GLOBAL TRENDS OF STUDIES ON HUMAN RESOURCES DEVELOPMENT OF SCIENCE AND TECHNOLOGY: A BIBLIOMETRIC ANALYSIS

LINH VU CANH DANG[1], HOA VIET NGUYEN[2], TRUNG THANH NGUYEN[3], ANH THI KIM DO[4], AN PHUONG TO[5], HAI NAM HOANG[6]

[1]Youth Studies Institute, Ho Chi Minh Communist Youth Union
[2]Central Committee for Propaganda and Education, Vietnam Communist Party
[3]Ministry of Science and Technology
[4]Institute of Regional Sustainable Development
[4]KPMG Company
[6]The University of Da Nang - University of Science and Education
[1]linhvya@gmail.com
[2]cskhcnhoa6@gmail.com
[3]thanhtrungxhtn@gmail.com
[4]kimanh1310@gmail.com
[5]anphuongto@gmail.com
[6]hoangnamhai2091962@gmail.com (Corresponding author)

Abstract *– Science and technology, because of their importance, always play key roles in the social and economic developments of any society. More importantly, human beings who have been working and contributing to any features of science and technology determine the whole meaning of science and technology. This study uses bibliometric analysis to show research trends on human resource development in science and technology (HRD in S&T), published sources, authors, and organizations with high research efficiency, as well as the country in the group that does the most research on human resource development in science and technology. The findings show that S&T research has increased rapidly in recent years; the journals belonging to the scientific group account for the majority of publications; and most of the authors have a low and remarkable number of publications. It means that China has the leading organizations for publishing in this area, and this country is in the top group if you look at it by country and region. There is a need for further studies on the trends in the development of S&T human resources in each field as well as the correlation between HRD in this field and the development of other sectors in society.*
Keywords: *science and technology, human resource development, human resource*

INTRODUCTION

The term HRD has different meanings depending on the situation. According to F.H.Harbison, human capital is "the energy, skills, talents, and knowledge of persons who have the potential to be or be used in the production of products or the performance of useful services". HRD is defined as "organizational learning activities within an organization that enhance performance or personal development for the purpose of job, personal, or organizational development". According to this definition, HRD includes the areas of training and development, career development, and organizational development. But we use the term HRD in the sense of human capital development. The most important HRD indicators can be broadly classified into (1) a measure of a country's total human capital and (2) a measure of factors that complement this capital. Human capital indicates a country's HRD level, while human capital formation rates indicate human capital enhancement rates. When talking about human capital, it refers to individuals who invest in levels to improve their own capabilities. It includes (1) medical facilities and services; (2) on-the-job training (including apprenticeships); (3) formal education; (4) adult learning programs (e.g., informal education); and (5) the mobility of families and individuals in the job search.

Psacharopoulos and Woodhall (1997) assert that "human resources are the ultimate basis of the wealth of nations (Psacharopoulos & Woodhall, 1985). Capital and natural resources are passive factors of production; humans are the active subjects of capital accumulation, exploitation of resources, the building of social, economic, and political organizations, and national development. An organization's

workforce is the human capital that the organization acquires, deploys, and retains to maximize profits, market share, and customer satisfaction (Herbert G. Heneman (III), Tim Judge, 2016). Human resources are the greatest assets for organizations (Okpala & Chidi, 2010). An organization's workforce is the human capital that the organization acquires, deploys, and retains to maximize profits, market share, and customer satisfaction. Human resources are the greatest assets for organizations (Okpala & Chidi, 2010).

"Businesses claim that the human factor is the source of their competitive advantage, whether they are technology specialists, customer service specialists, or visionary managers. In an age of great technological advancement, it is human resources that are the key to the success or failure of all companies, and especially businesses" (Katz et al., 2000). Human capital theory holds that education or training that imparts useful knowledge and skills will enhance workers' productivity, which in turn will raise their incomes (Burgelman, 1983).

Human resource development plays an important role in business development. Therefore, small and medium enterprises need to improve to be able to compete in the market and continue to survive. According to Harrison (1997) (Rowley, 2001), human resource development currently focuses on strategy in the fields of human resource management and business strategy. Some aspects of initiating human resource development include investing in human resource competencies and changing the interests of both organizations and individuals to enhance the core competencies of human resources. Human resource development is the process of developing and/or unlocking human expertise through organizational development and personnel training and development for the purpose of improving performance. Organizational development is the systematic process of implementing organizational change for the purpose of improving performance, and personnel development for the purpose of improving performance is the process of developing professional expertise in a systematic way. systems in individuals for the purpose of improving performance. Three important application areas of human resource development include human resource management, career development, and quality improvement(Swanson, 2001).

Siti Sarah bt. Omar, Lawrence Arokiasamy, and Maimunah Ismail show that there is a causal link between investment in human resource development and the performance of organizations and enterprises. Specifically, human resource development can include training and development, organizational development, and career development. Training includes fostering learning and educational activities designed to enhance an employee's overall competence (Omar et al., 2009). Therefore, human resource development basically increases the capacity of the workforce, skill development and quality, motivation, commitment, and organizational development. At the same time, developing human resources helps small and medium-sized enterprises make more progress and increase their competitiveness.

1. Methods

Two methods which are commonly used by authors (Aktoprak & Hursen, 2022),(Hajek et al., 2022), (Jeris et al., 2022) are applied to carry out this study: one is applying bibiliometrics method with keywords related to human resource development of science and technology to find documents in the Scopus data system, thereby indicating research trends on human resource development of science and technology in recent decades, the organizations that publish the most, the authors doing a lot of research on human resource development of science and technology, the national published, the type of publication, the relevant sector or organization sponsoring these publications, and the language used for publication. The other is from the most relevant studies, a content analysis was used to select the 10 most cited studies for analysis, focusing on three aspects: 1) research topic or problem; 2) methods used in these case studies; 3) key findings from the studies The information obtained from these two methods is the basis for making the most general judgments, comments, and conclusions about the research and development of human resources in science and technology in recent times.

Table 1 Main query string used for document database collection.

