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Impact of IOT Application and Smart Cities

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Abstract -Smart cities are made possible by the integration of IoT technology into existing urban infrastructure. As a result, living quality is enhanced by the efficient handling of data created by the real-time integration of electronic sensors. The study's primary goal is to summarise the findings of previous studies conducted throughout the world on smart cities that make use of IoT technologies. A total of 1232 papers covering the years 2011-2019 were analysed using bibliometric methods to conclude the state of research on this issue and its most prevalent themes. The number of scientific papers published has been rising steadily, with 83.23 percent of all papers being produced in the previous three years. Computer science and engineering were the two most impressive topics. Study expansion on IoT-based smart cities has been broken down into seven distinct tracks. Also, seven potential new lines of inquiry have been uncovered as a result of this study. As a whole, there is a rising interest in building smart city features based on Internet of Things applications, and this interest is reflected in the world's scientific output. This research adds to the ongoing conversation in academic, scientific, and institutional settings on how best to use accessible data to guide policy decisions.

Keywords - Impact, IOT Application, Smart Cities

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1. INTRODUCTION

The notion of the "Smart City" has recently gained widespread attention in academic circles and international policy. The idea behind this is to make cities smarter for their residents by using the abundance of IT advancements that are rapidly becoming available. About half of the global population lives in metropolitan areas. In recent decades, rising urban populations have hurt the availability and quality of public services. To solve problems, smart cities try to think of creative ways to do it. To address the ever-expanding list of problems that plague cities, several public and private sector organizations have launched "Smart City" (SC) programs, which have led to the introduction of ICT to discover long-term, efficient, and effective solutions. Some of these difficulties include managing issues related to education, health, traffic, energy, trash, unemployment, and crime.[1]

IoT, in its broadest definition, refers to the digital connectivity of commonplace things using embedded sensors that collect data from the physical world and transmit it to service platforms, where it is processed and transformed into knowledge and action. Doing data analysis paves the way for a more thorough comprehension of the information at hand and the most informed judgments. The Internet of Things (IoT) enables the creation of smart cities, therefore the two are intrinsically related. As a result of its widespread implementation, new consumption and production models based on the Circular Economy's innovations will emerge as a driving force behind the rise of "Industry 4.0." smart cities, smart inhabitants, and smart mobility stemming from smart infrastructure for mass transit and traffic management. The importance of mobile connection is highlighted here, and the foundation of this hierarchy is 5G technology.[2]

1.1 Features of Internet of Things (IoT)

The following characteristics are standard for any device connected to the Internet of Things:

i. Connectivity

While discussing IoT, connectivity is of paramount importance. Without faultless communication among the linked components of IoT ecosystems, it is difficult to accomplish any relevant commercial use case (sensors, compute engines, data hubs, and so on). Internet of Things devices may communicate with one another via a variety of methods, including radio waves, Bluetooth, Wi-Fi, Li-Fi, and so on. Several protocols of internet communication layers may be used to optimize efficiency and establish a generic connection across IoT ecosystems and industries. The Internet of Things ecosystem may be built on-premises or on a private network.[3]

ii. Sensing

Humans have an innate capacity to learn from experience and make judgments about their

immediate environment. The best way to make advantage of the Internet of Things is to learn how to decode analog data and change it into a form from which actionable insights may be drawn. We use a wide variety of sensors—Electrochemical, gyroscope, pressure, light, global positioning system (GPS), Electrochemical, pressure, radio frequency identification (RFID), etc.—to gather information for each unique problem. Vehicle applications make use of a wide variety of sensors, including those that sense light, pressure, velocity, and even images. To ensure the success of a use case, we must choose the most suitable sensing paradigm.

iii. Scale

Devices in the Internet of Things should be modular in design so that they may be expanded or contracted as needed. There is a broad variety of use cases for the Internet of Things, ranging from smart home automation to the automation of large factories and workstations. The current and projected scale of a carrier's participation should inform the design of their IoT infrastructure.[4]

iv. Dynamic Nature

The collection and preparation of data for use in making business decisions is the starting point for each Internet of Things use case. Many Internet of Things components must often change statuses throughout this procedure. The reading from a temperature sensor, for instance, will fluctuate over time as a result of variables including location, altitude, and the surrounding environment. IoT gadgets should be designed with this in mind.

