HOTSPOTS AND TRENDS IN KEY COMPETENCIES ON SDG: A VISUALIZED ANALYSIS BASED ON CITESPACE

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ABSTRACT

Objective: Key competencies, regarded as essential elements in the development of curricula, have attracted considerable attentions in educational theory. To enhance comprehension of recent advancements, trending subjects, and research frontiers in the field of key competencies, this study collected related research and to provide a more distinct overview of the developmental patterns in key competencies.

Methods: This study reviewed key competencies research from 2000 to 2022 using Scopus and CiteSpace for visualization and analysis. Annual publishing volume and country (region) distributions were analyzed. Key competencies fields, basic contents, and research hotspots were analyzed using keyword co-occurrence. Research frontiers and development trends were analyzed using high-frequency keywords.

Results: The number of articles has steadily increased since 2005. The USA published the most, collaborating with Indonesia, the Netherlands, Russia, and India. Key competencies development and focus areas include "student", "21st century skill", "education", "curriculum", "learning". Developmental trends in key competencies include "education", "article", "professional competence", "problem solving".

Conclusion: The definition of key competencies and the content of curriculum reforms are attributed to variations in environments, cultures, and values among different international organizations and countries. Key competencies such as "communication", "information technology", "collaboration", and "mother tongue" are prioritized in educational environments.

Keyword: key competencies, citespace, country (regional) distribution, keyword co-occurrence, sustainable development goals (SDGs).

11 SUSTAINABLE CITIES AND COMMUNITIES

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1 INTRODUCTION

Since the 1990s, the emergence of globalized networked information technologies such as Google, Facebook, and Twitter has transformed society into what is commonly called "modern" and "post-modern". This shift has made conventional concepts of abilities, skills, and literacy inadequate to meet the rapidly changing demands of the information age (Lin, 2021). Information literacy skills, competency in navigating digital platforms, and readiness to adapt to changing trends in social informatization such as "Internet +", are considered essential (Huang *et al.*, 2016). In this context, the concept of key competencies has emerged, resulting in global educational and curricular reforms.

The Organization for Economic Co-operation and Development (OECD) conducted the "Definition and Selection of Competencies: Theoretical and Conceptual Foundations (DeSeCo)" educational project from 1997 to 2005. The DeSeCo project was the first to introduce the concept of key competencies worldwide (Organization for Economic Co-operation and Development, 2005). Various international organizations and countries give importance to developing educational curricula that emphasize key competencies to improve the education systems. For instance, the United Nations Educational Scientific and Cultural Organization Institute for Education (UIE) and the European Commission (EC) prioritize lifelong learning in their value orientation. UIE defined key competencies for individuals aged 0 to 19, including physical well-being, social and emotional, culture and the arts, literacy and communication, learning approaches and cognition, numeracy and mathematics, science and technology (Learning Metrics Task Force, 2013). The EC developed the "Key Competences for Lifelong Learning: A European Reference Framework" based on the DeSeCo Project to align with the requirements of European educational systems (European Commission, 2005). In addition, the Partnership for 21st Century Skills (P21) aims to address the needs of the modern workplace by highlighting the promotion of creativity and entrepreneurship (21st Century Skill Maps, 2013). Singapore's 21st century competencies focus on core values and the development of responsible and competent citizens (Tan *et al.*, 2017).

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Currently, international organizations and countries acknowledge the importance of theoretical development and practical application in key competencies for curriculum reform. Existing research primarily focuses on analyzing individual cases and practical experiences through content analysis. However these studies often provide descriptive analysis and do not systematically explore the theoretical underpinnings and developmental tends in key competencies. Moreover, the utilization of scientometrics in key competencies is not widely adopted, leading to a lack of comprehensive representation of research dynamics and developmental trends in this field. Therefore, this study will utilize CiteSpace as an analytical tool to conduct a comprehensive review to improve understanding of recent advancements, popular topics, and frontiers in research on key competencies. This study focused on the following research inquiries:1) What is the country (regional) distribution of research related to key competencies? 2) What are the current developmental and focal areas of interest regarding key competencies? 3) What are the developmental trends in relation to key competencies?

