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Original Research

Investigation of Digital Citizen Science and its Challenges in Iran

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Abstract

Purpose: This study aims to investigate digital citizen science projects in Iran and the challenges in this field from the perspective of experts.

Method: The present study is exploratory with a content analysis approach. First, scientometric research was conducted in Scopus to

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assess the status of digital citizen science. Second, to identify the challenges of digital citizen science in Iran, experts were interviewed
Findings: Though the number of scientific publications in this field has been growing recently, Iran's share of the scientific output is quite small. A Review of qualitative data obtained from interviews showed that the main challenges in this field in Iran are: Funding, Government policy, Engagement, Time, Recognition, Data quality for citizen science, Volunteers for citizen science, Capacity and skills, and Communication.
Conclusion: This research can be a guideline for experts in the field of digital citizen science. These technologies can also facilitate interactions and communication between professionals and non-professionals. Despite the spread of digital citizen science projects in European and American countries, the term is unfamiliar in Iran.
Keywords: Digital Citizen Science, Scientometric, online citizen science, Iran

Introduction

Citizen science is an essential tool for democratizing science and advancing the goal of universal and equitable access to scientific data and information. Citizen science theorists believe that "the practice of collaboration between independent researchers and the general public became known as" citizen science "in the 20th century." (Bonney et al., 2009; Dickinson, et al., 2012; Hand, 2010; Irwin, 2002). Also, Raddick, et al. believe Citizen Science is a scientific practice performed, in whole or part, by volunteers from the general public (Raddick, et al., 2013). This will allow the general public to contribute directly to scientific research (Yang, et al., 2019). With public participation in scientific research, scientists can often use the power of volunteers to perform otherwise exorbitantly costly and time-consuming tasks (Braschler, 2009).

Citizen science has potential benefits for professionals and citizens. These allow the incorporation of local, traditional, or indigenous knowledge of citizens in scientific research, providing learning opportunities for citizens, raising awareness in citizens, increasing advocacy among citizens, promoting behavior change among citizens, and enhancing citizens' physical and mental health, personal enjoyment, social interaction, and satisfaction through contributing to scientific evidence (Walker, Smigaj and Tani, 2021).

Over the last two decades, the emergence of information and communication technology (ICT) and the growth of web 2.0(Thackeray, 2008) have created many citizen science opportunities. Online digital technologies make it easier for professionals to set up and manage citizen science projects and process, distribute, and present content created in them (Haklay, Mazumdar, and Wardlaw, 2018).

Digital citizen science has grown in popularity worldwide over the last decade (Ruge, 2015), with millions observing environmental and social phenomena on platforms such as Safecast and eBird. The Digital Citizen Science Platform aims to support the collection of personal data via mobile devices (Burke, et al., 2006; Goldman et al., 2009)

These technologies facilitate interaction and communication between professionals and people, enable geographically dispersed people to participate in citizen science projects, facilitate citizen data collection and content creation, and contribute by volunteers. (Aristoidou and Herodotou, 2020).The data generated by the Citizen Science Group is becoming an increasingly important resource for scientists, practitioners, and those pursuing the 2030 Agenda for Sustainable Development.

In studies of biodiversity and pollution, citizen science data are extensively used; U.N. operational agencies are using crowdsourced data for humanitarian activities; and citizen scientists are providing data relevant to monitoring the sustainable development goals (SDGs) (sherbinin et al., 2021).

In general, citizen science engages citizens to address and respond to complex environmental and social issues and can generate large amounts of data (Asingizwe et al., 2020; Van Brussel and Huyse, 2019). Participating in citizen science projects can enhance participants' scientific literacy and enable researchers to collect data on a larger scale and at a lower cost than previously possible (Shirk et al., 2012). Citizen science is under General Participation in Scientific Research (PPSR), which includes all collaboration between scientific researchers and general participants (Shirk et al., 2012). Citizen Science was first coined in the late 1980s (Gharesifard et al., 2017). The various definitions of citizen science include three components: Collaboration between scientists and non-scientists. Cooperation between stakeholders of multiple institutions (universities, research institutes, governmental and non-governmental organizations, etc.). Participant activity is part of the scientific process (Haklay, 2015). Other definitions of citizen science emphasize active participation rather than active participation of non-scientists in scientific research projects and increased public understanding of science (Wiggins and Crowston, 2011).

