promises. In short, incorporating digital storytelling into crowdsourcing in science may prove useful for building Internet users' engagement, long-term relationships, and trust.

5.3.3 Gamification

Gamification refers to the use of game mechanisms and is one of the most important forms of hedonic systems and technologies (Hamari, Koivisto, 2015). Its potential and benefits make gamification increasingly important in medicine, human resources management, education, internal communication, service delivery, social involvement, shaping social behaviour, marketing, advertising (Morschheuser et al., 2017), and promoting the desired motivational effects, behaviour, and learning (Zainuddin et al., 2020).

According to the theory of technological affordance, gamification can shape and stimulate the external and internal motivations of Internet users, and ultimately promote their participation and involvement (Prestopnik, Tang, 2015). The specificity of gamification means that members of the virtual community taking part in a crowdsourcing in science initiative can take part in various challenges, interact (Marczewski, 2017), compete with each other, collect points, badges/achievements, complete levels, track the progress of their work, collect, carry out missions or take on the form of an avatar or other virtual character (Morschheuser et al., 2017).

The mentioned potential benefits of gamification have made it already present in the context of crowdsourcing per se. There is even talk of the so-called "gamified crowdsourcing" (Morschheuser et al., 2017). Organizations include game mechanisms in crowdsourcing initiatives to make it more attractive for members of the virtual community to perform tasks. This seems important in the context of those Internet users who are motivated by the desire for entertainment, fun, or competition.

There are opportunities to use gamification in the scientific community (Fuchs et al., 2014), in particular, in the context of searching, mapping, collecting, recognizing and classifying various data, scientific communication, proofreading and translating texts (Prestopnik, Tang, 2015). The literature highlights that gamification can contribute to "better accuracy and lower costs than conventional approaches that only use incentives" (Feyisetan et al. 2015, p. 333) and improved productivity (Deterding et al., 2011), especially in the context of tasks addressed to virtual communities gathered on crowdsourcing platforms (Kuek et al., 2015).

As practice shows, crowdsourcing solution providers seem to recognize the potential of gamification in the context of creating scientific knowledge. For example, on the Figure Eight (formerly Crowdflower) crowdsourcing platform, the introduction of gamification elements increased productivity, and accuracy of task performance. It is said that there is an improvement of 10% compared to the situation before the introduction of gamification (Feyisetan et al., 2015, p. 334). In turn, on the Amazon Mechanical Turk platform, members of the virtual community carrying out tasks can earn qualifications-badges, which are a ticket to more tasks and activities, and thus the possibility for Internet users to gain access to higher remuneration. There are also "gamified" crowdsourcing in science platforms used in the areas of biotechnology, medicine, psychology, and computer science. One of them is the Foldit game, which "involves 'folding' proteins, i.e. forming them into stable structures". Another game is EteRNA, which allows players to design RNA molecules. And one more example, the EyeWire game, in which users take on the challenge of mapping neurons in the retina. The above examples show that gamification may become the future norm in crowdsourcing in science initiatives. As De Lellis (2020) points out, the gamification of crowdsourcing in science aims to strengthen competition between Internet users and determine the differences between them based on the badges obtained. The reward is the above-mentioned opportunity to gain access to better-paid tasks. However, the question arises about further possibilities and limits of including gamification mechanisms in crowdsourcing in science initiatives. And finally, should creating scientific knowledge become fun?

5.3.4 Metaverse

In short, Metaverse involves transferring reality to the virtual world, which is possible thanks to virtual and augmented reality. The metaverse is an outgrowth of the development of advanced technologies such as virtual/augmented reality, artificial intelligence, cloud computing, blockchain, and 5G/6G wireless communication networks. Metaverse refers to a three-dimensional virtual world where an avatar acts on behalf of the user, explores the virtual space, communicates with other people, and achieves the user's goals (Kim, 2021).

Findings so far show that the Metaverse may have potential for creating scientific knowledge. As Gartner's report indicates, it is predicted that by 2026, 25% of people will spend at least an hour a day in the Metaverse for work, shopping, education, social media, and/or entertainment: from attending virtual classes to buying digital land and building virtual houses. Everything indicates that the Metaverse will change the face of creating scientific knowledge and redefine it. Scientific cooperation and involvement of communities in scientific research will be possible at any time using a virtual avatar or digital twin. Researchers will be able to visualize and interact with other researchers or people from outside the scientific community in real time in a virtual reality environment to find answers to their questions faster. This may also assist in inviting members of the virtual community to complete the research task(s).

5.3.5 Artificial Intelligence

Generally, the concept of artificial intelligence refers to advanced technology and software capable of performing tasks that imitate the cognitive-behavioural functions of the human brain, including in the areas of learning, reasoning and planning (Pereira et al., 2021). The term "artificial intelligence" is a category that includes, among others: machine learning, deep learning, genetic algorithms, Internet of Things, artificial neural networks, intelligent robots, and virtual and augmented reality applications (Lu et al., 2018).

Research on artificial intelligence indicates that the potential benefits of its use include improving efficiency, productivity, effectiveness of tasks performed (Von Krogh, 2018), work design (Nguyen, Malik, 2022), and human resources management (Budhwar et al., 2022), task automation (Coombs et al., 2020), processing large amounts of information (Jarrahi, 2018), decision-making (Keding, 2021), innovating and transforming business processes (Wamba-Taguimdje et al., 2020), identifying opportunities to enter the market with a new offer (Mishra, Pani, 2020), improving the quality of existing products and services (Davenport, Ronanki, 2018), increasing revenues and reducing costs (Alsheiabni et al., 2019), improving reputation, and increasing share in the market (Toniolo et al., 2020). Research has shown that artificial intelligence also provides the opportunity to redefine business models (Duan et al., 2019).