Query string	Document results
TITLE-ABS-KEY (*human* AND *resource* AND *development* AND *of* AND *science* AND *tec hnology*)	4,291
TITLE-ABS-KEY (*human* AND *resource* AND *development* AND *of* AND *science* AND *technology*) AND (LIMIT-TO (EXACTKEYWORD , *"Human"*) OR LIMIT-TO (EXACTKEYWORD , *"Humans"*) OR LIMIT-TO (EXACTKEYWORD , *"Human Resource Management"*) OR LIMIT-TO (EXACTKEYWORD , *"Sustainable Development"*) OR LIMIT-TO (EXACTKEYWORD , *"Science And Technology"*) OR LIMIT-TO (EXACTKEYWORD , *"Education"*) OR LIMIT-TO (EXACTKEYWORD , *"Technology"*)) AND (LIMIT-TO (LANGUAGE , *"English"*))	2,125

2. Findings

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Orci a scelerisque purus semper eget duis at tellus at. Quisque egestas diam in arcu cursus. Pulvinar mattis nunc sed blandit. Tempus iaculis urna id volutpat lacus laoreet non curabitur. Morbi tincidunt ornare massa eget egestas purus viverra accumsan in. Vehicula ipsum a arcu cursus. Sapien et ligula ullamcorper malesuada proin. Ut diam quam nulla porttitor. Tincidunt dui ut ornare lectus sit. Neque ornare aenean euismod elementum nisi quis eleifend. Mus mauris vitae ultricies leo integer. In nulla posuere sollicitudin aliquam ultrices. Eget duis at tellus at urna condimentum mattis. Tellus molestie nunc non blandit. Quam quisque id diam vel quam elementum pulvinar. Integer quis auctor elit sed vulputate mi. Pellentesque elit eget gravida cum sociis natoque penatibus et. Aliquet risus feugiat in ante. Commodo ullamcorper a lacus vestibulum sed.

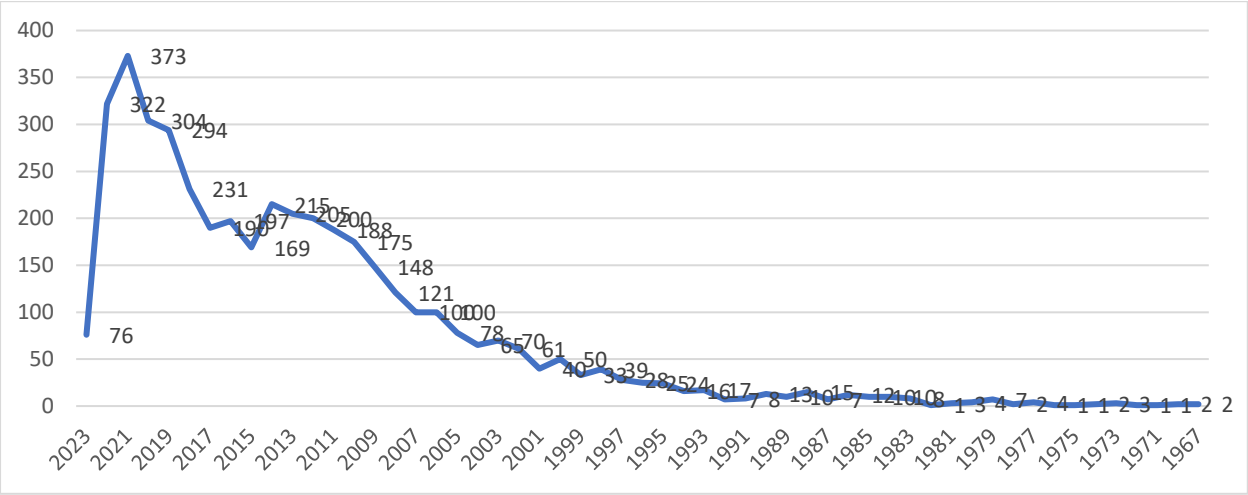

Figure 1 Document by year

The chart above provides information on the number of documents published between 1967 and 2023. In general, there is a difference between the beginning and end of the period in the number of published works on human resource development of science and technology. In 1967, there were 2 documents; in the next 10 years, there was an increase or decrease of 1.2 documents per year, which doubled to 4 documents in the 10th year, 1977. In the following years, there was a slight but rapid increase and decrease, reached eight documents in 1983. From 1983 to 1991, there was a slight increase and decrease between the years during this period, and the final mark remained 8 documents per year. From 1991 to 2001, it started to increase rapidly and reached 40 documents per year. From 2001 to 2015, a strong growth gradually increased to a peak of 215 documents per year and then dropped to 169 documents. From 2015 to 2023, the growth rate has skyrocketed over the

years and peaked in 2015 at 373 documents, then quickly decreased to 76 documents in 2023. In short, research and development of scientific and industrial human resources in technology tends to increase gradually over time; notably, in the last few decades, the number increased rapidly and peaked in the last five years.

Table 2 Document by year by source

No	SOURCE TITLE	No	%
1.	Proceedings Of The International Astronautical Congress Iac	60	13.9
2.	Journal Of Physics Conference Series	43	9.9
3.	Iop Conference Series Earth And Environmental Science	29	6.7
4.	ACM International Conference Proceeding Series	28	6.5
5.	Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics	28	6.5
6.	Advances In Intelligent Systems And Computing	20	4.6
7.	International Journal Of Environmental Research And Public Health	20	4.6
8.	Plos One	20	4.6
9.	Kexue Tongbao Chinese Science Bulletin	19	4.4
10.	E3s Web Of Conferences	18	4.2
11.	Communications In Computer And Information Science	17	3.9
12.	Studies In Health Technology And Informatics	17	3.9
13.	Advanced Materials Research	16	3.7
14.	Environmental Monitoring And Assessment	16	3.7
15.	Acta Astronautica	15	3.5
16.	International Journal Of Medical Informatics	14	3.2
17.	Journal Of Medical Internet Research	14	3.2
18.	Applied Mechanics And Materials	13	3.0
19.	Lecture Notes In Electrical Engineering	13	3.0
20.	Proceedings Of SPIE The International Society For Optical Engineering	13	3.0

The table above shows the top 20 largest sources of HRD in S&T documents each year. 1st place with the number of appearances is "Proceedings Of The International Astronautical Congress Iac" with 13.9% contribution to total offers; 2nd place is "Journal Of Physics Conference Series" with a contribution rate of 9.9%; 3rd place is "Iop Conference Series Earth And Environmental Science" accounting for 6.7%; followed by 2 sources at No. 4 with a weight of 6.5% are "ACM International Conference Proceeding Series Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial; Intelligence And Lecture Notes In Bioinformatics"; 3 sources in the 5th position with a share of 4.6% are "Advances In Intelligent Systems And Computing; International Journal Of Environmental Research And Public Health and Plos One". The rest are sources with contribution rates ranging from 3.0% to 4.2%. Thus, it can be seen that the number of annual publications from the source are publications related to conferences on Astronautical and Physics, followed by publications in the field of Environmental Science and Artificial Intelligence. In addition, works in the fields of information science, health and mechanical engineering are also researched and published by scholars in specialized journals as described in Table 2.