1.2 Challenges Faced for Developing Smart Cities

Nowadays, many urban centers want to evolve into the "smart cities" of the future. Nevertheless, to do so, they will need to surmount the difficulties of formulating a comprehensive plan that includes both public and private actors, direct and indirect stakeholders, integrators, network and managed service providers, product vendors, and IT infrastructure suppliers. Starting with sensors for the Internet of Things, measurement and analytics tools, and AI/ML-powered solutions, smart cities require a robust, standards-based IT infrastructure to support a wide variety of uses and evolve with new technologies.[5]

Citizens, public organizations, state and municipal governments, and private businesses all need to work together to strike a balance in smart city development. If this equilibrium is reached, several possibilities arise for enhancing business, sustainability, disaster preparedness, public safety, and quality of life. With so many moving pieces and components to think about, it's hard to pin down just what it is that smart cities offer. Intelligent structures, administration, healthcare, transportation, security, energy, business, and infrastructure are all examples.[6]

i. Infrastructure Must Be a Foundational Element

A smart city's foundation is currently pieced together from a wide variety of sources, including stakeholders, suppliers, and technology. This results in a decentralized system. This infrastructure will not be able to keep up with the expanding needs of the initiative, accommodate emerging technology, or coordinate efficiently with forthcoming municipal services or building projects.[7]

Most cities that are capable of launching large-scale smart city programs also have physical infrastructure that is not suitable to support them without major adjustments to the current components. This not only increases the expense of the project but also causes severe disruption for people.

ii. Smart City IT Infrastructure Must Be Agile and Flexible to Scale

As the possibilities of smart cities advance, inflexible infrastructure will become obsolete. Yet, the data needed to power these modular components must be scalable for smart cities to keep up with the exponential growth in data production.[8]

For example, as cities continue to integrate transportation infrastructure like traffic signals with things like bus routes, ride-sharing applications, and congestion patterns, demand for data will increase accordingly. The potential advantages of a networked, smart city can only be realized to their full extent if the data collected from all of these sources can be efficiently scaled and linked.[9]

iii. Cities Must Protect Residents' Data to Assuage Privacy Concerns

Despite the importance of shared infrastructure, which lays the groundwork for expanded capabilities, the success of a smart city initiative hinges on two other factors: open data and public trust. There is a growing need for public openness and supervision, which has increased the pressure on both public and commercial organizations to be more careful about the data they gather. It is up to municipal administrators and urban planners to demonstrate that their data-gathering practices are above board and ultimately serve the public good.[10]

To win back the public's trust, governments may consider enacting legislation along the lines of Europe's General Data Protection Regulation (GDPR), which shows that leaders are starting to pay attention to privacy concerns by placing new constraints on how businesses can use people's personal information. Although initiatives like these may help restore faith in government, confidence can only be restored when public authorities show a genuine dedication to promoting government agency and private sector openness and a long-term commitment to preserving individuals' privacy without jeopardizing public safety.

iv. Public and Private Sector Organizations Need to Coordinate

One such challenge that smart cities may face is fostering collaboration and cooperation among important municipal and private sector entities. It's not uncommon for public and private businesses to be hesitant about sharing sensitive information or using a single set of technologies. Cities can avert terrorist attacks, enhance water and trash collection, and lessen noise and light pollution by working together, but this sort of cross-collaboration is hindered by the "need-to-know" policy of data sharing.[11]

The creation of stakeholder groups, the provision of incentives to foster open cooperation, and the emphasis on the advantages to each group may win over the police, fire, school, utility, and service provider agencies. For instance, "intelligence-led policing" may be supported by a digital infrastructure that enables the monitoring of data, the identification of trends and patterns, and the extraction of useful insights.

There is a wide range of difficult and ever-changing obstacles to overcome in the process of creating smart cities. It's important for everyone involved to see this work as a long-term infrastructure project, but they also need to focus on the current need for short-term answers to the world's growing digital, interconnected, and complicated problems. Smart cities can only reach their full potential if individuals have faith in them and companies and governments work together to ensure their inhabitants' safety, efficiency, and sustainability. [12]

2. METHODOLOGY

The research strategy used, as well as the data-gathering methods used to compile the articles that will make up the sample for this study, are described. After that, we'll sort, evaluate, and deduce what it all means.

