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Social network analysis of digital learning in Southeast Asia: trends and insights from X

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Abstract

Purpose – This study investigates how digital learning is discussed, structured and disseminated through social media in Southeast Asia. It aims to uncover the influential actors, thematic patterns and platform dynamics shaping discourse on K-12 digital education, with emphasis on visibility, engagement and cross-sector collaboration.

Design/methodology/approach – The study employs social network analysis (SNA) using NodeXL to examine a dataset of 745 X (formerly Twitter) users from the Philippines, Malaysia, Indonesia and Thailand. Centrality metrics, modularity scores, hashtag usage and shared URL data were analyzed to map actor influence, cluster formation and discourse patterns within the digital learning ecosystem.

Findings – The study revealed that digital learning discourse on Platform X in Southeast Asia is shaped by a fragmented network of actors, including global organizations, ministries, tech companies and community groups. Central users such as Huawei Tech4All, UNESCO and MDEC played bridging roles across modularity clusters. However, cross-sector interactions remained limited. Hashtag and URL analysis showed themes of equity, infrastructure and sustainability, with media and institutional links anchoring discourse. Local actors like Phil-IT Org and GM Learning Club contributed grassroots visibility. These patterns highlight a need for stronger regional coordination to align digital learning narratives with school-level transformation goals.

Research limitations/implications – This research is limited to data collected from Platform X and does not account for discussions on other platforms or private groups. While central actors are identified, the content of interactions and their sentiment were not analyzed, limiting insights into tone and intention.

Practical implications – The findings underscore that governments, nongovernment organizations, technology firms and grassroots groups can be more effective in advancing digital learning when their efforts are coordinated rather than fragmented. Strengthening partnerships among these actors can bridge existing gaps, reduce duplication and create synergies that maximize resources for K-12 digital education. These insights provide a basis for designing collaborative strategies that align policy, technology and community engagement toward more equitable learning outcomes.

Social implications – The study reveals that digital learning discourse remains fragmented across institutional, corporate and community-based actors. Strengthening alignment and visibility among these groups can reduce duplication of efforts, amplify marginalized voices and promote digital equity, particularly within K-12 education systems.

Originality/value – This study is among the first to apply social network analysis to digital learning discourse in Southeast Asia. It offers a data-driven lens on how digital learning narratives circulate, who drives them and how communication networks can be leveraged for broader educational transformation.

Keywords Southeast Asia, Social network analysis, Digital learning

Paper type Research article

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Introduction

Digital learning has become a defining feature of 21st-century education, broadly understood as the purposeful integration of digital technologies into teaching and learning. It encompasses pedagogy, infrastructure, assessment and systemic reform (Marcus-Quinn & Hourigan, 2017; McFarlane, Mieruch, & Wann Si, 2024; Zou, Kuek, Feng, & Cheng, 2025) and is embedded in national strategies (Fang *et al.*, 2022; Pillay & Pant, 2022) across Southeast Asia to improve outcomes and foster digital citizenship and competitiveness in the digital economy (Fang *et al.*, 2022; Marcus-Quinn & Hourigan, 2017; Nguyen *et al.*, 2024; UNESCO, 2021).

Early pre-pandemic efforts of digital learning in Southeast Asia aimed at expanding access to education, leveraging online platforms and integrating technology into traditional learning environments. Countries like Malaysia, the Philippines, China and India had already begun incorporating Massive Open Online Courses (MOOCs), learning management systems (LMS) and blended learning models to address educational gaps, particularly in remote and underserved areas (Bandalaria & Alfonso, 2015).

According to Priyanto and Suhandi (2022), Indonesia's digital learning efforts have been primarily driven by the Ministry of Education and Culture's initiatives to enhance online platforms and digital competencies among lecturers, despite disparities in internet accessibility, particularly in Eastern Indonesia, remaining a major challenge. Thailand, on the other hand, has long recognized the transformative potential of digital technologies in education, integrating digital learning initiatives into national development strategies. The Thailand 4.0 policy framework and the ICT2020 Policy Framework laid the foundation for leveraging technology to enhance education accessibility and quality (Rukspollmuang, 2016).