Table 3 Keywords

Keywords	No	%
Human	1165	22.7
Humans	850	16.6
Article	683	13.3
Human Resource Management	413	8.1
Sustainable Development	401	7.8
Review	381	7.4
Science and Technology	328	6.4
Education	324	6.3

Technology	297	5.8
Priority Journal	281	5.6

The above table shows the search results for the top 10 keywords related to HRD in S&T. The data shows us that the keyword "human" for the largest number is 1165 with a weight of 22.7%; in second place is "humans" with the number of 850, a proportion of 16.6%; holding the 3rd position is "article" with the number of 683, a proportion of 13.3%; "human resource management" holds the No. 4 position with 413 results, accounting for 8.1%; "sustainable development" holds the 5th place with 401 results and 7.8%. The remaining keywords account for a proportion of about 5.6% to 7.4%. In summary, research on human resource development in science and technology should focus on people. Notably, the terms human resource management and sustainable development also appear quite a lot in the statistical documents for research in this article. Besides, the keyword education appears, which can demonstrate the relationship between science and technology and human resource development for education or sustainable development.

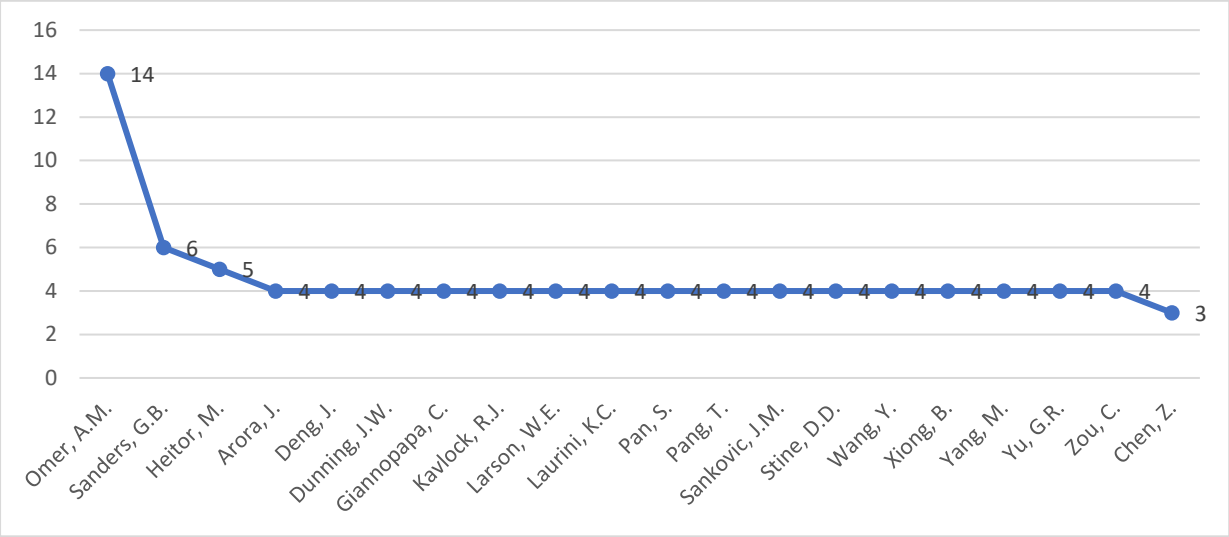

Figure 2 Document by author

The chart above provides information about the authors of research on HRD in S & T, it can be clearly seen that the majority of authors have an average frequency of 3 to 4 times, and there are 3 authors occupying the top 3: Omer, A.M.; Sanders, G.B.; and Heitor, M., with 14, 6, and 5 occurrences, respectively. Thus, it can be said that, in addition to the author with the highest publication level with 14 works, the authors have many studies on the topic of human resource development in science and technology have been published in quite equal numbers. Such a number shows that, on the one hand, individuals' scientific publications on the topic of research and development of scientific and technological human resources are not many, and on the other hand, it shows the level and problem of research in the field of science and technology. This area still has a lot of space and issues that can be researched and published.

Table 4 Document by affiliation

No	AFFILIATION	No	%
1.	Chinese Academy of Sciences	88	17.6
2.	University of Chinese Academy of Sciences	30	6.0
3.	National Aeronautics and Space Administration	28	5.6
4.	Universidade de São Paulo	27	5.4
5.	Stanford University	27	5.4
6.	University College London	27	5.4
7.	National Institutes of Health NIH	24	4.8
8.	NASA Johnson Space Center	24	4.8

9.	University of Toronto	22	4.4
10	Ministry of Education China	20	4.0
11	Tsinghua University	20	4.0
12	Massachusetts Institute of Technology	19	3.8
13	The University of North Carolina at Chapel Hill	19	3.8
14	Harvard Medical School	18	3.6
15	Arizona State University	18	3.6
16	University of Oxford	18	3.6
17	Wuhan University	18	3.6
18	University of Florida	17	3.4
19	University of Washington	17	3.4
20	University of California, San Francisco	17	3.4

The above table provides information on the top 20 documents by affiliation in science and technology and human resource development. In general, the documents with the highest number of links belong to Chinese organizations, which have the lowest number of links in the list. The universities of the United States Specifically, the Chinese Academy of Sciences has the largest number of articles with 88 documents; the second is the University of the Chinese Academy of Sciences with 30 documents; and the National Aeronautics and Space Administration has 28 documents. Three institutions each have 27 documents associated with them, including the Universidade de São Paulo, Stanford University, and University College London. Organizations with the number of documents implemented by linkage increasing from 18 to 24 include the National Institutes of Health NIH, NASA Johnson Space Center, University of Toronto, Ministry of Education China, Tsinghua University, Massachusetts Institute of Technology, The University of North Carolina at Chapel Hill, Harvard Medical School, Arizona State University, University of Oxford, Wuhan University. In summary, the studies with many links are those of Chinese institutions and those of US institutions.