The literature emphasizes that artificial intelligence seems to be a promising technique for researchers specializing in, among others, computer science, mathematics, medical sciences, materials science, earth sciences, natural sciences, physics, and chemistry (Xu et al., 2021). It is indicated that artificial intelligence allows "to conduct research in a different way, radically accelerating the discovery process and enabling breakthroughs" (UKRI, 2021, p. 19). On the one hand, artificial intelligence technologies accelerate and facilitate access to knowledge acquisition, its collection and storage (Eseryel, 2014), filtering, ranking and grouping (Extance, 2018) and enable the processing and analysis of large data sets, information and knowledge. (Teodoridis, 2018). Artificial intelligence is also used to automate procedures for systematic literature reviews (Wagner et al., 2022) or to improve the generation and validation of research hypotheses (Extance, 2018). Artificial intelligence also shows the potential to create relationships between concepts (Wagner et al., 2022). On the other hand, artificial intelligence seems to be promising in the context of increasing openness and cooperation among academics to share knowledge and find potential reviewers and conduct reviews (Cyranosky, 2019).

Moreover, the challenges related to the quality of data obtained through crowdsourcing in science, indicated in chapter two, necessitate new methods for verifying the resulting scientific knowledge. Considering the potential of artificial intelligence, it seems to be promising in this context, in particular for verifying whether the data was actually provided by members of the virtual community and not automated. It can also be useful to prevent various offenses from occurring on crowdsourcing in science platforms (Xia et al., 2017). Finally, duplicate entries by members of the virtual community can lead to outdated records, resulting in poor data quality. Artificial intelligence can therefore be used to eliminate duplicate records in the database on crowdsourcing in science platforms.

Another issue concerns the performance of tasks by artificial intelligence that may involve human errors. This may mainly concern tasks such as tagging, searching, classifying, or transcribing text. Thanks to this, the initiator-researcher will avoid the need to spend additional time and energy on training the virtual community. The collected data will be assigned by artificial intelligence. It can create more complex versions of labels, such as language translations and transcriptions. Artificial intelligence can evaluate and select the best solution sent by the virtual community and classify them depending on the expectations of the initiator and the level of knowledge and skills of Internet users. Thanks to this, the initiator will receive a ready ranking of solutions of the highest quality.

Another problem that initiators may face is reaching, inviting, and then coordinating and managing the virtual community taking part in a crowdsourcing in science initiative. Artificial intelligence-based solutions enable identification of virtual community members and their assignment to a task based on their previous results or tasks performed. Moreover, AI-based engines can identify patterns in the behaviour of virtual community members. They can also predict possible task abandonment or unethical behaviour. Thanks to artificial intelligence, it is also possible to monitor work of the virtual community and transfer tasks to other performers of unprocessed data, images, videos, and sound when the initiator sees insufficient potential in the implementation of tasks.

5.3.6 Virtual Reality

Virtual reality (VR) means that the world is computer-generated (Guttentag, 2010) and people can experience situations that resemble real ones (Loureiro et al., 2020). There are many directions in which VR technology can be used: from augmented reality projections to 3D virtual reality, ending with interactive 360° films. VR technology allows researchers to be taken to places that are physically restricted, e.g. hard-to-reach, guarded laboratories. Additionally, it allows you to interact with 3D models or designs in orientations and scales that were not possible before. VR also improves competences in spatial visualization, innovative thinking, creative problem-solving, and critical thinking (Hernandez-de-Menendez et al., 2020).

In the context of creating scientific knowledge, one of the most promising areas of VR applications seems to be research on consumer behaviour, e.g. in virtual supermarkets (Ares, 2019). Moreover, in marketing research, VR is used to measure and evaluate user behaviour, such as eye tracking in retail to better understand consumers' visual attention (Meiβner et al., 2019). Additionally, tourism and marketing researchers can use VR to visualize experiences from remote locations or to explore potential purchase intentions based on low-immersion visualizations (Yung, Khoo-Lattimore, 2019).

With regard to crowdsourcing in science, the need to train members of the virtual community before starting the task is repeatedly emphasized in the literature, which is due to uncertainty in their research experience and understanding of the research process (Bassi et al., 2019). In this case, VR may prove useful for organizing immersive training of virtual community members before starting a crowdsourcing in science initiative (Zuiercher et al., 2022). Some draw attention to the possibility of conducting experimental research on a crowdsourcing platform using virtual reality, which may contribute to solving the threats of methodological rigour resulting from non-representative samples and the lack of replication possibilities (Blascovich et al., 2002).

Previous research on crowdsourcing in science indicates that it is a direction that is constantly developing and gaining in importance. Previous research focused, among other things, on the characteristics of virtual communities participating in crowdsourcing in science initiatives. Research was also conducted in the context of the success factors of initiatives, the importance of crowdsourcing in science, and the functionality of platforms (more on this in Chapter 2 of this book). Despite that, answers to various questions that researchers were facing are still being sought. Due to the specificity of crowdsourcing in science, it is also postulated to conduct interdisciplinary research in the field of crowdsourcing behaviour of initiators, dynamics of behaviour of virtual communities, creation of scientific knowledge using crowdsourcing and management of a crowdsourcing in science initiative. Transdisciplinary research is also needed on the issues of exploitation of virtual communities, intellectual property, reliability, and quality of crowdsourcing data, and privacy in crowdsourcing in science. Finally, longitudinal research on the intention to use crowdsourcing in science and the retention of virtual community members is important.