At the practical level, digital learning has been most visible through digital technologies such as Information and Communication Technology (ICT) infrastructure and internet connectivity, which form the backbone for computer-mediated instruction, adaptive platforms and other technology-enabled practices (Nguyen *et al.*, 2024). However, these digital technologies do not operate in isolation but are embedded within broader ecosystems of systemic policy and stakeholder support. In a study of Timotheou *et al.* (2023), they highlight that while ICT integration has transformed teaching and learning, its impact depends on interconnected factors such as infrastructure quality, government and institutional support, teacher competence and socio-economic contexts. Their review shows that gains in student achievement, teacher practices, and school operations are uneven, often hindered by inadequate connectivity, insufficient training or gaps in systemic readiness.

Although government across Southeast Asia have begun addressing these concerns through national strategies that expand broadband, provide devices and integrate digital skills into curricula, the efforts remain insufficient, particularly where structural inequalities and digital divides persist (Pillay & Pant, 2022). Evidence from Malaysia reveals that such divides can be mitigated when policymakers and stakeholders work hand in hand and the call for collaborative efforts between the Ministry of Education, local schools and technology providers has begun to bridge these gaps and promote greater educational equity (Fang *et al.*, 2022; Yap *et al.*, 2024).

However, research on digital learning in Southeast Asia has focused primarily on how it is implemented in schools, infrastructure challenges and equity gaps (Fang *et al.*, 2022; Greenhow, Graham, & Koehler, 2022; Tang, Kamarudin, Rahman, & Zhang, 2024; Timotheou *et al.*, 2023) without examining how these initiatives are represented and interconnected in public communication. This study addresses that gap by applying social network analysis (SNA) to discourse on Platform X, mapping the influential actors, partnerships and narratives that shape digital learning across the region with particular attention to the complementary roles of NGOs, private corporations and international organizations (Williamson & Jun, 2023).

Review of past studies

Research on digital learning in Southeast Asia has consistently highlighted two parallel narratives: the introduction of technology-enabled initiatives and the challenges that have

constrained their effectiveness. Early studies described national investments in LMS, MOOCs and blended learning programs as strategies to expand access and modernize pedagogy (Bandalaria & Alfonso, 2015; Priyanto & Suhandi, 2022; Rukspollmuang, 2016). These initiatives demonstrated strong policy commitment but also revealed barriers that limited their impact, including uneven infrastructure, disparities between rural and urban contexts, and insufficient teacher training (Timotheou *et al*., 2023).

The promise of digital learning as a tool for equity was therefore undercut by systemic gaps in readiness. While LMS platforms were introduced to provide continuity and reach remote learners in Sabah, Malaysia, studies noted persistent issues with connectivity, lack of devices, and low levels of digital competence among educators (Fang *et al*., 2022; Nguyen *et al*., 2024). This aligns with evidence in a study by Sailer, Murböck, and Fischer (2021) who found that teachers' digital skills and their ability to integrate technology into pedagogy were more crucial than the mere availability of digital resources. Their results indicate a needed shift in focus from infrastructure provision toward strengthening teacher capacities to use digital technologies effectively.

In a study on the digitalization of Philippine education highlighted both opportunities and systemic challenges, particularly in underserved communities. Using a phenomenological design with focus group discussions and interviews, the research identified three key barriers: inadequate infrastructure and resources, socioeconomic inequalities that deepen the digital divide, and difficulties faced by teachers and students in adapting to digital methods due to limited training and systemic constraints (Kunjiapu, Sinnappan, Anor Salim, & Kunasegaran, 2025). The authors recommend a unified digital education ecosystem supported by public–private partnerships, expanded broadband access and affordable device provision.

Studies across ASEAN consistently point to the digital divide as the central challenge in advancing digital learning. McFarlane *et al*. (2024) reviewed policies in Cambodia, Malaysia, Thailand and the Philippines and found a heavy emphasis on demand-side measures such as device provision, teacher training and digital curriculum integration, but relatively weak supply-side policies for reliable school connectivity. Through a systematic review of Tang *et al*. (2024), they claim that the digital divide remains multidimensional. While infrastructure access is the most visible barrier, socioeconomic status, affordability and digital literacy significantly shape who benefits from online learning. Marginalized groups, particularly rural learners, low-income families and students with special needs, continue to face compounded disadvantages. Teacher self-efficacy and emotional resilience also emerged as critical, but they have paid less attention to the factors that affect the quality of digital teaching and student engagement.