2 DATA AND METHODS

2.1 DATA COLLECTION

The Scopus database was used to conduct a literature search from 2000 to April 6, 2022. The search criteria comprised the TITLE-ABS-KEY terms: "Key competencies" OR "21st Century Skill" OR "21st Century Competencies". The literature types considered were article OR conference paper OR review. A total of 2728 articles were retrieved, and the downloaded bibliographic data included citation information, title details, abstracts, and keywords.

2.2 ANALYTICAL METHODS

The research tool CiteSpace 5.8.R3c, a visualization analysis software created by Professor Chaomei Chen, was utilized. CiteSpace emphasizes knowledge domains by visually representing the process of development and

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structural relationships within scientific knowledge. The CiteSpace knowledge map is created using advanced technology that analyzes citations in a multi-dimensional, real-time, and dynamic manner. The map illustrated the evolution of a knowledge domain within a unified citation network. The system automatically identified literature nodes as the knowledge base in the map, highlighting research frontiers through co-citation clusters (Chen *et al*., 2015).

3 RESULTS ANALYSIS

3.1 ANNUAL DISTRIBUTION OF PUBLICATIONS

Figure 1 showed the chronological development of research on key competencies. There is a notable decline in the number of articles from 2000 to 2004, with articles consistently remaining below 10. From 2005 to 2021, the number of articles gradually increased, reaching in a peak of 458 in 2021. This suggested that researchers are increasingly recognizing and valuing key competencies, which are gaining a significant attention for future educational developments.

Figure 1

Chronological development of research on key competencies.

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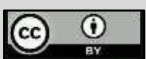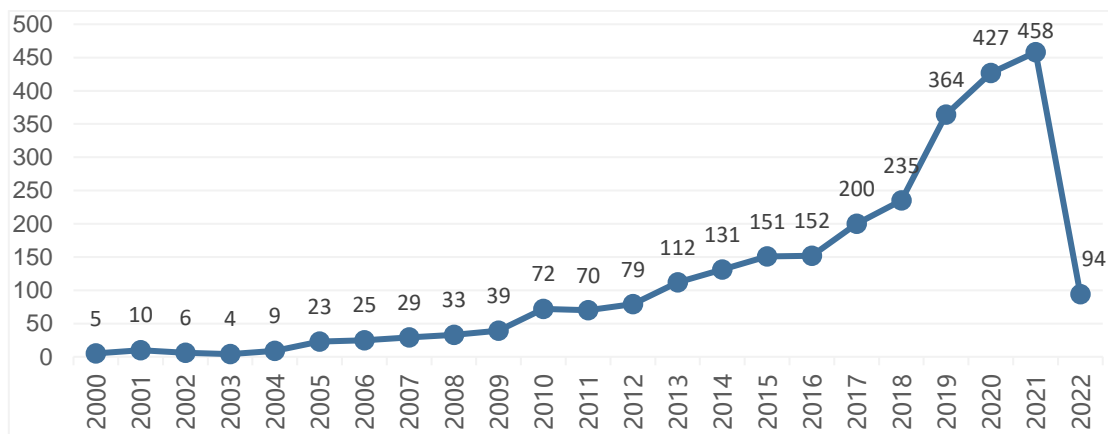
3.2 COUNTRY (REGIONAL) DISTRIBUTION ANALYSIS

The country (or regional) distribution can elucidate the research scope and impact, along with their interdependent cooperative relationships. The CiteSpace software was configured with time slicing, covering the time from January 2000 to May 2022. Each time slice had a duration of 1 year. The node types were labeled as "Country", with the selection criteria set to Top N=50, while the remaining parameters were maintained at their default values. Figure 2 showed the visualization map. Only nodes with a minimum of 20 articles were shown to enhance clarity. The statistical data in the upper left corner of the map indicated that the final knowledge map had 319 nodes and 429 edges, with a density of 0.0085. The map illustrated numerous connections between nodes, with the number of edges indicating the level of connectivity between nodes. More edges indicate strong connections between nodes. Moreover, the analysis included ranking and examining the number of publications that are not depicted on the map, as well as the significance of betweenness centrality among intermediaries, as shown in Table 1.

Figure 2

Visual mapping of country (region) distribution (number of posts ≧ 20).