According to many researchers, but also practitioners and decision-makers, crowdsourcing in science will evolve with the development of technology, but also with changes in the expectations of initiators and members of the virtual community. Blockchain, digital storytelling, metaverse gamification, virtual reality, and artificial intelligence are, among others, directions that will give a new image of crowdsourcing in science. Of course, this involves new challenges for theory, but also for practice – because so far, existing crowdsourcing platforms do not allow the inclusion of the indicated solutions or functionalities.

Notes

1 https://ois.lbg.ac.at/ois-materials/guides.
2 https://www.ecn-berlin.de/open-innovation-153/lab-for-open-innovation-in-science-lois.html.

Bibliography

Adelle C., Görgens T., Kroll F., Losch B. (2021), Co-production of knowledge in transdisciplinary communities of practice: Experiences from food governance in South Africa, *Science and Public Policy*, 48(2), 145–153.

Aleinikov A.V., Kurochkin A.V., Mal'Tseva D.A. (2018), The information efficiency of new knowledge production in the era of network communications, *Scientific and Technical Information Processing*, 45(1), 22–27.

Aloisi A. (2015), Commoditized workers: Case study research on labor law issues arising from a set of on-demand/gig economy platforms, *Comparative Labor Law & Policy Journal*, 37, 653–690.

Alsheiabni S., Cheung Y., Messom C. (2019), *Towards an artificial intelligence maturity model: From science fiction to business facts*, PACIS 2019 Proceedings, 46. https://aisel.aisnet.org/pacis2019/46.

Antin J., Shaw A. (2012), *Social desirability bias and self-reports of motivation: A study of amazon mechanical turk in the US and India*, Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 2925–2934, https://doi.org/10.1145/2207676.2208699.

Arditte K.A., Çek D., Shaw A.M., Timpano K.R. (2016), The importance of assessing clinical phenomena in Mechanical Turk research, *Psychological Assessment*, 28(6), 684.

Ares G. (2019), Special issue on Virtual reality and food: Applications in sensory and consumer science, *Food Research International*, 117, 1, https://doi.org/10.1016/j.foodres.2019.02.001.

Arrow K.J. (1962), Economic welfare and the allocation of resources for invention, In: Nelson R.R. (ed.), *The rate and direction of inventive activity*, Princeton University Press, Princeton, 609–626.

Aruguete M.S., Huyn H., Browne B.L., Jurs B., Flint E., McCutcheon L.E. (2019), How serious is the 'carelessness' problem on Mechanical Turk?, *International Journal of Social Research Methodology*, 22(5), 441–449.

Auer E.M., Behrend T.S., Collmus A.B., Landers R.N., Miles A.F. (2021), Pay for performance, satisfaction and retention in longitudinal crowdsourced research, *PLoS One*, 16(1), e0245460.

Bassi H., Lee C., Misener L., Johnson A. (2019), Exploring the characteristics of crowdsourcing: An online observational study, *Journal of Information Science*, 46(3), 1–2.

Beck S., Brasseur T.-M., Poetz M., Sauermann H. (2022), Crowdsourcing research questions in science, *Research Policy*, 51(4), 104491.

Behrend T.S., Sharek D.J., Meade A.W., Wiebe E.N. (2011), The viability of crowdsourcing for survey research, *Behavior Research Methods*, 43, 800–813.

Bergvall-Kåreborn B., Howcroft D. (2014), Amazon Mechanical Turk and the commodification of labour, *New Technology, Work and Employment*, 29(3), 213–223.

Berinsky A.J., Huber G.A., Lenz G.S. (2012), Evaluating online labor markets for experimental research: Amazon.com's mechanical Turk, *Political Analysis*, 20(3), 351–368.

Blascovich J., Loomis J., Beall A.C., Swinth K.R., Hoyt C.L., Bailenson J.N. (2002), Immersive virtual environment technology as a methodological tool for social psychology, *Psychological Inquiry*, 13(2), 103–124.

Blohm I., Zogaj S., Bretschneider U., Leimeister J.M. (2018), How to manage crowdsourcing platforms effectively?, *California Management Review*, 60(2), 122–149.

Bonaccorsi A., Vargas J. (2010), Proliferation dynamics in new sciences, *Research Policy*, 39(8), 1034–1050.

Brænder M., Andersen L.B. (2013), Does deployment to war affect public service motivation? A panel study of soldiers before and after their service in Afghanistan, *Public Administration Review*, 73(3), 466–477.

Bryson J. (2016), *What are academics for? Can we be replaced by AI?*, https://joanna-bryson.blogspot.com/2016/01/what-are-academics-for-can-we-be.html.

Budhwar P., Malik A., De Silva M.T., Thevisuthan P. (2022), Artificial intelligence–challenges and opportunities for international HRM: A review and research agenda, *The International Journal of Human Resource Management*, 33(6), 1065–1097.

Buecheler T., Sieg J., Füchslin R., Pfeifer R. (2010), *Crowdsourcing, open innovation and collective intelligence in the scientific method: A research agenda and operational framework*, Artificial Life XII – Twelfth International Conference on the Synthesis and Simulation of Living Systems, http://ecas.issuelab.org/resources/29661/29661.pdf.

Buhrmester M., Kwang T., Gosling S.D. (2011), Amazon's mechanical turk: A new source of inexpensive, yet high-quality, data?, *Perspectives on Psychological Science*, 6(1), 3–5.

Buhrmester M.D., Talaifar S., Gosling S.D. (2018), An evaluation of Amazon's Mechanical Turk, its rapid rise, and its effective use, *Perspectives on Psychological Science*, 13(2), 149–154.