2.1. Bibliometric Method

Scientific literature is analyzed using bibliometrics, which employs mathematical and statistical methodologies. E. Garfield pioneered this approach in the middle of the 20th century, and it has since become standard practice for critiquing the results of scientific studies and integrating findings from diverse fields of study. During this process, bibliometrics has developed as a result of researchers' access to multiple databases and their consideration of the history of science.

Managers and management professionals, as well as those working in businesses that create initiatives for research and innovation, now find it a vital tool. Researchers may learn more about the dynamics of activity and scientific output via quantitative investigations grounded in bibliometrics.

Now, the bibliometric approach has pushed for a rethinking of previously held scientific tenets. Experts in many fields have found it useful, including management, finance, economics, and education. The outputs of scientific endeavors may be measured by bibliometric markers.

2.2. Data Processing

This study investigated scientific output by author, research organization, and country productivity and publication distribution by year. The quality indicators used to discuss the impact of the various agents in this research are the citation count, the h-index (which can be used to determine which authors are the most prominent in a field by looking at the number of citations their articles have received), and the 2018 Cite Score indicator (which can be determined by looking at how many citations an article received in a given year). The 2018 Source Normalized Impact per Paper (SNIP), which divides a journal's three-year citations by its scientific field's potential citation, and the 2018 SC Imago Journal Rank (SJR), which rates Scopus' scientific journals.

Using the co-authorship technique, processing tools, and network maps were used to study cooperation structure indicators. Co-authorship acknowledges that two or more persons, organizations, or countries contributed to a work. Writers, organizations, and countries may be nodes in co-authoring networks, with edges indicating a shared authorship connection.

Keyword analysis has helped identify the main study topics by examining co-occurrences in scientific works. Two concepts co-occur often in one collection of publications but seldom in another. Co-occurrence analysis links terms in a text unit. Co-occurrence networks may be seen. VOSviewer, a partnership and content evaluation application was utilized to analyze these link indicators and estimate research network productivity.

3. RESULT

describes and analyses the most significant findings from a growing body of research on smart cities built on Internet of Things (IoT) applications throughout the world. Next, we look at how papers are scattered throughout different fields and periodicals. The study of the most important keywords about this issue is then addressed, along with the findings, which reveal the most important streams of thought. The most prolific writers, research organizations, and nations are then displayed, together with their most common keywords and subjects. Finally, recommendations for further study are offered.

3.1 Scientific Production

Scientific research on the Internet of Things-enabled "smart cities" and its development through time. Since 2011, when the first two publications on this issue were published, there has been a substantial surge in interest from the scientific and academic

community, with 95 articles published on the subject in the most recent year studied (2019).

95.78% of the total (1180 articles) on this topic have been published during the previous five years, 83.20% (1025) over the last triennium, and 40.02% within the last year (493).

The 1232 articles found in the Scopus database search are shown in Figure 3.1 below, showing their accumulation over time. According to a polynomial trend line of order 2, the number of publications on this subject has been rising at an ever-increasing rate during the last decade. This parabola-shaped trend line exhibits almost ideal goodness of fit to the data, with an R2 value near 1 (R2 = 0.983). The best model for determining the development curve was found to be a second-order polynomial.

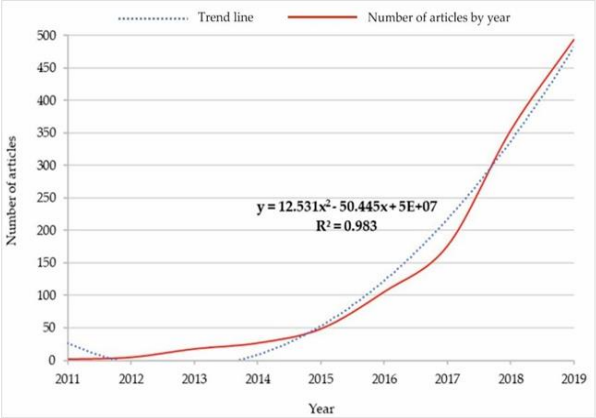

Figure 1: Evolution of scientific production (2011–2019)

Because of advances in computation, transmission, and analysis of data; sensors; inexpensive communication devices; and hyperconnectivity made possible by the digital ecosystem, scientific output in this domain has evolved.