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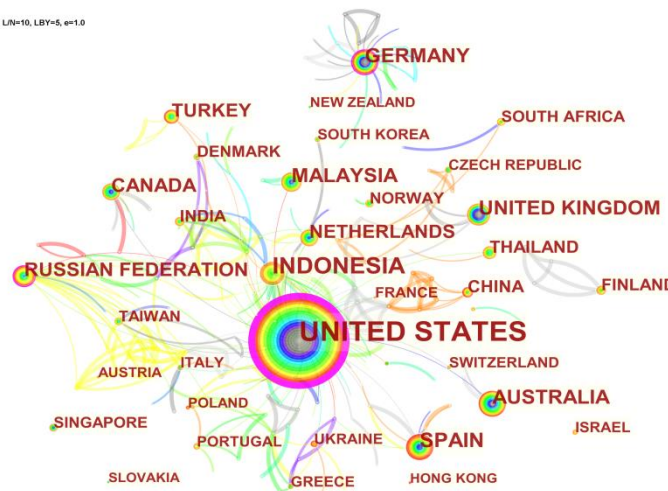
Table 1

*Country (region) literature counts and **betweenness** centrality (top ten).*

	Country (region) counts(top ten)	literature	Country (region) centrality(top ten)	betweenness
Ranking	Country (region)	Literature counts	Country (region)	Betweenness centrality
1	UNITED STATES	704	UNITED STATES	0.88
2	INDONESIA	235	GERMANY	0.18
3	SPAIN	112	RUSSIAN FEDERATION	0.13
4	MALAYSIA	100	INDONESIA	0.06
5	GERMANY	97	CANADA	0.05
6	AUSTRALA	95	TURKEY	0.04
7	UNITED KINGDOM	93	INDIA	0.04
8	RUSSIAN FEDERATION	87	ITALY	0.04
9	CANADA	84	SPAIN	0.03
10	TURKEY	71	NETHERKANDS	0.03

Table 1 showed that the United States had the highest number of publications, with 704 articles, accounting for 25.8% of the total. Indonesia, Spain, Malaysia, Germany, Australia, the United Kingdom, Russia, Canada, and Turkey are placed behind the United States. The centrality strength coefficients for the United States, Germany, and Russia all exceed 0.1. This indicates that their research outputs were frequently cited and had a significant influence. Strong connections in collaboration existed across countries such as the United States, Indonesia, the Netherlands, Russia, and India. In contrast, Singapore, Slovakia, Israel, and Hong Kong conducted independent research on key competencies.

3.3 KEYWORD CO-OCCURRENCE ANALYSIS

The term "keyword" refers to the core research topics concentrated within a specific period (Chen *et al.*, 2015). The CiteSpace software was configured with the node type marked as "Key Word". The selection criteria were set to Top N=50. The minimum spanning tree and pruning the merged network were applied, while the remaining parameters were maintained at their default settings. The keyword co-occurrence visualization map in Figure 3 utilized a node threshold of a minimum of 3 for enhanced clarity. The statistical data in the upper left corner of the knowledge map showed 823 nodes and 405 edges, with a density of 0.0012. This suggests a network structure with

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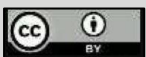
low density, indicating a loosely connected network. Furthermore, the data related to primary keywords underwent statistical analysis based on word frequency, as shown in Table 2.

Figure 3

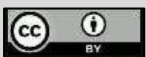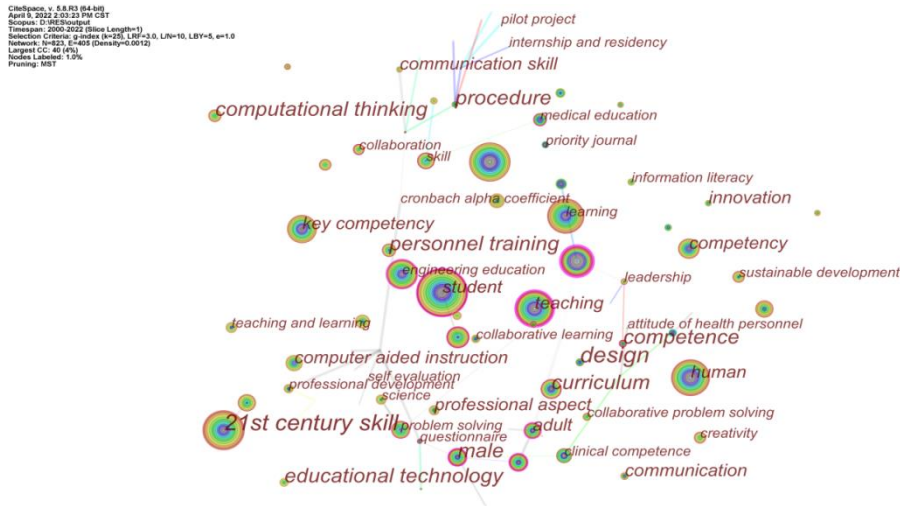*Visual mapping of keyword co-occurrence on key competencies (frequency ≧ 3)*