The origin of civic science research lies in the biological study of climate change (Dickinson et al., 2012). Citizens' involvement in scientific research is called "citizen science" by natural scientists. Geographers refer to citizens' participation in scientific research as "voluntary geographic information" and "cloud sourcing of geospatial data," while computer scientists refer to "human-centered sensing" and "participatory sensing." I am using it (Wehn and Evers, 2014). Another related participatory approach is the public participation geographic information system (PPGIS). Community Science; Crowdsourcing (Grainger, 2017); Public Participation in Scientific Research (Bonney et al., 2009). This study aims to investigate digital citizen science scientific documents in Scopus and the challenges in this field from the perspective of experts. The main goals of this research are:

1) Investigating the status of digital citizen science in the world and Iran. A scientometric analysis provides the first insight into the spread

of the concept of citizen science and charts the status of digital citizens' science articles over time.
(2)To highlight some of Iran's challenges in citizen science. Answers to these questions are precious to fill the current research gap between theory and practice in digital citizen science in Iran.

Digital citizen science

Digital citizen science projects that combine surveillance and participatory intervention are popular in many scientific disciplines (Rotman et al., 2014). In large part, this is due to the widespread adoption of mobile technology, which allows us to collect, classify, and send information such as locations, images, and audio clips (Estrin, Chandy, Young, Smarr, Odlyzko, Clark, Reding, Ishida, Sharma, Cerf, et al., 2010; Goldman, Shilton, Burke, Estrin, Hansen, Ramanathan, Reddy, Samanta, Srivastava, West, 2009).

Digital Citizen Science uses technology to support activities such as collecting, classifying, transcribing, and analyzing scientific data about phenomena of interest (Bonney, Shirk, Phillips, Wiggins, Ballard, MillerRushing, Parrish, 2014; Burke, Estrin, Hansen, Parker, Ramanathan, Reddy, Srivastava, 2006; Heggen, 2013). Today's people regularly use technology for civic purposes, from open governance to community behavior and participatory science. A huge digital citizen science platform was born, with millions of people observing natural and social phenomena. Some have already achieved excellent results, including Safecast's most significant radiation record in history (Safecast, 2019) and large-scale bird records. Population from the bird, Identification of new galaxy elements from Zooniverse Discovery of various protein types from the fold.

Public participation in digital citizen science involves a variety of roles (Bonney, Cooper, Dickinson, Kelling, Phillips, Rosenberg, Shirk, 2009; Palacin, Ginnane, Ferrario, Happonen, Wolff, Piutunen, Kupiainen, 2019). Collecting data on predefined topics (data providers), working with authorities to monitor predefined cases by authorities (employees), and co-creating solutions to address issues of common interest. Passive non-participation or negative participation

(confusion) that considers citizens' actions (co-creators) confuses established processes.

Motivations to participate in digital citizen science

The Digital Citizen Science initiative faces many challenges in maintaining volunteer participation (Foody, Fritz, Fonte, Bastin, OlteanuRaimond, Mooney, See, Antoniou, Liu, Minghini, et al., 2017; Jennett, Cox, 2018; Orchard, 2018). This motivated research to identify and report participant motivations from interviews and surveys (Curtis, 2015; Iacovides, Jennett, CornishTrestrail, Cox, 2013; Jennett, Cox, 2018; Orchard, 2018; Reed, Radidick, Lardner, Carney, 2013; Rotman, Preece, Hammock, Procita, Hansen, Parr, Lewis, Jacobs, 2012) and creating reward-centric incentive mechanisms to increase volunteer involvement (Jaimes, VergaraLaurens, Raij, 2015; Restuccia, Das, Payton, 2016). However, the link between self-reported motives and specific actions is lost because the former relies on self-reported data (such as surveys). On the other hand, the latter assumes that reward-based mechanisms (such as financial incentives) can facilitate participation, but the effectiveness of such mechanisms has been shown to undermine continued involvement in volunteer initiatives (Knowles, 2013).