Burnette C.B., Luzie J.L., Bennett B.L., Weisenmuller C.M., Kerr P., Martin S., Keener J., Calderwood L. (2022), Concerns and recommendations for using Amazon MTurk for eating disorder research, *International Journal of Eating Disorders*, 55(2), 263–272.

Casler K., Bickel L., Hackett E. (2013), Separate but equal? A comparison of participants and data gathered via Amazon's MTurk, social media, and face-to-face behavioral testing, *Computers in Human Behavior*, 29(6), 2156–2160.

Chandler J., Mueller P., Paolacci G. (2014), Nonnaïveté among Amazon Mechanical Turk workers: Consequences and solutions for behavioral researchers, *Behavior Research Methods*, 46(1), 112–130.

Chen J.J., Menezes N.J., Bradley A.D., North T. (2011), Opportunities for crowdsourcing research on Amazon Mechanical Turk, *Interfaces*, 5(3), 1–4.

Chmielewski M., Kucker S.C. (2020), An MTurk crisis? Shifts in data quality and the impact on study results, *Social Psychological and Personality Science*, 11(4), 464–473.

Coombs C. (2020), Will COVID-19 be the tipping point for the intelligent automation of work? A review of the debate and implications for research, *International Journal of Information Management*, 55, 102182.

Couldry N. (2008), Mediatization or mediation? Alternative understandings of the emergent space of digital storytelling, *New Media & Society*, 10(3), 373–391.

Cozma R., Dimitrova D. (2021), Research Gate or Revolving Door? Uses and Gratifications of Academic Social Media Among Communication Scholars, *Journalism & Mass Communication Educator*, 76(3), 282–296.

Curty R.G., Crowsto K., Specht A., Grant B.W., Dalton E.D. (2017), Attitudes and norms affecting scientists' data reuse, *PLoS One*, 12(12), e0189288.

Cyranoski D. (2019), Artificial intelligence is selecting grant reviewers in China, *Nature*, 569(7756), 316–318.

Dahlander L., Piezunka H. (2020), Why crowdsourcing fails, *Journal of Organization Design*, 9(1), 1–9.

Dahlstrom M.F. (2014), *Using narratives and storytelling to communicate science with nonexpert audiences*, „Proceedings of the National Academy of Sciences", https://www.pnas.org/doi/10.1073/pnas.1320645111.

Darden L., Maull N. (1977), Interfield theories, *Philosophy of Science*, 44(1), 43–64.

Davenport T.H., Ronanki R. (2018), Artificial intelligence for the real world, *Harvard Business Review*, 96(1), 108–116.

Davey N.G., Benjaminsen G. (2021), Telling tales: Digital storytelling as a tool for qualitative data interpretation and communication, *International Journal of Qualitative Methods*, 20, 16094069211022529.

Davies H. (2015), Ted Cruz using firm that harvested data on millions of unwitting Facebook users, *The Guardian*, https://www.theguardian.com/us-news/2015/dec/11/senator-ted-cruz-president-campaign-facebook-user-data.

De Jager A., Fogarty A., Tewson A., Lenette C., Boydell K.M. (2017), Digital storytelling in research: A systematic review, *The Qualitative Report*, 22(10), 2548–2582.

De Lellis L. (2020), How gamification affects crowdsourcing: The case of amazon mechanical Turk, *Eludamos. Journal for Computer Game Culture*, 10(1), 27–37.

De Stefano V. (2016) Introduction: Crowdsourcing, the gig-economy and the law, *Comparative Labor Law & Policy Journal*, 37(3), 1–10.

Deterding S., Sicart M., Nacke L., O'Hara K., Dixon D. (2011), *Gamification. using game-design elements in non-gaming contexts*, CHI'11 Extended Abstracts on Human Factors in Computing Systems, 2425–2428, https://dl.acm.org/doi/10.1145/1979742.1979575.

Duan Y., Edwards J.S., Dwivedi Y.K. (2019), Artificial intelligence for decision making in the era of Big Data–evolution, challenges and research agenda, *International Journal of Information Management*, 48, 63–71.

Dubinsky E. (2014), A current snapshot of institutional repositories: Growth rate, disciplinary content and faculty contributions, *Journal of Librarianship and Scholarly Communication*, 2(3), eP1167.

Dutra A., Tumasjan A., Welpe I.M. (2018), Blockchain is changing how media and entertainment companies compete, *MIT Sloan Management Review*, 60(1), 39–45.

Eklund L., Stamm I., Liebermann W. (2019), The crowd in crowdsourcing: Crowdsourcing as a pragmatic research method, *First Monday*, 24(1), 1–14.

Erdogan E. (2021), The impact of digital storytelling on the academic achievement and democratic attitude of primary school students, *Educational Policy Analysis and Strategic Research*, 16(1), 427–448.

Eseryel D., Law V., Ifenthaler D., Ge X., Miller R. (2014), An investigation of the interrelationships between motivation, engagement, and complex problem solving in game-based learning, *Journal of Educational Technology & Society*, 17(1), 42–53.

Ettinger J. (2020), What Hollywood can teach researchers about scientific storytelling, *Nature*, https://www.nature.com/articles/d41586-020-01731-9.

Etzkowitz H., Leydesdorff L. (2000), The dynamics of innovation: From National Systems and "Mode 2" to a Triple Helix of university-industry-government relations, *Research Policy*, 29(2), 109–123.

Extance A. (2018), How AI technology can tame the scientific literature, *Nature*, 561(7722), 273–275.

Farrell M., Sweeney B. (2021), Amazon's MTurk: A currently underutilised resource for survey researchers?, *Accounting, Finance & Governance Review*, 27(1), 1–18.