Connecting society and business via IoT has also resulted in the emergence of novel business models, efficient healthcare systems, innovative goods and services, and, most notably, smarter, more environmentally friendly urban areas. The scientific community has also been impacted by this shift, with an increase in international scientific engagement in recent years. Simply said, the advancements and shifts in science and technology that have resulted from disruptive technologies and increased connectedness are reflected in the output of the scientific community. Equally important to this expansion is collaboration amongst the leading players at the center of research into the IoT's potential for use in smart cities.

There are 98.30% of English-language papers in this field of study (1211). As a result, more people see your publication when it's written in this language, which is reflected in the frequency with which it appears in Scopus searches. As a bonus, the pieces have also been published in other languages with less coverage: There were 12 native speakers of Chinese (0.97 %), 3 native speakers of Persian (0.24 %), 2 native speakers of German (0.16 %), 1 native speaker each of Polish, Portuguese, and Russian (0.08 %).

3.2 Subject Areas and Journals

In this part, we examine the leading journals covering smart cities that use IoT technology and demonstrate the key topic categories into which scientific output is categorized from 2011 to 2019.

So, the 1232 articles may be broken down into 23 broad categories based on the Scopus database.

As such, a given piece of writing may be filed under more than one general category. The publisher is the journal that ultimately categorizes each article into a topic area, therefore there is a relationship between the subject areas and the journals. The 23 key categories into which papers on IoT-based smart city research throughout the globe are organized are shown in Figure 3.2.

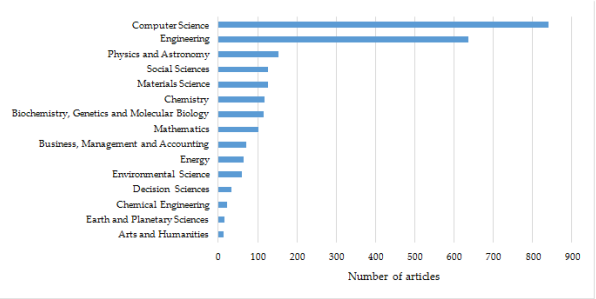

Figure 2: Top 15 subject areas (2011–2019).

The field of computer science has the highest concentration of published papers (68.10 percent; 839 total), followed by the field of engineering (51.9 percent; 638 total). Subsequently, physics and astronomy (12.58%, 155), materials science (10.31%), social sciences (10.31%), chemistry (9.58%, 118), biochemistry, genetics, and molecular biology (9.50%, 117), mathematics (8.44%, 104), business, management, and accounting (5.76%, 71), energy (5.28%, 65), and environmental science (5.03%, 62) all have a similar number of students. In terms of the percentage of total published papers, the other topics do not even get close to 2%.

Multidisciplinary studies examine the process by which cities are transformed into "smart" communities. Analysis of it is difficult since it reflects the contributions of many fields. Although it has its roots in the field of computer science and engineering, the social sciences, business, the health sector, and even urban planning are all affected by this topic in some way.

The 10 most prolific scientific journals on the subject from 2011-2019 are shown in Table 3.1 below. number of articles, the total number of citations, citations per article, nation, subject area, h-index for

this field of study, Scopus key quality metrics (Cite Score, SJR, and SNIP), and years of first and final article publication.

Table 1: Top 10 journals (2011–2019)

Journal	A	C	C/A	Country	Subject Area	h*	Citescore *	SJR *	SNIP *	1A*	LA*
Sensors	101	1112	0.901	Switzerland	BGM-CH-EN-PA	23	3.72	0.592	1.576	2013	2019
IEEE Access	92	1408	1.141	USA	CS-EN-PA	20	4.96	0.609	1.718	2015	2019
IEEE Internet of Things Journal	80	4774	3.869	USA	CS	25	11.33	1.396	3.874	2014	2019
Future Generation Computer Systems	66	2362	1.914	Netherlands	CS	25	6.30	0.835	2.464	2016	2019
IEEE Communications Magazine	24	843	0.683	USA	CS-EN	15	11.27	2.373	4.681	2013	2019
International Journal of Innovative Technology and Exploring Engineering	23	0	0.000	India	CS-EN	1	NA	NA	NA	2019	2019
Sustainable Cities and Society	17	283	0.229	Netherlands	EY-EN-SS	9	5.22	1.100	1.745	2017	2019
International Journal of Recent Technology and Engineering	16	3	0.002	India	BMA-EN	1	NA	NA	NA	2018	2019
Sustainability	16	86	0.070	Switzerland	EY-ES-SS	7	3.01	0.549	1.169	2016	2019
International Journal of Advanced Computer Science and Applications	13	9	0.007	UK	CS	2	NA	NA	NA	2018	2019