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Table 2

Statistics on high-frequency keywords on key competencies (top 20)

Serial number	Word Frequency	Keyword	Between ness centrality	Year	Serial number	Word Frequency	Keyword	Between ness centrality	Year
1	636	Student	0.47	2000	11	129	Competency	0.05	2001
2	540	21st Century Skill	0.03	2005	12	129	Critical Thinking	0.08	2006
3	357	Education	0.00	2002	13	123	Higher Education	0.05	2009
4	288	Curriculum	0.22	2000	14	104	Problem Solving	0.25	2006
5	285	Learning	0.02	2005	15	97	Learning System	0.01	2005
6	264	Human	0.01	2002	16	86	male	0.31	2007
7	259	Teaching	0.92	2000	17	86	Female	0.36	2007
8	241	Engineering Education	0.43	2000	18	85	Computer Aided Instruction	0.02	2012
9	203	Key Competency	0.02	2001	19	84	Survey	0.00	2012
10	153	Education Computing	0.29	2009	20	82	Clinical Competence	0.14	2005

Through analyzing co-occurrence and high-frequency keywords on key competencies, this study summarized four themes: connotations of key competencies, dimensions of key competencies, and the correlation between key competencies and curriculum. First, the keywords related to the connotations of key competencies included "21st century skill", "key competency", and "competency". Second, the keywords related to the dimensions of key competencies included "critical thinking", "problem solving", "computer aided instruction", and "clinical competence". Third, the keywords related to the correlation between key competencies and curriculum included "student", "education", "curriculum", "learning", "teaching", and "learning system".

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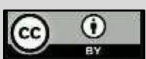
3.3.1 The connotations of key competencies

The DeSeCo project proposes that competencies encompass more than just knowledge and skills. The concept involves utilizing psychosocial resources such as skills and attitudes (Organization for Economic Co-operation and Development, 2005). The EC suggests that key competencies are essential for personal growth, active participation in society, social integration, and career opportunities (European Commission, 2005). New Zealand aligns its education philosophy with the OECD's definition of key competencies, which are essential for **people to acquire and develop for present and future living and learning** (New Zealand Curriculum Online, 2017). In 2003, the UIE proposed five fundamental principles of learning for lifelong learning: "learning to know, learning to do, learning to live together, learning to be, and learning to change." (United Nations Educational Scientific and Cultural Organization Institute for Education, 2003).

In 2002, corporations such as Dell, Apple, Cisco, and Intel founded the P21. The primary goal of P21 was to develop the essential "21st century skills" required for the information age and knowledge-based economy (Partnership for 21st Century Learning, 2007). The "21st Century Skills" framework has had a profound impact on Singapore and Japan. In 2010, Singapore established the Framework for 21st Century Competencies and Student Outcomes, which includes core values, social-emotional competencies, and 21st century competencies" (Tan *et al.*, 2017). In 2013, the Japan's National Institute for Education Policy Research (NIER) developed a framework of "21st century competencies" based on the educational concept of "zest for life", incorporating academic ability, humanity, and a sound body. NIER focused on developing interdisciplinary competencies and creating three categories: basic literacy, thinking ability and practical ability to act for the world (NIER, 2014).