Feger S.S., Dallmeier-Tiessen S., Woźniak P.W., Schmidt A. (2019), *Gamification in science: A study of requirements in the context of reproducible research*, Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, 1–14, https://cds.cern.ch/record/2688997/files/1746203%20Insp.pdf.

Feyisetan O., Simper E., Van Kleek M., Shadbolt N. (2015), *Improving paid microtasks through gamification and adaptive furtherance incentives*, Proceedings of the 24th International Conference on World Wide Web, 333–343, https://eprints.soton.ac.uk/385885/1/www2015_submission_912_final.pdf.

Fiore S.M., Hoffman R.R., Salas E. (2008), Learning and performance across disciplines: An epilogue for moving multidisciplinary research toward an interdisciplinary science of expertise, *Military Psychology*, 20, 155–170.

Fuchs M., Fizek S., Ruffino P., Schrape N. (2014), *Rethinking gamification*, Meson Press, Milton Keynes, https://meson.press/wp-content/uploads/2015/03/9783957960016-rethinking-gamification.pdf.

Godoe P., Johansen T. (2012), Understanding adoption of new technologies: Technology readiness and technology acceptance as an integrated concept, *Journal of European Psychology Students*, 3(1), 38–52.

Guttentag D.A. (2010), Virtual reality: Applications and implications for tourism, *Tourism Management*, 31(5), 637–651.

Hamari J., Koivisto J. (2015), Why do people use gamification services?, *International Journal of Information Management*, 35(4), 419–431.

Hautala J. (2011), Cognitive proximity in international research groups, *Journal of Knowledge Management*, 15(4), 601–624.

Helson H. (1947), Adaptation-level as frame of reference for prediction of psychophysical data, *The American Journal of Psychology*, 60(1), 1–29.

Hering J.G., Hoffmann S., Meierhofer R., Schmid M., Peter A.J. (2012), Assessing the societal benefits of applied research and expert consulting in water science and technology, *Gaia-Ecological Perspectives for Science and Society*, 21(2), 95–101.

Hernandez-de-Menendez M., Escobar Díaz C.A., Morales-Menendez R. (2020), Educational experiences with Generation Z, *International Journal on Interactive Design and Manufacturing*, 14(3), 847–859.

Hettiachchi D., van Berkel N., Hosio S., Kostakos V., Goncalves J. (2019), *Effect of cognitive abilities on crowdsourcing task performance*, Proceedings International Conference, Paphos, Cyprus, https://doi.org/10.1007/978-3-030-29381-9_28.

Hjørland B. (2013), Facet analysis: The logical approach to knowledge organization, *Information Processing & Management*, 49(2), 545–557.

Hung N.Q.V., Tam N.T., Tran L.T., Aberer K. (2013), An evaluation of aggregation techniques in crowdsourcing, In: Lin X., Manolopoulos Y., Srivastava D., Huang G. (eds.), *Web information systems engineering*, Lecture Notes in Computer Science, vol 8181. Springer, Berlin, Heidelberg, https://doi.org/10.1007/978-3-642-41154-0_1.

Jarrahi M.H. (2018), Artificial intelligence and the future of work: Human-AI symbiosis in organizational decision making, *Business Horizons*, 61(4), 577–586.

Joubert M., Davi L., Metcalfe J. (2019), Storytelling: The soul of science communication, *Journal of Science Communication*, 18(5), 1–5.

Kadadha M., Singh S., Mizouni R., Otrok H. (2022), A context-aware blockchain-based crowdsourcing framework: Open challenges and opportunities, *IEEE Access*, 10, 93659–93673, https://doi.org/10.1109/ACCESS.2022.3203850.

Kandappu T., Friedman A., Sivaraman V., Boreli R. (2015), Privacy in crowdsourced platforms, In: Zeadally S., Badra M. (eds.), *Privacy in a digital, networked world, Computer Communications and Networks*, Springer, Cham, https://doi.org/10.1007/978-3-319-08470-1_4.

Kaufmann N., Schulze T., Veit D. (2011), *More than fun and money. Worker motivation in crowdsourcing. A Study on Mechanical Turk,* AMCIS 2011 Proceedings, https://aisel.aisnet.org/amcis2011_submissions/340.

Keding C. (2021), Understanding the interplay of artificial intelligence and strategic management: Four decades of research in review, *Management Review Quarterly*, 71(1), 91–134.

Keith M.G., Tay L., Harms P.D. (2017), Systems perspective of Amazon Mechanical Turk for organizational research: Review and recommendations, *Frontiers in Psychology*, 8, 1359.

Kennedy R., Clifford S., Burleigh T., Waggoner P.D., Jewell R., Winter N.J. (2020), The shape of and solutions to the MTurk quality crisis, *Political Science Research and Methods*, 8(4), 614–629.

Kim J. (2021), Advertising in the Metaverse: Research agenda, *Journal of Interactive Advertising*, 21(3), 141–144.

Kim M.J., Hall C.M. (2020), What drives visitor economy crowdfunding? The effect of digital storytelling on unified theory of acceptance and use of technology, *Tourism Management Perspectives*, 34, 100638.

Kuek S.C., Paradi-Guilford C., Fayomi T., Imaizumi S., Ipeirotis P., Pina P. Singh M. (2015), *The global opportunity in online outsourcing*, World Bank, Washington, https://openknowledge.worldbank.org/handle/10986/22284.

Kwon H.R., Silva E.A. (2020), Mapping the landscape of behavioral theories: Systematic literature review, *Journal of Planning Literature*, 35(2), 161–179.