Citizen science challenges

Citizen science, like any other scientific approach, has strengths and weaknesses. Citizen science is very cost-effective in effectively collecting big data collected over a wide range of places and over a long period. In these projects, due to the impact of data on the research results, the data's quality and reliability are very important. The data obtained in these projects are qualitatively very diverse; hence the validity of these data is debatable. Considering the huge amount of collected data, it is very important to check their validity and quality because these are used in policy-making, management, and forecasting. The important point is the accuracy of the collected

data. Because with accurate, correct, and valid data, more correct decisions can be made. According to the topics raised and considering the importance of citizen science in predicting the issues of ecology, climate, land, and even the growth rate of plant and animal species, it is essential to address the main challenge of this field, i.e., the reliability of its data. One of the challenges related to the reliability of the data is related to the validity of the data, its accuracy, and quality. Most of the data collected in citizen science projects are based on human observations and may contain a human error because most contributors don't necessarily have formal experience.

The form of data collection (manual or automatic), lack of awareness and negative attitude of citizens towards citizen science projects, work pressures, and economic status, lack of social support and financial resources, individual and personal behavioral factors (age, mistrust, lack of knowledge) are other challenges of citizen science. Vahidi, et al. (2021), in a study entitled Digital citizen science for responding to a covid-19 crisis, have stated about the experiences of Iran and explored the tools, challenges, and potentials of these projects. This research has revealed the most important scientific projects of online citizen science to respond to the COVID-19 crisis in Iran. In addition, it highlights some of the opportunities and challenges associated with the strengths and weaknesses of these projects. In addition, an overview of and discussion of some of the lessons learned from the failures and successes of these projects is provided in this study, as well as solutions to overcome some of the well-known challenges and weaknesses of these projects are explored. This article is the most relevant background in connection with the present study. Which compared to the top countries in this field has a small share of scientific documents in this field. It is dedicated to itself and needs serious attention to the relevant discussion.

Data quality as a challenge

Data quality is a common concern in citizen science, while it strongly depends on the training, expertise, and level of volunteer participation (Dickinson et al., 2010).

Data challenges may be related to Observer behavior (b) Data structures. C) Statistical models. And (d) communication. Potential solutions to these challenges are a combination of the following:

(a) Collecting additional data or metadata. (B) The analytical composition of the various datasets and (c) developing or modifying statistical models (Johnston, Matechou, & Dennis, 2022). There are also several issues related to data ownership, usage, privacy, and access.

Many citizen science projects have little flexibility in scheduling and resource allocation, and examining these issues will always be challenging for many citizen science coordinators and program managers. Informal environments where citizen science projects are taught are also challenging. Each environment creates unique challenges for volunteers. Challenges may also arise due to the different needs of scientists, students, teachers, educators, researchers, and other actors involved. The main challenge is communicating and sharing information in informal settings (Roche et al., 2020). Finally, the financial sustainability of these projects is often challenging, especially for community-based projects (US-EPA, 2018).

However, concerns about data quality remain an obstacle to the usefulness of citizen science. There are also other challenges to implementing citizens' science that this article addresses.

The citizen science field has made significant advances over the past two decades. Previous literature review efforts have aimed to conceptualize, discuss and generate new insights about citizen science. Due to the lack of comprehensive research with a scientometric approach and content analysis of the challenges in this field,

considering the importance of digital citizen science as a new tool for participatory research and community management, this article can provide new insights into the field of digital citizen science. New insights help start further research. In addition, examining the challenges in this area is considered by experts as a document in the hands of policymakers of Iran regarding evidence-based decision-making.