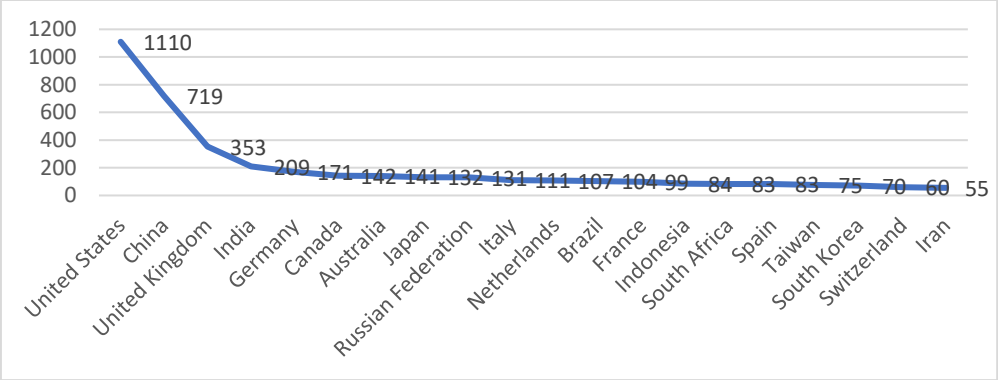

Figure 3 Document by countries or territories

The chart above provides information about the country and territory that provided the HRD document. The country providing the lowest number of documents is Iran with 55 documents, and the most is the United States with 1110 documents. Holding No. 2 is China with 719 documents; 3rd place is the United Kingdom with 353 documents. India and Germany are in positions 4 and 5, respectively, with the number of documents at 209 and 171. The remaining countries and territories have a number of documents ranging from 60 to 142. If China is not included, the published research is concentrated in developed countries, but there are developed countries that do not have many publications on human resource development in science and technology, such as France or Switzerland last time. There are 104 and 70 documents, respectively.

Table 5 Document by type

No	DOCUMENT TYPE	No	%
1	Article	2044	47.67
2	Conference Paper	1111	25.91

3	Review	556	12.97
4	Book Chapter	309	7.21
5	Book	131	3.06
6	Conference Review	45	1.05
7	Note	32	0.74
8	Editorial	22	0.51
9	Short Survey	17	0.40
1	Erratum	9	0.21
1	Retracted	8	0.18
1	Letter	3	0.07
1	Report	1	0.02

The table above shows the number of documents by type. First place is the "article" format, with 2044 documents accounting for the majority of the proportion of 47.67%. In second place is "Conference Paper," with 1111 documents with appropriately 25.91%. Holding the 3rd position is "Review" with 556 documents, weight 12.97%; the 4th and 5th positions are "Book Chapter" and "Book," respectively, with the number and proportion of contributions being 309 documents, 7.21%, and 131 documents, 3.06%; the remaining types account for the number of documents ranging from 1 to 45 documents with a contribution rate of 0.02% to 1.05%.

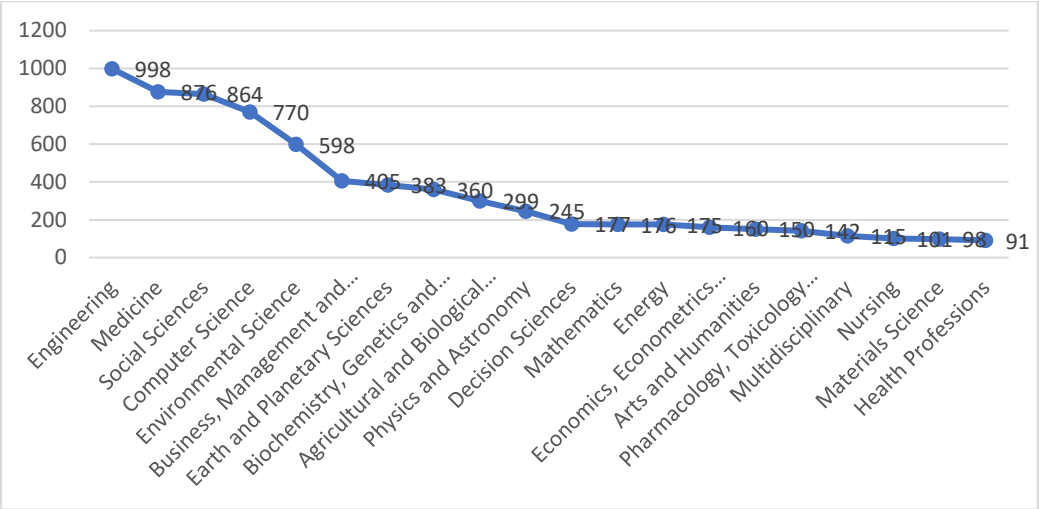

Figure 4 Document by sectors

The chart above provides information about research institutions in science and technology, human resource management, and the number of research projects. The organization with the least number of works is "Health Professions," with 91 works, and the most is "Engineering" with 998 works. Holding the 2nd and 3rd places are "Medicine" and "Social Sciences," respectively, with a total of 876 and 864 works. The 4th and 5th positions are "computer science" and "environmental science," respectively, with the number of works. The number of works is 770 and 598, respectively. The remaining 14 organizations contributed a number of works ranging from 98 to 405.