Lambert J., Hessler B. (2018), *Digital storytelling: Capturing lives, creating community*, Routledge, New York.

Lasecki W.S., Gordon M., Leung W., Lim E., Bigha J.P., Dow S.P. (2015), *Exploring privacy and accuracy trade-offs in crowdsourced behavioral video coding*, Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems, 1945–1954, https://dl.acm.org/doi/10.1145/2702123.2702605.

Lawrence R. (2004), Housing and health: From interdisciplinary principles to transdisciplinary research and practice, *Futures*, 36(4), 487–502.

Lenart-Gansiniec R. (2017), Zaufanie a crowdsourcing w organizacjach publicznych, *Organizacja i Kierowanie*, 176(2), 229–240.

Lenart-Gansiniec R. (2018), Selected crowdsourcing paradoxes: A literature review, *Przedsiębiorczość i Zarządzanie*, 19(9.3), 407–421.

Lenart-Gansiniec R. (2019), *Organizacyjne uczenie się w organizacjach publicznych. Perspektywa crowdsourcingu*, Wydawnictwo Naukowe PWN, Warszawa.

Lenart-Gansiniec R. (2021), The effect of crowdsourcing on organizational learning: Evidence from local governments, *Government Information Quarterly*, 38(3), 101593.

Lenart-Gansiniec R. (2022), Toward a typology development of crowdsourcing in science, *Journal of Information Science*, 1–23. https://doi.org/10.1177/01655515221118

Liu J., Peng S., Long C., Wei L., Liu Y., Tian Z. (2020), *Blockchain for data science*, Proceedings of the 2020 The 2nd International Conference on Blockchain Technology, 24–28, https://doi.org/10.1145/3390566.3391681.

Loureiro S.M.C., Guerreiro J., Ali F. (2020), 20 years of research on virtual reality and augmented reality in tourism context: A text-mining approach, *Tourism Management*, 77, 104028.

Lu H., Li Y., Chen M., Kim H., Serikawa S. (2018), Brain intelligence: Go beyond artificial intelligence, *Mobile Networks and Applications*, 23(2), 368–375.

Lubchenco J. (1998), Entering the century of the environment: A new social contract for science, *Science*, 279(5350), 491–497.

Marczewski A. (2017), The ethics of gamification, *XRDS: Crossroads, The ACM Magazine for Students*, 24(1), 56–59.

Martin S.L., McLean J., Brooks C., Wood K. (2019), I've been silenced for so long": Relational engagement and empowerment in a digital storytelling project with young women exposed to dating violenc, *International Journal of Qualitative Methods*, 18, 1609406919825932.

Meißner M., Pfeiffer J., Pfeiffer T., Oppewal H. (2019), Combining virtual reality and mobile eye tracking to provide a naturalistic experimental environment for shopper research, *Journal of Business Research*, 100, 445–458.

Menard S. (2002), *Longitudinal research*, Sage Publications, Thousand Oaks, California.

Mennis E.A. (2006), The wisdom of crowds: Why the many are smarter than the few and how collective wisdom shapes business, economies, societies, and nations, *Business Economics*, 41(4), 63–65.

Mesgari M., Okoli C., Mehdi M., Nielsen F.Å., Lanamäki A. (2015), The sum of all human knowledge": A systematic review of scholarly research on the content of Wikipedia, *Journal of the Association for Information Science and Technology*, 66(2), 219–245.

Mishra A.N., Pani A.K. (2020), Business value appropriation roadmap for artificial intelligence, *VINE Journal of Information and Knowledge Management Systems*, 51(3), 353–368.

Mitręga M. (ed.) (2016), *Networking akademicki jako czynnik produktywności pracowników naukowych*, Uniwersytet Ekonomiczny w Katowicach, Katowice.

Morschheuser B., Hamari J., Koivisto J., Maedch A. (2017), Gamified crowdsourcing: Conceptualization, literature review, and future agenda, *International Journal of Human-Computer Studies*, 106, 26–43.

Mortensen K., Hughes T.L. (2018), Comparing Amazon's Mechanical Turk platform to conventional data collection methods in the health and medical research literature, *Journal of General Internal Medicine*, 33(4), 533–538.

Moss A.J., Rosenzweig C., Robinson J., Jaffe S.N., Litman L. (2020), *Is it ethical to use Mechanical Turk for behavioral research? Relevant data from a representative survey of mturk participants and wages*, https://doi.org/10.31234/osf.io/jbc9d.

Nguyen-Anh T., Nguyen A.T., Tran-Phuong C., Nguyen-Thi-Phuong A. (2022), Digital transformation in higher education from online learning perspective: A comparative study of Singapore and Vietnam, *Policy Futures in Education*, https://doi.org/10.1177/14782103221124181.

Noel-Storr A., Gartlehner G., Dooley G. Persad E., Nussbaumer-Streit B. (2022), Crowdsourcing the identification of studies for COVID-19-related Cochrane Rapid Reviews, *Research Synthesis Methods*, 13(5), 585–594.

Novikov S.P., Kazakov O.D., Kulagina N.A., Azarenko N.Y. (2018), *Blockchain and smart contracts in a decentralized health infrastructure*, IEEE International Conference Quality Management, Transport and Information Security, Information Technologies, St. Petersburg.

Oberfield Z.W. (2014), Public management in time: A longitudinal examination of the full range of leadership theory, *Journal of Public Administration Research and Theory*, 24(2), 407–429.

OECD *Science, Technology and Innovation Outlook 2018*, OECD Publishing, Paris, https://www.oecd-ilibrary.org/science-and-technology/oecd-science-technology-and-innovation-outlook-2018_sti_in_outlook-2018-en.