2- Methodology

The present study is an exploratory study with a content analysis approach. First, scientometric research was conducted at Scopus to assess the status of digital citizen science. To examine the quality of scientific documents in this field following advanced search command was used to search:

2.1 Search strategy

ALL("Citizen science") OR ALL("community science") OR ALL("crowd science") OR ALL("crowd-sourced science") OR ALL("civic science") OR ALL("volunteer monitoring") OR ALL("Digital citizen science") OR ALL("Online citizen science")

Second, interviews were conducted with experts in this field to identify the challenges of digital citizen science in Iran. For this purpose, during the six months from October to February 2021, 30 experts in the field of citizen science were interviewed throughout Iran. In some cases, group interviews and, in some cases, individual interviews were conducted. The interviewees were selected based on the availability of the participants and continued until the content was saturated. Interviews were often conducted via Skype and Google Meet. All group interviews were also online. The study was conducted voluntarily, and all participants agreed to participate in the interviews. Interviews were recorded in a semi-structured manner. This study

used two types of coding: initial coding to create categories and more focused coding for in-depth analysis.

3. Data Analysis and Findings

3.1. The state of scientific documents in the field of digital citizen science

According to the research findings, 29,497 scientific documents in this field have been published in the Scopus citation database. As shown in Figure 1, most of these documents are dedicated to scientific research articles with about 71%, followed by conference papers (9.9%), reviews (8.9%), chapters of the book (5.2%), books (1.2%), notes (1.3%), editorial (1.1%), letter (0.5%), short survey (0.2%), conference review (0.2%) and documents of unspecified type (0.3%).

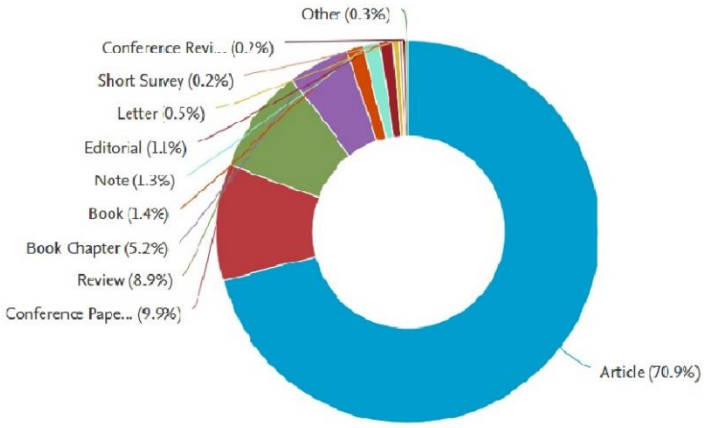


Figure 1. Descriptive statistics of scientific documents in digital citizen science

Based on Figure 2. the number of scientific documents in the mentioned field is shown every year (from the beginning to 2021). As can be seen, the trend of these productions has an upward trend from the beginning to 2021 and has reached its maximum in 2021. In the years before 1990, the number of these productions is small and under 5 degrees.

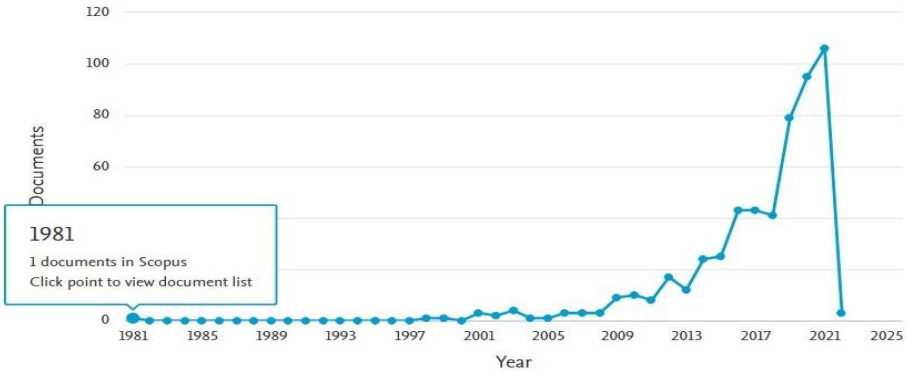


Figure 2. documents by year in digital citizen science in Scopus database (retrieved from Scopus on 2021.16.1)