Table 3

Definitions of key competencies by international organizations and countries

International Organizations/Countries	Connotations
Organization for Economic Co-operation and Development	Key competencies empower individuals to have a successful life and a well-functioning society.
United Nations Educational Scientific and Cultural Organization Institute for Education	Key competencies emphasize lifelong learning and are guided by the concept of lifelong learning, which encompasses the principles of "learning to know, learning to do, learning to live together, learning to be, and learning to change."
European Commission	key competencies are those which all individuals need for personal fulfilment and development, active citizenship, social inclusion and employment.
United States	21st century skills describes the skills, knowledge, and expertise students must master to succeed in work and life; it is a blend of content knowledge, specific skills, expertise, and literacies.
United Kingdom	Key competencies describe the skills, knowledge, and attitudes necessary for individuals to succeed in adult life and increase employment opportunities
Australia	Key competencies are competencies essential for effective participation in the emerging patterns of work and work organization. They focus on the capacity to apply knowledge and skills in an integrated way in work situations
New Zealand	**Key competencies are the capabilities people have and need to develop, to live and learn today and in the future.**
Japan	Holistic qualities and abilities that include not only knowledge but skills and attitudes.
Singapore	21st century competencies aim of developing in students the necessary knowledge and competencies to respond to challenges ahead.
China	Key competencies for student development are essential qualities that students need to adapt to lifelong and social development.

From Table 3, the conceptualization of key competencies in international organizations and countries emphasizes being future-oriented and contemporary, highlighting their political, economic, and cultural traits. Discrepancies in the definitions of key competencies stem from differences in environments, cultures, and values across various organizations and countries. Furthermore, they play significant emphasis on connecting key competencies with the realms of politics, economy, and culture. For instance, the educational system in China is heavily influenced by confucianism, which prioritizes moral development over skill acquisition (Peng & Deng, 2017). China focuses on the development of "well-rounded individuals" by considering the country's historical and contemporary cultural characteristics. This framework seeks to

combine Chinese heritage and innovation to enhance the fundamental competitiveness of the nation's talent in the 21st century (Lin, 2021). In contrast, the educational system in the United States is significantly influenced by pragmatism, which emphasizes independent thinking. It focuses on individuality, aiming advance the economy rather than public (moral) (Braun, 2013). The United States framework for 21st century skills emphasizes the value of skills but seems to give less importance on the development of moral norms. Some researchers argued that the United States framework for 21st century skills places excessive emphasis on skills and neglects the significance of subject knowledge (Ravitch, 2009; Hirsch, 2011).

It is essential to recognize that the cultural, historical, economic development, and social structures across various countries and organizations have a considerable influence on the implementation of key competencies. Developed countries prioritize innovation and technological advancements, while developing countries prioritize fundamental education and social citizenship skills to address their specific requirements. With the evolution of society and technological progress, the definition and criteria for key competencies are constantly changing. Policymakers need to be sensitive and flexible, adapting key competency frameworks promptly to accommodate the changing environment.

3.3.2 The dimensions of key competencies

International organizations and countries have not yet to reach a consensus on defining key competencies, leading to variations in their value propositions. Despite the diversity, key competency indicators share common content dimensions.

This study systematically synthesized 17 components of key competencies. Table 4 presented the key competencies across 10 prominent international organizations and countries.

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Table 4

A comparison of key competencies among international organizations and countries

Indicators	OECD	UIE	EC	United States	United Kingdom	Australian	New Zealand	Singapore	Japan	China
Communication	√	√	√	√	√	√	√	√	√	√
Collaboration	√	√	√	√	√	√		√	√	√
Mother tongue	√		√	√	√		√	√	√	√
Foreign languages	√		√	√				√		
Critical thinking		√		√				√	√	√
Problem solving				√	√	√			√	√
Creativity and innovation				√	√			√	√	√
Learning to learn			√	√						√
Information technology	√	√	√	√	√	√	√	√	√	√
Autonomous development	√	√			√		√		√	√
self-management				√				√	√	
Mathematical competencies	√		√		√		√	√	√	
Socially engaged				√	√	√	√		√	√
Civic awareness	√		√	√				√		
Respect and tolerance	√	√	√							√
Environmental awareness and sustainable development thinking					√				√	
Aesthetic competencies				√						√