Table 6 Documents funder sponsor

	Funder/sponsor	**No**	**%**
	National Natural Science Foundation of China	104	17.81
	National Science Foundation	89	15.24
	National Institutes of Health	67	11.47
	European Commission	38	6.51
	National Key Research and Development Program of China	29	4.97
	National Cancer Institute	27	4.62
	Chinese Academy of Sciences	22	3.77
	Horizon 2020 Framework Programme	21	3.60

	Conselho Nacional de Desenvolvimento Científico e Tecnológico	20	3.42
	National Aeronautics and Space Administration	19	3.25
	Ministry of Education of the People's Republic of China	17	2.91
	National Center for Advancing Translational Sciences	17	2.91
	Seventh Framework Programme	17	2.91
	National Institute of General Medical Sciences	16	2.73
	Japan Society for the Promotion of Science	15	2.56
	Economic and Social Research Council	14	2.40
	Coordenação de Aperfeiçoamento de Pessoal de Nível Superior	13	2.23
	Ministry of Science and Technology of the People's Republic of China	13	2.23
	National Office for Philosophy and Social Sciences	13	2.23
	U.S. National Library of Medicine	13	2.23

The table above provides information on the relationship between organizations that fund research on science and technology and human resource management and the number of funded works. Leading the way is the "National Natural Science Foundation of China," with 104 funded works and a contribution proportion of 17.81%. Holding second place is the "National Science Foundation," with a number of funded works of 89 and a proportion of 15.24%. In third place is the "National Institutes of Health," with 67 works, a proportion of 11.47%. The 5th and 6th positions are "National Key Research and Development Program of China" and "National Cancer Institute," with the number of works and proportions of 29.4.97% and 27.4.62%, respectively. The remaining organizations sponsored a number of projects ranging from 13 to 22, with a proportion of 2.23% to 3.77%.

Table 7 Languages used in the documents of HRD in S&T

Language	**No**	**%**
English	3930	92.04
Chinese	220	5.15
Russian	36	0.84
Portuguese	24	0.56
French	20	0.47
Japanese	16	0.38
German	9	0.21
Persian	9	0.21
Polish	6	0.14

The table above provides information about the languages used in research projects on scientific and technological human resource management. It can be seen that English is the most commonly used language, with the majority of works using 3930, accounting for 92.04%. In second place is China, with 220 works accounting for 5.15%. In third place is Russian with 36 works and a 0.84% share. A few languages are spoken, such as Portuguese, French, Japanese, German, Persian, and Polish, with a number of works ranging from 6 to 24 and a proportion of 0.14% to 0.56%. Thus, it can be said that English is the main language used in most of the published scientific works in the Scopus data system on human resource development in science and technology.

3. DISCUSSION

Regarding the number of publications, the data shows a trend of rapidly increasing publications on science and technology and human resource development in recent years. This can be explained for a number of reasons, such as: first, the field of science and technology is increasingly interested in the investment and development of countries around the world. Second, the participation of many social forces or partners related to the development of science and technology. Thirdly, the development of science and technology fields not only in these fields themselves but also at the level of application of science and technology fields to other socio-economic fields. The developments are

both intrinsic to the industries, along with the resonance of other socio-economic needs and factors, which leads to more and more scientists interested in researching and publishing issues of human resource development in science and technology.

Petra Andries, Dirk Czarnitzki (2011) (Andries & Czarnitzki, 2014)conducted research, formulated hypotheses and tested them:

+ *The company's resource-based perspective:* A company's innovation capacity is considered one of the most important competencies for developing a sustainable competitive advantage. Innovation is essentially about identifying and using opportunities to create new products, services, or ways of working. The speed with which companies develop new products, services and processes impacts a company's performance and long-term survival(Balland & Boschma, 2022), (Damanpour, 1991). The individual is the main actor of knowledge creation and, in the case of tacit knowledge, the main repository of knowledge (Hitt et al., 2001). In addition, individual knowledge and skills (like other intangible resources such as brand equity) are more likely to generate competitive advantage because they are often rare and socially complex, so difficult to imitate (Hitt et al., 2001). Thus, human capital is seen as an important resource in developing innovations and sustainable competitive advantage (Hitt et al., 2001), (Borch et al., 1999),(Brundin et al., 2008), (Lado & Wilson, 1994), (Brush et al., 2002), (Huselid, 1995), (Wright & McMahan, 1992), (Wiig, 1997).

+ *The view of the upper management emphasizes the role of top management skills and knowledge in enterprise innovation:* The human capital of CEOs and top managers is expected to influence affect the company's innovation activities in both direct and indirect ways. More educated and experienced owners/managers/managers are expected to be more successful in recognizing opportunities (Hambrick & Mason, 1984), (Andries & Czarnitzki, 2014), (Shane, 2000), (Ucbasaran et al., 2009), thus directly contributing ideas and insights to a company's innovation performance. (2) owner/manager knowledge is useful for gathering resources (Damanpour, 1991), including human resource selection and management (Cook et al., 2002), (Aktoprak & Hursen, 2022), (Klaas et al., 2010), which in turn has an impact on knowledge and skill accumulation. Furthermore, managers who demonstrate confidence and satisfaction about business ventures will improve employees' willingness to take action (Brundin et al., 2008). As a result, top executives and managers are said to also have an indirect impact on a company's innovation performance.

However, when it comes to the innovation performance of small firms specifically, the empirical evidence on the impact of founders' human capital remains controversial. While Chaganti et al. (2008) (Chaganti et al., 2008) discovered the relationship between the background of founding team members and the tendency of new business ventures to seek and pursue business opportunities; Lynskey (2004), in contrast, did not find any link between the CEO's human resources and the development of new products in new projects. Similarly, Davidsson and Honig (2003) (Lynskey, 2004) did not find an effect of entrepreneurship's human capital on first product sales or profitability. A study by De Winne and Sels (2010) shows that owners and managers of new projects do not directly contribute to the company's innovation output by generating ideas or realizing the basis of innovation society, but instead contribute only indirectly by hiring more qualified staff and using more human resource practices(De Winne & Sels, 2010).

+ *The strategic view of human resource management:* many researchers acknowledge that a company's strategy is not always driven by its top managers (Mintzberg & Waters, 1985), (Burgelman, 1983), (Stopford & Baden-Fuller, 1994). In parallel with the views of upper management, a flow of literature has been developed that emphasizes the critical role the skills and knowledge of non-management employees play in innovation and corporate performance. Karma. The natural abilities, intelligence and skills of key employees acquired through formal education and work experience are considered to be an important part of an organization's human resources (Andries & Czarnitzki, 2014). Empirical research on large established companies (e.g. Smith et al. 2005) does confirm that the human capital of non-managerial employees has a positive effect on the ability to generate knowledge. of the company. For small businesses, surveys show that owners/managers of some small firms consider employees an important resource (Cook et al., 2002) and a prerequisite for product innovation. products (Andries & Czarnitzki, 2014). The work of Klaas et al. (2010) (Klaas et al., 2010)

suggests that especially CEOs who have been exposed to HR practices before, should understand the value of such practices.