3.2. Subject area

According to Figure 3. the subject areas to which digital citizen science is related are social science, computer science, environmental science, etc. This evidence suggests that the field of digital citizen science is an interdisciplinary subject and does not belong to a particular discipline or field.

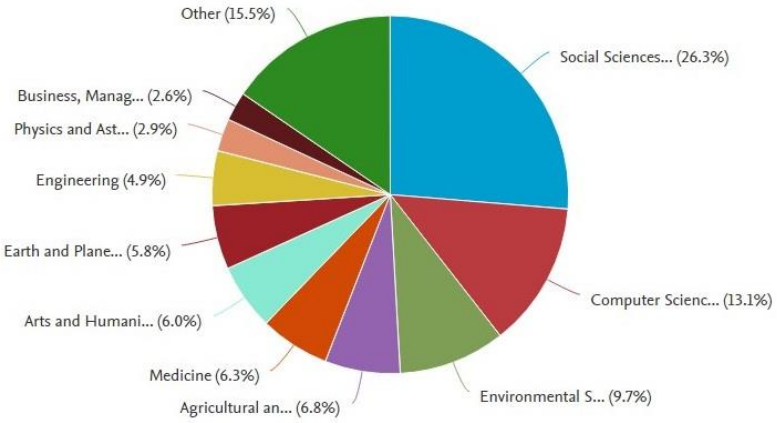
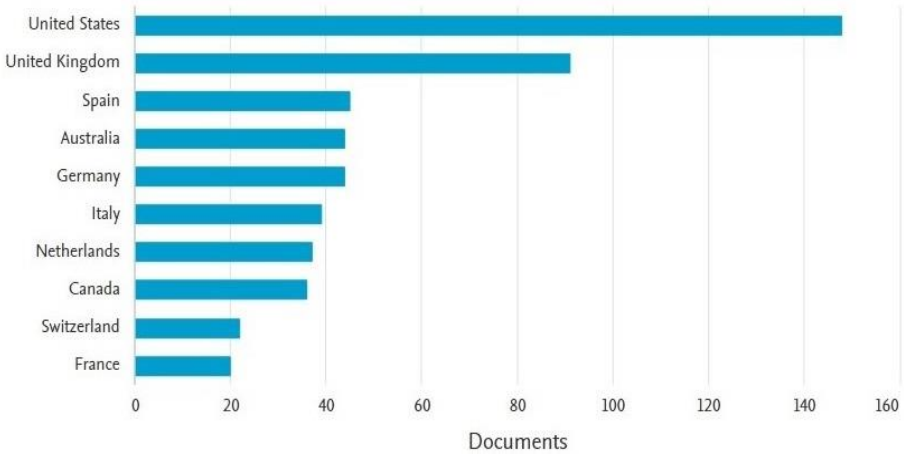


Figure 3. The subject area of digital citizen science (retrieved from Scopus on 2021.16.1)

3.3. Top countries in digital citizen science

The Scopus database data shows that the United States, England, Spain, Australia, and Germany are the leading countries in digital citizen science, as shown in Figure 4.**Figure 4. Top countries in digital**



citizen science (retrieved from Scopus, on 2021.16.1)

Based on Table 1. Iran is in line with Egypt, Ecuador, Malaysia, Nigeria, Pakistan, and some other countries and has only two articles

(Vahidi, et al., 2021; Jamali, et al., 2016) indexed in the Scopus database in this field.