[a]OECD, Organization for Economic Co-operation and Development
[b]UIE, United Nations Educational Scientific and Cultural Organization Institute for Education
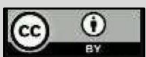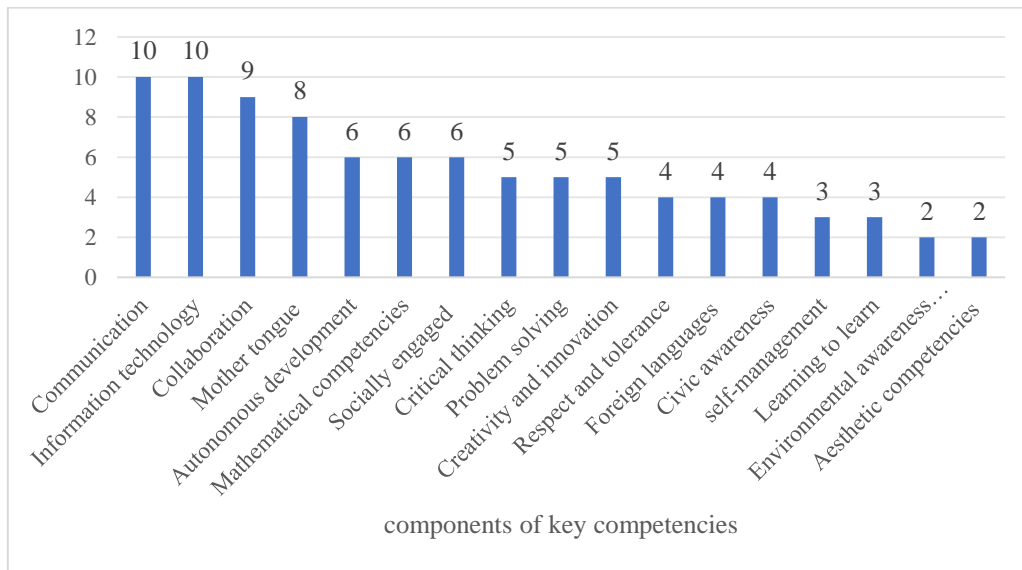[c]EU, European Commission

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Figure 4

Components of key competencies across international organizations and countries.

components of key competencies

Communication, information technology, collaboration, and mother tongue are highly valued as important components of key competencies. The emphasis of key competencies reflects the current trends in education and social development. Hymes (1972) introduced the concept of "Communicative Competence" as the ability to communicate effectively in a specific context. Effective communication competence allows individuals to interact smoothly across social classes, advance in their careers, and engage actively in society (Ellis, 2002). Furthermore, there is a strong correlation between communication competence and students' academic performance. Proficient reading abilities are indicative of academic success. Conversely, individuals with communication anxiety tend to communication less with their instructors outside of the classroom, leading to lower academic performance and a higher risk of discontinuing their studies (Metusalem *et al*., 2017).

The competency in information technology is essential in the contemporary digital era. This skill has an impact not only on individuals' job advancement but also on the progress of the economy and society. Research showed that enhanced information technology skills can improve student's learning outcomes and competitiveness in the job market (John, 2015). Possessing strong information technology skills in the workplace can increase

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employees' work efficiency (Ünal & Mete, 2012), collaboration, information acquisition, and decision-making abilities (Tafti *et al.*, 2007). Advanced technologies such as artificial intelligence and big data are expected to lead to a greater diversity and complexity of information technology competencies in the near future.

The collaboration highlights the significance of teamwork and cross-cultural communication in effectively addressing globalization and the blending of diverse cultures. Research showed that the development of collaboration skills can improve students' learning abilities. For instance, collaboration has shown to enhance academic achievement, motivation, and independence (Gillies, 2003). Additionally, it facilitates the cultivation of advanced cognitive abilities, including higher-order thinking skills, long-term memory consolidation, and critical thinking (Gokhale, 1995). Furthermore, research indicated that teamwork offered greater adaptability, productivity, and creativity in comparison to individuals (Salas *et al.*, 2005). It also enhances job satisfaction and employee retention rates (Heywood & Jirjahn, 2004). Therefore, developing collaboration competency is essential for individual growth, achieving organizational objectives, maintaining social interactions, and promoting social advancement.

The cultural heritage and mother tongue education of a country or ethnic group are intricately interconnected. The acquisition of mother tongue involves comprehending the culture of the ethnic community as well as establishing cultural identity. Proficiency in mother tongue is essential for personal cognitive growth and preservation of cultural legacy. Language serves not only to express ideas but also to deepen understanding of ethnic traditions.

Table 3 and Figure 4 indicate that the emphasis on key competencies by international organizations and countries transcends specific domains, reflecting a pronounced inclination towards diversity and comprehensiveness. This emergent trend, directed towards fostering the holistic development of individuals and facilitating sustainable social progress, has assumed a pivotal role in the landscape of global education.