Omeragic E. (2016), *The effect of storytelling on willingness to invest in crowdfunding projects*, Erasmus Universiteit Rotterdam, Netherlands, https://thesis.eur.nl/pub/36127/Omeragic-E.-425285eo-.pdf.

Opazo-Basáez M., Vendrell-Herrero F., Bustinza O.F. (2022), Digital service innovation: A paradigm shift in technological innovation, *Journal of Service Management*, 33(1), 97–120.

Ouellette J.A., Wood W. (1998), Habit and intention in everyday life: The multiple processes by which past behavior predicts future behawior, *Psychological Bulletin*, 124(1), 54.

Paolacci G., Chandler J. (2014), Inside the Turk: Understanding Mechanical Turk as a participant pool, *Current Directions in Psychological Science*, 23(3), 184–188.

Păunescu C., Nikina-Ruohonen A., Stukalina Y. (2022), Fostering research with societal impact in higher education institutions: A review and conceptualization, In: Păunescu C., Lepik K.L., Spencer N. (eds.), *Social innovation in higher education. Innovation, technology, and knowledge management*, Springer, Cham, https://doi.org/10.1007/978-3-030-84044-0_8.

Peer E., Brandimarte L., Samat S., Acquisti A. (2017), Beyond the Turk: Alternative platforms for crowdsourcing behavioral research, *Journal of Experimental Social Psychology*, 70, 153–163.

Pera R., Viglia G. (2016), Exploring how video digital storytelling builds relationship experiences, *Psychology & Marketing*, 33(12), 1142–1150.

Pereira V., Hadjielias E., Christofi M., Vrontis D. (2021), A systematic literature review on the impact of artificial intelligence on workplace outcomes: A multi-process perspective, *Human Resource Management Review*, 100857, https://www.sciencedirect.com/science/article/abs/pii/S105348222100036X/.

Pittman M., Sheehan K. (2016), Amazon's Mechanical Turk a digital sweatshop? Transparency and accountability in crowdsourced online research, *Journal of Media Ethics,* 31(4), 260–262.

Ployhart R.E., Vandenberg R.J. (2010), Longitudinal research: The theory, design, and analysis of change, *Journal of Management*, 36(1), 94–120.

Poliakoff E., Webb T.L. (2007), What factors predict scientists' intentions to participate in public engagement of science activities?, *Science Communication*, 29(2), 242–263.

Prestopnik N.R., Tang J. (2015), Points, stories, worlds, and diegesis: Comparing player experiences in two citizen science games, *Computers in Human Behavior*, 52, 492–506.

Raasch C., Lee V., Spaeth S., Herstatt C. (2013), The rise and fall of interdisciplinary research: The case of open source innovation, *Research Policy*, 42(5), 1138–1151.

Rea S.C., Kleeman H., Zhu Q., Gilbert B., Yue C. (2020), Crowdsourcing as a tool for research: Methodological, fair, and political considerations, *Bulletin of Science, Technology & Society*, 40(3–4), 40–53.

Report Research Futures 2.0, https://www.elsevier.com/__data/assets/pdf_file/0017/1250423/Research-Futures-2_0-Full-Report.pdf.

Riesch H., Potter C. (2014), Citizen science as seen by scientists: Methodological, epistemological and ethical dimensions, *Public Understanding of Science*, 23(1), 107–120.

Robin B.R. (2008), Digital storytelling: A powerful technology tool for the 21st century classroom, *Theory into Practice*, 47(3), 220–228.

Ruspini E. (1999), Longitudinal research and the analysis of social change, *Quality and Quantity*, 33, 219–227.

Schlagwein D., Bjorn-Andersen N. (2014), Organizational learning with crowdsourcing: The revelatory case of LEGO, *Journal of the Association for Information Systems*, 15(11), 3.

Schleider J.L., Weisz J.R. (2015), Using mechanical Turk to study family processes and youth mental health: A test of feasibility, *Journal of Child and Family Studies*, 24(11), 3235–3246.

Shapiro D.N., Chandler J., Mueller P.A. (2013), Using mechanical Turk to study clinical populations, *Clinical Psychological Science*, 1(2), 213–220.

Sheldon M.D. (2018), Using blockchain to aggregate and share misconduct issues across the accounting profession, *Current Issues in Auditing*, 12(2), 27–35.

Siedlok F., Hibbert P. (2014), Organization of interdisciplinary research, *International Journal of Management Reviews*, 16(2), 194–210.

Sonderegger A., Zbinden G., Uebelbacher A., Sauer J. (2012), The influence of product aesthetics and usability over the course of time: A longitudinal field experiment, *Ergonomics*, 55(7), 713–730.

Stritch J.M. (2017), Minding the time: A critical look at longitudinal design and data analysis in quantitative public management research, *Review of Public Personnel Administration*, 37(2), 219–244.

Surowiecki J. (2010), *Mądrość tłumu: większość ma rację w ekonomii, biznesie i polityce*, Wydawnictwo Helion, Gliwice.

Tenorio-Fornés Á., Tirador E.P., Sanchez-Ruiz A.A., Hassan S. (2021), Decentralizing science: Towards an interoperable open peer review ecosystem using blockchain, *Information Processing & Management*, 58(6), 102724.

Teodoridis F. (2018), Understanding team knowledge production: The interrelated roles of technology and expertise, *Management Science*, 64(8), 3625–3648.

Thiebes S., Lins S. Sunyaev A. (2021), Trustworthy artificial intelligence, *Electronic Markets*, 31(2), 447–464.