Sensors (101, 8.18%) and IEEE Access (92, 7.46%) lead the pack here in terms of the quantity and percentage of papers published. The IEEE Internet of Things Journal (6.48%) and Next Generation Computer Systems (5.55%) follow closely behind. In this ranking, the remaining journals do not account for more than 2%. Half of these magazines are European (two from Switzerland, two from the Netherlands, and one from Britain), thirty percent are North American, and twenty percent are Indian.

Many socioeconomic parameters, such as investment in R&D, GDP, economically active population, number of researchers, etc., are linked to the diversity of nations publishing in the most prestigious journals. Cultural variables, educational system influence, historical tradition, government science policy, and private sector growth are only a few examples of other elements that have an impact. As a consequence, certain places may devote more money and resources to research and development than others, leading to more innovation and progress in science. The scientific community, including researchers, scientists, editors, and readers, remains geographically dispersed despite the world's increasingly interconnected and technological nature.

The IEEE Internet of Things Journal (80 articles) has been publishing papers on this subject for just 6 years, yet it already has the most citations (4774), as well as the greatest average number of citations per piece (3.869). The Netherlands Next Generation Computer Systems (2362, 1.914), which followed in 2016, released the first paper on IoT in smart city research. The combined h-index of these top two journals is 25.

Six of the journals define their articles as belonging to the Computer Science and Engineering fields, making them the most prominent in both the individual and overall rankings (see Figure 3). The next two periodicals are in the fields of social sciences and physics and astronomy. This feature demonstrates that, beyond Computer Science and Engineering, a broad variety of topic fields categorize the articles on smart cities based on IoT technology applications.

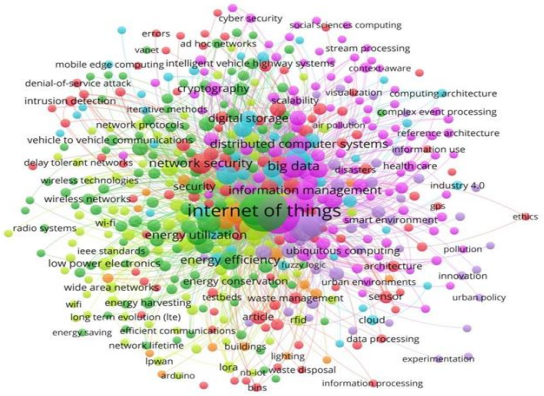

Figure 3: Keywords network based on the co-occurrence method (2011–2019)

Nevertheless, the 2018 Scopus database suggests the following impact measures for the top 10 journals: Citation Score, SC Imago Journal Rank (SJR), and Source Normalized Impact per Paper (SNIPP) (SNIP).

Also surprising is the fact that the worldwide scientific community has shown such a keen interest in studies of smart cities built on the foundation of IoT applications.

The two journals with the highest Citation Scores were the IEEE Communications Magazine (11.27), followed closely by the IEEE Internet of Things Journal (11.33). When comparing SJR (2.373) with SNIP, IEEE Communications Magazine came out on top (4.681).

It also draws attention to the fact that three publications (International Journal of Innovative Technology and Exploring Engineering, International Journal of Recent Technology and Engineering, and International Journal of Advanced Computer Science and Applications) have not been able to calculate the

metrics because they have only recently been included in the study theme.

Furthermore, in 2011, Hernández-Muoz, J. M., Vercher, J. B., Munoz, L., Galache, J. A., Presser, M., Hernández Gómez, L. A., and Pettersson, J. wrote "Smart Cities at the Forefront of the Future Internet" for Lecture Notes in Computer Science. There are 207 references in the bibliography right now. Comparatively, "Internet of Things for Smart Cities," by Zanella, A.; Bui, N., Castellani, A., Vangelista, L., and Zorzi, M., was the most-cited article in the IEEE Internet of Things Journal in 2014, with 2387 citations.