3.3.3 The correlation between key competencies and curriculum

In the analysis of keyword co-occurrence, "students", "education", and "curriculum" ranked first, third, and fourth, respectively. This underscores the fact that international organizations and countries emphasize the educational significance of key competencies. Policymakers stress the importance of educational institutions preparing students for knowledge-based societies through competency-based curriculum. Several countries implemented curriculum reforms driven by key competencies through the revision of specific content standards. For example, "The New Course of Study" in Japan focuses on key competencies to promote knowledge and critical thinking skills. It emphasizes the development of particular skills through formal education in schools (Kimura & Tatsuno, 2017). Similarly, the curriculum in New Zealand, known as "The New Zealand Curriculum", is structured based on values, key competencies, and learning areas. This framework aims to support young individuals in achieving their aspirations of developing into confident, connected, and actively involved lifelong learners (New Zealand Curriculum Online, 2017).

Educational standards and curricular systems are based on key competencies within diverse socio-cultural contexts. Due to the cultural, racial, and religious variations in American society, the majority of states have adopted the Common Core State Standards (CCSS) in the absence of a standardized national curriculum (Halász & Michel, 2011). Conversely, China has developed a unified national curriculum and standards that are grounded in the framework of key competencies. All school across the country adopt essential features derived from the national curriculum, aiming to cultivate a wide range of key competencies throughout the academic curriculum.

In recent years, Asian countries have shown a growing emphasis on improving key competencies within schools, whereas several European nations have redirected their research attention towards student learning (Voogt & Roblin, 2012). For instance, the educational policy in Denmark has transitioned its focus from prioritizing 21st-century skills to placing greater importance on examinations and the student learning (Bryderup *et al.*, 2009). Conversely,

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Singapore placed a greater emphasis on addressing students' needs during the execution of the curriculum. This approach provides students with greater autonomy in their learning process, which facilitates the development of diverse skills and knowledge (Koh *et al.*, 2009).

3.4 TRENDS IN KEY COMPETENCIES RESEARCH THEMES

Burst terms refer to keywords that experience a sudden increase in frequency within a specific timeline. In order to explore the emerging trends of key compeyencies, CiteSpace was utilized with the parameter configuration "Burstterms" to generate a burst term graph illustrating the top 10 keywords in key competencies (Figure 5).

Figure 5

Mutability analysis of the first 10 high-frequency keywords

All keywords demonstrated a strength exceeding 8.0, with the highest one reaching a peak of 26.58. The primary keywords before to 2014 were "article", "professional competence", "priority journal", "key competency", "United States", and "information technology". Following 2014, a notable shift occurred in the primary keywords of research focus, highlighting terms such as "education," "problem solving", "standard", and "learning process". The variability in keywords may indicate a change in academic focus during this timeline. The alterations in keywords may be attributed to a variety of factors, including societal, technological, and educational reforms. The prevalence of

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information technology and shifts in educational ideologies may have contributed to a decrease in the usage of terms such as "information technology". Conversely, the rise in terms like "education", "problem solving", and "learning process" indicates emerging interests and considerations regarding educational standards and pedagogical approaches. By conducting a thorough analysis of the changes in keyword usage, a deeper comprehension of the research dynamics and trend progression within the academic community can be achieved. This offers crucial insights and guidance for forthcoming academic research endeavors.

4 CONCLUSIONS

Research on key competencies showed a consistent increase annually, particularly since 2005. The United States has significantly contributed to this field by engaging in extensive collaborations with other countries, including Indonesia, the Netherlands, Russia, and India. The keyword co-occurrence analysis suggests that the connections between research themes are limited. Current research trends predominantly center around themes like "student", "21st century skill", "education", "curriculum", "learning". The research frontier is currently investigating various areas such as "education", "article", "professional competence", "problem solving". This study further explored the connotations, dimensions of key competencies, and correlation between key competencies and curriculum. It revealed variations and similarities in the definitions, implementations, and policy developments of key competencies among different international organizations and countries. Through a comparative analysis, this study revealed that, notwithstanding cultural and policy variations, a significant international organizations and countries underscore the paramount significance of communication skills, proficiency in information technology, and collaborative capabilities. The acquisition of these skills is essential in contemporary society and plays a significant role in shaping individual career advancement and successful integration into intricate social frameworks.

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