Table 1. Status of scientific documents of countries in the field of digital citizen science (retrieved from Scopus, 2021.16.1) Country/Territory	Documents	Country/Territory	Documents	Country/Territory	Documents
United States	148	Belgium	11	Hungary	4
United Kingdom	91	India	11	Poland	4
Spain	4	Greece	10	Romania	4
Australia	44	Ireland	9	Singapore	4
Germany	44	Austria	7	Chile	3
Italy	39	Indonesia	7	Cyprus	3
Netherland	37	Japan	7	Czech Republic	3
Canada	36	Colombia	6	Ethiopia	3
Switzerland	22	New Zealand	6	Kenya	3
France	20	Norway	6	Malta	3
Sweden	19	South Africa	6	Saudi Arabia	3
Brazil	16	Turkey	6	South Korea	3
Portugal	16	Lithuania	5	Argentina	2
China	14	Mexico	5	Costa Rica	2
Denmark	13	Bangladesh	4	Ecuador	2
Finland	12	Croatia	4	Egypt	2
Russian Federation	12	Hong Kong	4	Iran	2

3.4. Top foundations supporting citizen science research

The top 10 foundations that support research in this area have been identified. As it is known, the National Science Foundation is in the first place with the support of 1907 degrees, followed by the European Union with 679 degrees and the framework of the Horizon 2020 program, respectively, in the second and third places.

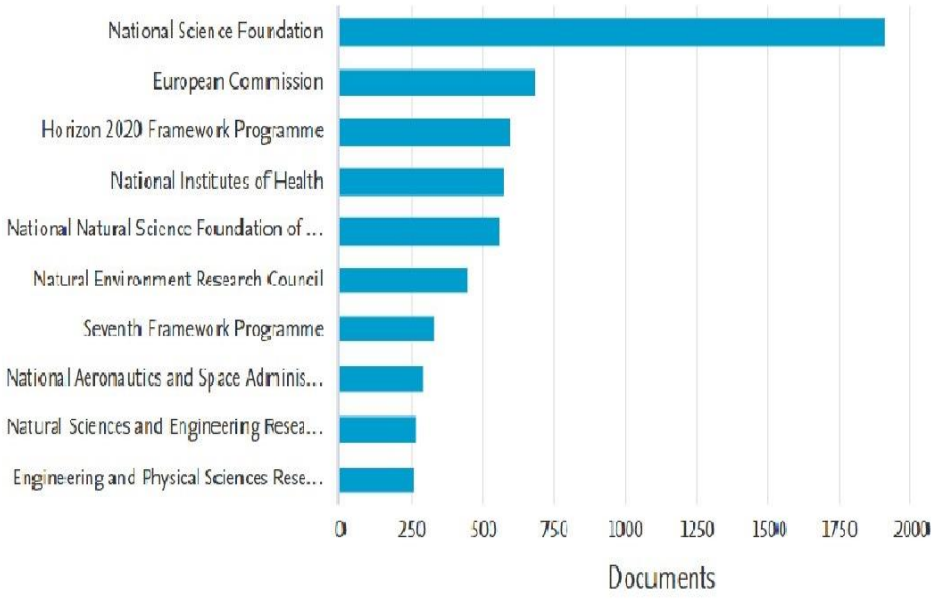


Figure5. Top foundations supporting citizen science research

2. What are the challenges of citizen science projects from the perspective of experts in this field?

To examine the challenges of citizen science projects in Iran, interviews were conducted with 30 experts in this field.

An interview form was used to record the data from the interview. Then, in order to record the opinions and views of each participants,

the summary of the interview was taken in the interview form and audio recordings of the conversations were taken. After conducting each interview and collecting the resulting data, the process of qualitative data analysis began. To analyze the qualitative data, open and axial coding was used in a systematic way. As a result of coding, removing duplicate data and final summarization of data, subcategories were identified and extracted.

The results of the interviews can be divided into 61 codes, 20 concepts, and nine categories (see Table 2). The results of these interviews were analyzed using the MAXQDA software. This qualitative research was undertaken to provide the study with evidence of the challenges of citizen science projects in Iran.