Although there are many ways to classify types of science and technology, e.g., basic research, applied research, implementation research, as well as issues that now belong to science and technology services, this does not stop at the product level but also depends on the size of the organization. There is multi-disciplinary research, including basic, applied, and implemented research in an organization or linkage between science and technology organizations, led by a single but multidisciplinary or multidisciplinary science and technology organization area. This leads to the development of science and technology human resources that are also diverse and complex because of the influence of many factors in different fields within an organization or between organizations operating together to provide products or systems of scientific and technological products.

Table 8 The most cited documents

Author/year	Title	Publisher	Citations
1. (Edvinsson, 1995)	Developing intellectual capital at Skandia	Long Range Planning, 30(3)	791
2. (Robledo & Sartor, 2013)	A simulation method for network performability estimation using heuristically computed pathsets and cutsets	International Journal of Technology Management, 22 (7-8), pp. 716-740	272
3. (Cook et al., 2002)	Human issues in service design	Journal of Operations Management, 20(2	185
4. (Taylor & Alexander, 2006)	Science, technology, and human factors in fire danger rating: The Canadian experience	International Journal of Wildland Fire, 15 (1), pp.121-135	138
5. (Fairhead et al., 2006)	Where techno-science meets poverty: Medical research and the economy of blood in The Gambia, West Africa	Social Science & Medicine, 63 (4)	135
6. (Chang & Shih, 2004)	The innovation systems of Taiwan and China: A comparative analysis	Technovation, 24 (7)	101
7. (Pham, 2019)	Green human resource management a comprehensive review and future research agenda	International Journal of Manpower, 41 (7)	78
8. (Kipper et al., 2021)	Scientific mapping to identify competencies required by industry 4.0.	Technology in Society, 64, 2021	74
9. (Balland & Boschma, 2022)	Do scientific capabilities in specific domains matter for technological diversification in European regions?	Research Policy	39
10. (Weiss, 1993)	Scientific and technological responses to structural adjustment: Human resources and research issues in Hungary, Turkey, and Yugoslavia	Technology in Society, 15(3)	1

The table above provides a summary of the most cited science and technology human resource development studies. In terms of time, these studies were also carried out in different stages, as

early as 1993 with Weiss (1993) and most recently with Balland & Boschma (2022), and most are all from the 2000s. In terms of research, it mainly focuses on: 1) human resources in science and technology and the relationship between human resources and science and technology (Bozeman et al., 2021); 2) the role of science and technology human resources in other fields [**Error! Reference source not found.**]; and 3) notably, there are many very important and up-to-date topics such as determining the capacity required by industry 4.0, green human resource management (Pham, 2019), models (Pham, 2019), models (Bozeman et al., 2021) and innovation systems (Andries & Czarnitzki, 2014)

Regarding research methods, Edvinsson, (1997) used the description method to identify two models to promote the real value potential of the organization, and the simulation method demonstrated its ability to achieve significant variance reductions when applied to mesh-like networks (Robledo and Sartor, 2013). Cook et al (2002) introduced the concept of applying behavioral science to service encounters and then how mystery shopping can be used to examine the link between the service organization and the contact personnel was discussed. Besides, the creation of the Canadian Forest Fire Danger Rating System (CFFDRS) and its application in Canada and other countries are reviewed by Talor et al (2006). In a previous book [**Error! Reference source not found.**], the author created a phenomenological model of the course of scientific and technical progress in a number of developing nations.

Fairhead et al., (2006) applied the case study to view the Gambian parents' perspectives on participation are shaped not by trial specifics but rather by the overall views and experiences of the MRC (Medical Research Council) as an institution. Balland and Boschma (2022) identifies regions that are pure technological leaders, pure scientific leaders, or just followers in 18 domains by comparing the scientific and technological capabilities of 285 European regions. Pham, N.T. et al., (2020) evaluates 74 papers, comprising 13 review articles and 61 research/empirical articles, all of which are connected with from the Scopus and Web of Science databases about the GHRM (Green human resource management) field. The databases Scopus, Web of Science, and Science Direct were searched for articles published between 2010 and 2018. The mapping of the field of study was made possible by this systematic review, which identified themes and authors who are currently specializing in the area [**Error! Reference source not found.**].

Regarding to the findings: there are many findings of human resource development of science and technology discovered by authors, that is the task is to manage the process of building intellectual capital from the creation of values through gathering, capturing, and sharing knowledge to leveraging and capitalizing on the values. Authors have made several discoveries about the development of human resources in science and technology. Therefore, rather than being a thing or an objective, intellectual capital is a relational issue. It is a resource that must be nurtured in a context and is both renewable and renewing. Though it can be facilitated, managing intellectual capital is a difficult process to master. It is an interconnected network (Edvinsson, 1995). The required and sufficient circumstances for a reduction in the variance of the estimated parameter with respect to the model are described by Robledo and Sartor (2013). The experiments also demonstrated that the suggested heuristic might produce sets that leveraged the potential for variance reduction at considerable levels. The efficiency gains are notable even when taking into account the additional time needed for running the heuristic and for sampling using the suggested plan, particularly when the links grow more trustworthy.

According to Cook et al. (2002), service system design can be approached with the same rigor and depth as in the manufacturing of things. The outcome is a greater understanding of how basic behavioral science concepts underpinning human interactions may be directly applied to service design. The distinguishing characteristic of the service encounter is perception. It is impossible to overstate the value of contact persons in effective service organizations. According to Talor and Alexander (2006), effective fire danger systems are easily internalized by and impact organizational culture, which in turn influences the creation of new technologies,. Most essential, for the successful adoption of a fire danger rating system, fire scientists and fire managers must share a same vision and a sense of common cause.

Despite the differences between their economic systems, Weiss (1993) argued that the Turkish economy of 1980 and the Hungarian and Yugoslav economies of 1988 share a number of key characteristics. Basic research and education were typically of very high quality in all three nations. Each of the three administrations financed major research institutions that, despite being largely cut off from the productive sector, funded a sizable amount of high-quality research, some of which might have resulted in practical applications in other economic contexts. Furthermore, there was a significant brain drain due to the lack of employment opportunities for highly qualified scientists and engineers in the productive sector. Chang and Shih (2004) show that while they both have distinctive qualities, they also have a lot in common that is complementary. Along with their geographic proximity, the two economies also share linguistic, cultural, racial, and historical traits. As a result, these events raise the possibility of future cooperation between the two innovation systems, and this study then suggests potential strategies for doing so.