Tobi H., Kampen J.K. (2018), Research design: The methodology for interdisciplinary research framework, *Quality & Quantity*, 52(3), 1209–1225.

Toniolo K., Masiero E., Massaro M., Bagnoli C. (2020), Sustainable business models and artificial intelligence: Opportunities and challenges, Knowledge, People, and Digital Transformation, 103–117.

Tran-Gia P., Hoßfeld T., Hartmann M., Hirth M. (2013), Crowdsourcing and its impact on future Internet usage, *Information Technology*, 55(4), 139–145.

Tress B., Tres G., Fry G. (2005), Integrative studies on rural landscapes: Policy expectations and research practice, *Landscape and Urban Planning*, 70(1/2), 177–191.

UKRI (2021), *Transforming our world with AI*, https://www.ukri.org/wp-content/uploads/2021/02/UKRI-120221-TransformingOurWorldWithAI.pdf.

Van Rossum J. (2017), *Blockchain for research*. *Perspectives on a new paradigm for scholarly communication*, https://pstorage-digitalscience-874864551.s3.amazonaws.com/9803344/Digital_Science_Blockchaini.pdf.

Venkatesh V., Davis F.D. (2000), A theoretical extension of the technology acceptance model: Four longitudinal field studies, *Management Science*, 46(2), 186–204.

Von Krogh G. (2018), Artificial intelligence in organizations: New opportunities for phenomenon-based theorizing, *Academy of Management Discoveries*, 4(4), 404–409.

Wagner G., Lukyanenko R., Paré G. (2022), Artificial intelligence and the conduct of literature reviews, *Journal of Information Technology*, 37(2), 209–226.

Wamba-Taguimdje S.L., Wamba S.F., Kamdjoug J.R.K., Wanko C.E.T. (2020), Influence of artificial intelligence (AI) on firm performance: The business value of AI-based transformation projects, *Business Process Management Journal*, 26(7), 1893–1924.

Wazny K. (2017), Crowdsourcing ten years, A review, *Journal of Global Health*, 7(2), 020602.

Wechsler D. (2014), Crowdsourcing as a method of transdisciplinary research. Tapping the full potential of participants, *Futures*, 60, 14–22.

Wexler M. (2011), Reconfiguring the sociology of the crowd: Exploring crowdsourcing, *International Journal of Sociology and Social Policy*, 31(1/2), 6–20.

White G.F., Haas J.E. (1975), *Assessment of research on natural hazards*, MIT Press, Cambridge.

Wieczorek A.L., Mitręga M., Spáčil V. (2021), Dynamic academic networking concept and its links with English language skills and research productivity–non-Anglophone context, *PLoS One*, 16(2), e0245980, https://doi.org/10.1371/journal.pone.0245980.

Wierzchosławski S. (2016), Wielodyscyplinarność i interdyscyplinarność statystycznych badań zjawisk społecznych, *Ruch Prawniczy, Ekonomiczny i Socjologiczny*, (1), 85–101.

Wiggins A. (2010), *Crowdsourcing science: Organizing virtual participation in knowledge production*, Proceedings of the International ACM SIGGROUP Conference on

Supporting Group Work, https://experts.nebraska.edu/en/publications/crowdsourcing-science-organizing-virtual-participation-in-knowled.

Wittmayer J.M., Schäpke N. (2014), *Action, research and participation: Roles of researchers in sustainability transitions*, *Sustainability Science*, 9(4), 483–496.

Xia H., McKernan B. (2020), Privacy in crowdsourcing: A review of the threats and challenges, *Computer Supported Cooperative Work*, 29(3), 263–301.

Xia H., Wang Y., Huang Y., Shah A. (2017), *Our privacy needs to be protected at all costs crowd workers' privacy experiences on Amazon Mechanical Turk*, Proceedings of the ACM on Human-Computer Interaction, 1–22, https://dl.acm.org/doi/10.1145/3134748.

Xu Y., Liu X., Cao X., Huang C., Li E., Qian S., Liu X., Wu Y., Dong F., Qiu C.W., Qiu J., Hua K., Su W., Jian Wu J., Xu H., Han Y., Fu C., Yin Z., Liu M., Roepman R., Dietmann S., Virta M., Kengara F., Zhang Z., Zhang L., Zhao T., Dai J., Yang J., Lan L., Luo M., Liu Z., An T., Zhang B., He X., Cong S., Liu X., Zhang W., Lewis J.P., James M., Tiedje J.M., Wang Q., An Z., Wang F., Zhang L., Huang T., Lu Ch., Cai Z., Wang F., Zhang J. (2021), Artificial intelligence: A powerful paradigm for scientific research, *The Innovation*, 2(4), 100179.

Yung R., Khoo-Lattimore C. (2019), New realities: A systematic literature review on virtual reality and augmented reality in tourism research, *Current Issues in Tourism*, 22(17), 2056–2081.

Zainuddin Z., Chu S.K.W., Shujahat M., Perera C.J. (2020), The impact of gamification on learning and instruction: A systematic review of empirical evidence, *Educational Research Review*, 30, 100326.

Zamir A., Khan H.U., Iqbal T., Yousaf N., Aslam F., Anjum A., Hamdani M. (2020), Phishing web site detection using diverse machine learning algorithms, *The Electronic Library*, 38(1), 65–80.

Zuercher P.-D., Bohné T.M., Eger V., Mueller F. (2022), *Optimising virtual reality training in industry using crowdsourcing*, Proceedings of the 12th Conference on Learning Factories, https://ssrn.com/abstract=4075130.

Index

Note: **Bold** page numbers refer to tables and *italic* page numbers refer to figures.