Table2: challenges of citizen science in Iran

Challenges	**Description**
Funding	continuity of funding
Government policy	Lack of policy documents in IRAN
Engagement	engagement is a crucial challenge when thinking about public engagement Academic Engagement Community Engagement
Time	time issues
Recognition	Management, the scientific community, community groups, and government
Data quality for citizen science	high-quality data
Volunteers for citizen science	finding people with the right skills
Capacity and skills	people that have experience and ability
Communication	communications between academic and non-academic stakeholders

Twenty-three participants believed that the most important challenge of citizen science is government policy and lack of interest in participating in science.

"I think it is obvious that in Iran, people do not have the opportunity to participate in science. And even if they have the opportunity, they don't have enough motivation and interest to participate because there is no government program in this regard in Iran"(male, age 56).

Participants also mentioned the quality of volunteer data, sufficient knowledge and expertise, interest, university-community connection, and supporting organizations.

"I mean, how can you trust the data collected by people? Are these data of sufficient quality? "(male, age 45).

"I don't think that the university and the research community are interested in communicating and defining joint research with citizens and volunteers "(female, age 42).

The participants listed the lack of sufficient skills to be involved in projects as one of the most important gaps in digital citizen science and emphasized the importance of acquiring enough knowledge and experience in data collection and interpretation.

"I think it is necessary to have enough skills in data collection, and I don't think the candidates have enough skills in the field of data. Unless training workshops are held for them".(female, age 45).

Having enough time to get involved in the projects was another challenge presented by the interviewees. According to them,

considering the conditions of the society and the greater importance of economic issues, people do not have enough time for voluntary work. *"We must give people the right. They don't have enough time for this kind of work because they are involved in economic issues".(male, age 52).*

The recognition of digital citizen science as a branch of science was another concern of the interviewers. Most of them believed that citizen science still has no independent identity in official Iranian societies and that government societies have no serious decisions.

"Well, let's look at what policy documents have been dealt with citizenship science, and is there a talk of citizenship in the Iranian parliament? Certainly not." (female, age 40).

Sixteen interviewees emphasized the lack of university and society links as the main challenge of citizen science. They believed that the formal existence of citizen science was doubted as long as science was behind the doors of the university and people had no role in it.

"Research decisions are now being made at universities and research institutes. Which university is aware of the role of citizens in research or believes as?" male, age 46).

4. Discussion

In this study, the authors tried to provide an overview of the state of digital citizen science worldwide. The results show that researchers worldwide have published articles in this field since 1980. Graph of the production growth trend in this field indicates the beginning of the growth of scientific documents after the 2000s. In other words, the scientific output of this field has increased from 1980 to 2021 and shows the attention of various researchers and organizations to the discussion of digital citizen science in the world. Findings show that

this area has grown by leaps and bounds since 2017. This finding is consistent with the results of Kullenberg and Kasperowski (2016) and Wiggins, & Wilbanks, J. (2019). A review of various databases shows current research articles with different and pristine methodologies in digital citizen science. This finding is in line with the study by Bonnie et al. (2009). They have surveyed the activities carried out in citizen science projects, mapped their scientific impact through a set of quantitative indicators, and found that the number of citizen science projects is increasing. C.S.[1]has gained significant momentum recently (Sauermann et al., 2020). This plays an essential role in implementing the broader idea of open science (Ayris & Ignat, 2018; League of European Research Universities, 2018).

Also, digital citizen science is an interdisciplinary field. It is not dedicated to a specific area. The diversity of scientific documents in this field includes social sciences to engineering, which shows the field's power in creating work nodes and defining various projects at the community level. Hajibayova, Coladangelo & Heather, and Soyka (2021) believe that the research questions addressed by Citizen Science Studies highlight seven broad areas of scientific interest: natural sciences, behavior, social justice, technology, education, research design, and health. This statement confirms the research and shows the variety of questions in the science of citizen science.