If medical research in resource-poor settings is to continue being sustainable and politically acceptable, cultural framings that guide local critical commentary on trans-national research orders need to be seriously considered and taken into account (Fairhead et al., 2006). Balland and Boschma (2022) discovered that the regional diversification model demonstrates that local scientific expertise in a field is a significant predictor of the growth of new technologies in that field in regions. This discovery is especially pertinent to the Smart Specialization policy because it suggests that the examination of scientific information that is exclusive to a given subject can be a potent tool for locating new chances for diversification in specific regions.

The analysis of the pertinent literature is presented in the following three main sections: an overview that highlights the research gaps and offers 16 specific recommendations; a description of the analysis that emphasizes the findings related to GHRM; and a research framework that centers on GHRM for a future research agenda (Pham, 2019). Kipper et al. (2021) used a conceptual map to demonstrate that the key competencies required are leadership, strategic vision of knowledge, self-organization, giving and receiving feedback, proactivity, creativity, problem solving, interdisciplinarity, teamwork, collaborative work, initiative, communication, innovation, adaptability, flexibility, and self-management, as well as knowledge of contemporary fields (information and communication technology, algorithms, automati).

CONCLUSION

Studies on the development of S&T human resources based on available data show that they all belong to countries with the highest scientific and technological development in the world. This shows, on the one hand, an inevitable trend due to development needs in these countries and regions; on the other hand, these studies do not clearly show that they are basic or applied research studies that are used or classified in other fields of study.

Science and technology human resources is too broad and diverse in terms of development because it can be based on the total number of human resources working in the fields of science and technology and trends, direction as well as the content or development characteristics of this group of human resources. In addition, it is possible to determine the development of a comprehensive nature from reserve resources, resources, and factors affecting the development of an organization's scientific and technological human resources, a country, or a region.

There should be in-depth studies on the development of scientific and technological human resources in different directions: development of scientific and technological human resources in the field of basic science; development of scientific and technological human resources and technology in the field of applied science; development of science and technology human resources in the field of deployed science; and other types of science and technology. In addition, there should be studies on the comprehensive development of science and technology human resources in a specific field, even from the lowest educational levels, to the population structure, and to the highest level of human resources. In addition, it is also possible to conduct research under various types of science and technology organizations, such as academies, institutes, centers, laboratories, etc., as well as science and technology service organizations.

ACKNOWLEDGEMENT

This work is part of the project “Policies and solutions to developing the young human resources of science and technology in small and medium enterprises in Vietnam in the period of 2021–2030, Code ĐTĐL.XH.07/22) (Chính sách và giải pháp phát triển nhân lực khoa học công nghệ trẻ trong các doanh nghiệp vừa và nhỏ ở Việt Nam trong giai đoạn 2021-2030, mã số ĐTĐL.XH.07/22).

REFERENCES

[1] *Aktoprak, A., & Hursen, C. (2022). A bibliometric and content analysis of critical thinking in primary education. Thinking Skills and Creativity, 44, 101029. https://doi.org/https://doi.org/10.1016/j.tsc.2022.101029*

[2] *Andries, P., & Czarnitzki, D. (2014). Small firm innovation performance and employee involvement. Small Business Economics, 43(1), 21–38. https://doi.org/10.1007/s11187-014-9577-1*

[3] *Balland, P. A., & Boschma, R. (2022). Do scientific capabilities in specific domains matter for technological diversification in European regions? Research Policy, 51(10), 104594. https://doi.org/10.1016/j.respol.2022.104594*

[4] *Borch, O. J., Huse, M., & Senneseth, K. (1999). Resource Configuration, Competitive Strategies, and Corporate Entrepreneurship: An Empirical Examination of Small Firms. Entrepreneurship Theory and Practice, 24(1), 49–70. https://doi.org/10.1177/104225879902400104*

[5] *Brundin, E., Patzelt, H., & Shepherd, D. A. (2008). Managers’ emotional displays and employees’ willingness to act entrepreneurially. Journal of Business Venturing, 23(2), 221–243. https://doi.org/https://doi.org/10.1016/j.jbusvent.2006.10.009*

[6] *Brush, C., Greene, P., & Hart, M. (2002). From Initial Idea to Unique Advantage: The Entrepreneurial Challenge of Constructing a Resource Base. Engineering Management Review, IEEE, 15, 86. https://doi.org/10.1109/EMR.2002.1022409*

[7] *Burgelman, R. A. (1983). A Process Model of Internal Corporate Venturing in the Diversified Major Firm. Administrative Science Quarterly, 28(2), 223–244. https://doi.org/10.2307/2392619*

[8] *Chaganti, R. (Raj) S., Watts, A. D., Chaganti, R., & Zimmerman-Treichel, M. (2008). Ethnic-immigrants in founding teams: Effects on prospector strategy and performance in new Internet ventures. Journal of Business Venturing, 23(1), 113–139. https://doi.org/https://doi.org/10.1016/j.jbusvent.2006.07.004*

[9] *Chang, P. L., & Shih, H. Y. (2004). The innovation systems of Taiwan and China: A comparative analysis. Technovation, 24(7), 529–539. https://doi.org/10.1016/S0166-4972(02)00117-7*

[10] *Cook, L. S., Bowen, D. E., Chase, R. B., Dasu, S., Stewart, D. M., & Tansik, D. A. (2002). Human issues in service design. Journal of Operations Management, 20(2), 159–174. https://doi.org/https://doi.org/10.1016/S0272-6963(01)00094-8*

[11] *Damanpour, F. (1991). Organizational Innovation: A Meta-Analysis Of Effects Of Determinants and Moderators. Academy of Management Journal, 34(3), 555–590. https://doi.org/10.5465/256406*

[12] *De Winne, S., & Sels, L. (2010). Interrelationships between human capital, HRM and innovation in Belgian start-ups aiming at an innovation strategy. The International Journal of Human Resource Management, 21(11), 1863–1883. https://doi.org/10.1080/09585192.2010.505088*

[13] *Edvinsson, L. (1995). Developing Intellectual Capital at Skandia Understanding Knowledge Management.*