3.3 Keyword Analysis

This article provides a keyword analysis covering the period from 2011 to 2019 for investigating smart cities based on the uses of IoT technology. Based on these findings, we may identify the most prominent themes from this period in worldwide research.

Hence, the 20 most often used terms in the 1232 articles of the studied sample are listed in Table 3.2 below according to the Scopus database. The phrases "Internet of Things" (730 articles, 73.1%) and "Smart City" (654 articles, 53.3%) are the most often used. Scopus database search query included these two terms. Smart Cities (280, 22.69%), Internet of Things (IoT) (269, 21.80%), and IoT (171, 13.86%) are related words that occur with similar frequency to the main phrases.

Table 2: Top 20 keywords (2011–2019)

Rank	Keyword	Articles	%	Links	Total Link Strength	Cluster (See Figure 3.3)
1	Internet of Things	901	73.13%	493	6811	2
2	Smart City	654	53.08%	489	5068	1
3	Big Data	147	11.93%	335	1355	1
4	Internet	126	10.23%	273	989	5
5	Wireless Sensor Networks	111	9.01%	304	1059	2
6	Automation	105	8.52%	306	1071	7
7	Network Security	97	7.87%	287	962	3
8	Intelligent Buildings	95	7.71%	280	979	7
9	Cloud Computing	88	7.14%	249	799	6
10	Energy Efficiency	80	6.49%	262	841	2
11	Network Architecture	78	6.33%	259	831	6
12	Information Management	74	6.01%	266	780	1
13	Distributed Computer Systems	72	5.84%	243	729	1
14	Energy Utilization	72	5.84%	246	696	2
15	Data Handling	57	4.63%	214	590	1
16	Sensors	55	4.46%	194	456	1
17	Fog Computing	53	4.30%	176	501	6
18	Digital Storage	51	4.14%	191	485	6
19	Decision Making	50	4.06%	199	476	1
20	Security	49	3.98%	162	391	2

These top 20 keywords also include terms from related fields, such as "data intelligence." Internet (126, 10.19%), Automation (105, 8.51%), Cloud Computing (88, 7.13%), Distributed Computer Systems (72, 5.79%), Architecture/Urban Planning (57, 4.62%), Networks/Sensors (111, 9%), Network Security (97, 7.86%), Network Architecture (78, 6.32%), Sensors (55, 4.46%), and Sensor Nodes (54, 4.38%); and Big Data (147, 11.91%), Information Management Energy efficiency (80, 6.48%), intelligent buildings (95, 7.70%), and energy utilization (72, 5.83%).

This study's topic calls for a concerted effort across several fields of study. Given the young age of this area of study, it is being investigated from a wide variety of technical and sociological angles, which in turn encourages the development of new international jargon exclusive to this method of inquiry.

Information about both individual links and the overall network's connectivity may be found in the VOS viewer. The first demonstrates a link between two terms, while the second shows the frequency with which they appear in the same post. Hence, "The Internet of Things" has more linkages (732), and the overall link strength is higher (6811) than "Smart City" (489, 5068). To prevent the program from incorrectly categorizing related phrases into separate clusters, the following criteria have been applied: only the term that appears in more articles is quantified.

As shown in Figure 3.3, the co-occurrence approach was used to create a network map of terms from the articles related to this study. Each cluster is represented by a distinct color, indicating the number of occurrences in common, and each node's size fluctuates proportionally to the frequency with which it appears.

4. CONCLUSION

The goal of this research was to examine the development of scientific output and research trends on smart cities based on IoT applications on a worldwide scale during the previous 9 years (2011-2019). As a response, we crafted a bibliometric study based on 1232 publications pulled from the Scopus database. It has been determined, for the most part, how the total number of articles has changed over time; how they are categorized; which journals they are published in; whose writers and institutions are responsible for the majority of the work; and which nations produce the most articles. In addition, the most promising avenues for ongoing and future study have been identified. With 1025 publications published in the past triennium (2017-2019), scientific output has grown. They account for 83.20 percent of all papers written on the topic of smart cities based on IoT technology applications, confirming the issue's worldwide significance and importance. Similar connections are made between these two bodies of knowledge by the authors, research institutes, and top-performing nations.

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