An examination of the situation of different countries in the field of digital citizen science shows United States, England, Spain, Australia, and Germany are the leading countries in this field. This research is in line with the findings of Feldman et al. (2021). According to this research, Western Europe and North America are the regions with the highest coverage (73%) of the scientific documents of citizen science.

Iran is aligned with Egypt, Ecuador, Malaysia, Nigeria, Pakistan, and other countries. This finding showed that Iran is in an unfavorable situation in the field of citizen science and does not have a good position compared to other leading countries. Investigating the reasons for this requires independent research.

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[1] Citizen science

The E.U. is increasingly emphasizing the potential of citizen science to help build the knowledge base needed to support policy decisions. Examine citizens in this policy (E.U. Citizen Science Survey, 2022).

In all areas of civil society, the progress of digital technology provides new opportunities. One example is the expansion of citizen science. By participating in scientific research, citizens gain a deeper understanding of science. In addition, civic engagement can support and advance scientific research.

- The principles on which citizen science 3.0 in the digital transformation age are based are:
- Free and open participation is open to everybody
- Removed barriers for participation, including to the extent possible relaxing the requirement to possess specialized knowledge
- Increased interactivity among projects, ensuring that projects actively share their data
- Extensive use of semantic and artificial intelligence tools for data integration and support of data entry by citizens

Single point of data capture - ensuring that observation of phenomena is only entered once on any platform of choice by citizens, which can then become available to all other interesting platforms (Lukyanenko, 2019).

Despite these benefits, the following ongoing issues and challenges were identified:

- The Lack of attention from universities and professors specializing in various scientific fields is one of the most critical challenges of citizen science in Iran.
- There is no reference to citizen science in any policy document or upstream documents, and organizations and companies are not familiar with the necessity of this branch of science. (Vahidi, et al., 2021).

- There is a substantial gap between the university and the public; generally, the public does not have the right to participate in science.

- Citizens often lack sufficient knowledge about participating in these projects and usually require an educator to oversee them, who has access to various resources.

- Citizens are generally unaware of the existence of these projects, and no news agency reports about these projects

Finally, these highlighted the need to think about the role of empowerment in public engagement work, how (marginalized) communities can be empowered through such projects, and how public engagement can be positioned to reach broad and varied audiences.

Given the existing challenges, the following solutions are proposed for a serious entry into the discussion of citizen science:

- Designing policy documents to implement citizen science
- Design standards for citizen scientists
- Design methods for citizen scientists based on the Status and facilities of Iran
    - Developing strategies to encourage citizens to participate by responsible organizations in Iran
- It is clear from the pandemic that we are all part of science as citizens, and we all benefit from its outputs. Additionally, this study demonstrated that science is not only about creating knowledge and addressing challenges but can also assist in solving real problems and is relevant to all walks of life. Scientists must reflect the diversity of the society they serve and ensure that science is accessible and understandable to everyone. As scientists in government, we have a responsibility to work across

boundaries, not simply to apply the scientific method sequentially but to frame problems in a way that enables us to develop solutions - solutions that can be understood and used by policymakers to improve citizen outcomes. Although there are systemic barriers to fully integrating citizen science into the scientific and policy processes over the next decade, there are indicators that the tide is turning in favor of increasingly participatory forms of governance, as suggested by a review of citizen science case studies in Iran shares insights on how citizen science can improve policymaking.

- The insights from this study can be used to overcome existing barriers to operationalizing citizen science projects that can be deployed to enhance the performance of these projects, particularly in developing countries.

5. Suggestions

According to the existing theoretical scope, the present findings and limitations, the following suggestions and research directions can be presented, which provide new research fields:

- ✓ It is suggested to examine the challenges of citizen science from the perspective of the participants in the projects.

- ✓ It is suggested that guidelines for implementing citizen science projects according to international standards be compiled and provided to local volunteers.

- ✓ It is also suggested to develop a framework for creating citizen science centers and clarify the detailed guidelines for participation in science to solve the challenges of citizen science.

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