[14] *Fairhead, J., Leach, M., & Small, M. (2006). Where techno-science meets poverty: Medical research and the economy of blood in The Gambia, West Africa. Social Science and Medicine, 63(4), 1109–1120. https://doi.org/10.1016/j.socscimed.2006.02.018*

[15] *Hajek, P., Youssef, A., & Hajkova, V. (2022). Recent developments in smart city assessment: A bibliometric and content analysis-based literature review. Cities, 126, 103709. https://doi.org/https://doi.org/10.1016/j.cities.2022.103709*

[16] *Hambrick, D. C., & Mason, P. A. (1984). Upper echelons: The organization as a reflection of its top managers. The Academy of Management Review, 9, 193–206. https://doi.org/10.2307/258434*

[17] *Herbert G. Heneman (III), Tim Judge, J. D. K.-M. (2016). Staffing organizations. Pangloss Industries Mishawaka, IN.*

[18] *Hitt, M. A., Bierman, L., Shimizu, K., & Kochhar, R. (2001). Direct and moderating effects of human capital on strategy and performance in professional service firms: A resource-based perspective. Academy of Management Journal, 44(1), 13–28. https://doi.org/10.2307/3069334*

[19] *Huselid, M. A. (1995). The Impact of Human Resource Management Practices on Turnover, Productivity, and Corporate Financial Performance. The Academy of Management Journal, 38(3), 635–672. https://doi.org/10.2307/256741*

[20] Jeris, S., Rahman Chowdhury, N., Akter, M. T., Frances, S., & Roy, M. H. (2022). Cryptocurrency and stock market: bibliometric and content analysis. Heliyon, 8, e10514. https://doi.org/10.1016/j.heliyon.2022.e10514

[21] Katz, J. A., Aldrich, H. E., Welbourne, T. M., & Williams, P. M. (2000). Guest Editor's Comments Special Issue on Human Resource Management and the SME: Toward a New Synthesis. Entrepreneurship Theory and Practice, 25(1), 7–10. https://doi.org/10.1177/104225870002500102

[22] Kipper, L. M., Iepsen, S., Dal Forno, A. J., Frozza, R., Furstenau, L., Agnes, J., & Cossul, D. (2021). Scientific mapping to identify competencies required by industry 4.0. Technology in Society, 64(November 2020). https://doi.org/10.1016/j.techsoc.2020.101454

[23] Klaas, B. S., Klimchak, M., Semadeni, M., & Holmes, J. J. (2010). The adoption of human capital services by small and medium enterprises: A diffusion of innovation perspective. Journal of Business Venturing, 25(4), 349–360. https://doi.org/https://doi.org/10.1016/j.jbusvent.2008.12.002

[24] Lado, A. A., & Wilson, M. C. (1994). Human Resource Systems and Sustained Competitive Advantage: A Competency-Based Perspective. The Academy of Management Review, 19(4), 699–727. https://doi.org/10.2307/258742

[25] Lynskey, M. J. (2004). Determinants of Innovative Activity in Japanese Technology-based Start-up Firms. International Small Business Journal, 22(2), 159–196. https://doi.org/10.1177/0266242604041312

[26] Mintzberg, H., & Waters, J. A. (1985). Of strategies, deliberate and emergent. Strategic Management Journal, 6(3), 257–272. https://doi.org/https://doi.org/10.1002/smj.4250060306

[27] Okpala, O., & Chidi, O. C. (2010). Human capital accounting and its relevance to stock investment decisions in Nigeria. European Journal of Economics, Finance and Administrative Sciences, 64–76.

[28] Omar, S. S. bt., Arokiasamy, L., & Ismail, M. (2009). The Background and Challenges Faced by the Small Medium Enterprises. A Human Resource Development Perspective. International Journal of Business and Management, 4(10), 95–102. https://doi.org/10.5539/ijbm.v4n10p95

[29] Pham, N. T. (2019). Green human resource management : a comprehensive review and future research agenda. https://doi.org/10.1108/IJM-07-2019-0350

[30] Psacharopoulos, G., & Woodhall, M. (1985). Education for development: an analysis of investment choices. In Education for development: an analysis of investment choices. (Issue September). https://doi.org/10.2307/2069840

[31] Robledo, F., & Sartor, P. (2013). A simulation method for network performability estimation using heuristically computed pathsets and cutsets. International Journal of Metaheuristics, 2(4), 370. https://doi.org/10.1504/ijmheur.2013.058476

[32] Rowley, C. (2001). Employee Development[2]20015Rosemary Harrison. Employee Development[2] . London: Chartered Institute of Personnel and Development 1997. xvii + 466 pp., ISBN: ISBN 0-85292-657-X £19.95 (paperback). Personnel Review, 30, 371–377. https://doi.org/10.1108/pr.2001.30.3.371.5

[33] Shane, S. (2000). Prior Knowledge and the Discovery of Entrepreneurial Opportunities. Organization Science, 11(4), 448–469. http://www.jstor.org/stable/2640414

[34] Stopford, J. M., & Baden-Fuller, C. W. F. (1994). Creating corporate entrepreneurship. Strategic Management Journal, 15(7), 521–536. https://doi.org/https://doi.org/10.1002/smj.4250150703

[35] Swanson, R. (2001). Human Resource Development and its underlying theory. Human Resource Development International, 4, 299–312. https://doi.org/10.1080/13678860110059311

[36] Taylor, S. W., & Alexander, M. E. (2006). Science, technology, and human factors in fire danger rating: The Canadian experience. International Journal of Wildland Fire, 15(1), 121–135. https://doi.org/10.1071/WF05021

[37] Ucbasaran, D., Westhead, P., & Wright, M. (2009). The extent and nature of opportunity identification by experienced entrepreneurs. Journal of Business Venturing, 24(2), 99–115. https://doi.org/https://doi.org/10.1016/j.jbusvent.2008.01.008

[38] Wiig, K. M. (1997). Integrating intellectual capital and knowledge management. Long Range Planning, 30(3), 399–405. https://doi.org/https://doi.org/10.1016/S0024-6301(97)90256-9

[39] Wright, P. M., & McMahan, G. C. (1992). Theoretical perspectives for strategic human resource management. Journal of Management, 18, 295–320. https://doi.org/10.1177/014920639201800205