Together, these reviews show that infrastructure and policy reform alone are insufficient unless paired with inclusive pedagogical practices, targeted support for disadvantaged learners and capacity-building for teachers. The trend in the literature moves from documenting basic access challenges toward advocating for integrated, multi-stakeholder solutions involving governments, private corporations, NGOs and grassroots communities to achieve genuine educational equity in the digital era.

UNESCO as a specialized agency of the United Nations (UN) plays a crucial role in supporting and advocating for digital learning initiatives across diverse socioeconomic contexts. Through multi-stakeholder networks such as the Global Education Coalition (GEC) and the Global Skills Academy, UNESCO collaborates with governments, educational institutions and private sector partners to promote digital learning, skill development, and employment readiness programs (Orr, 2023). However, for these initiatives to reach their full potential, visibility and engagement in digital spaces play a crucial role in amplifying their impact, fostering accountability and encouraging discourse within global and regional education communities.

While much of the literature has focused on digital learning adoption in schools and policy solutions to the digital divide, a growing body of research shows that social media is also becoming a digital learning space where students, educators, institutions and other stakeholders interact, share resources and shape discourse outside formal platforms. Social

media has evolved into a critical site of learning, complementing traditional platforms such as LMS. Web 2.0 technologies enabled interaction, collaboration and knowledge exchange, attracting students worldwide (Greenhow & Chapman, 2020; Kumar & Nanda, 2024). Platforms like Facebook, X (formerly Twitter), and Instagram have been shown to foster interactive learning and community engagement (Alshalawi, 2022; Literat & Kligler-Vilenchik, 2021; Momani, Alharahasheh, & Alqudah, 2023) often offering more participatory spaces than formal LMS (Barrot, 2021; Niu, 2019). While concerns about overuse persist (Aslan & Polat, 2024; Peng & Liao, 2023), research increasingly emphasizes the value of social networks as environments that promote peer interaction, knowledge sharing and skill development (Biddix, Park, Collom, Bailey, & Park, 2023; Pasquel-López, Rodríguez-Aceves, & Valerio-Ureña, 2022; Perez, Manca, Fernández-Pascual, & Mc Guckin, 2023; Smith-Mutegi, Mamo, Kim, Crompton, & McConnell, 2025).

Empirical studies confirm this shift. Sivakumar, Jayasingh, and Shaik (2023) demonstrated that student motivation and reputation strongly influence knowledge-sharing practices, reinforcing social media's role as an educational tool. Similarly, Bokányi, Heemskerk, and Takes (2023) showed how online networks differ from offline structures, noting that digital platforms like X facilitate more fluid, decentralized exchanges compared to traditional household or institutional ties. This positions X as a distinctive environment for education-related discourse, where hashtags, retweets and open discussions enable rapid dissemination and community formation (Rodríguez-Ibánez, Casánez-Ventura, Castejón-Mateos, & Cuenca-Jiménez, 2023). In a study conducted by Logan, LaCasse, and Lunday (2023), they were able to provide strong empirical evidence supporting SNA as a robust framework for studying user interactions, content dissemination and digital learning discourse on Twitter. By utilizing multilayer networks, topic modeling and community detection algorithms, SNA provides a structured approach to analyzing digital learning trends, adoption behaviors and community engagement. Given the increasing reliance on X and other social media platforms for education-related conversations, applying SNA allows researchers to move beyond individual case studies and gain large-scale, data-driven insights into digital learning ecosystems (Pasquel-López *et al.*, 2022; Perez *et al.*, 2023).

Beyond academic, social media has become an indispensable and deeply integrated part of modern life, influencing both personal and professional interactions across the globe. According to Chasanah and Maryam (2022), the digital landscape has evolved from a static repository of information into a dynamic, participatory ecosystem where users engage, share and curate content based on personal interests and societal trends. This shift has significantly impacted the way individuals seek information, as users now tend to gravitate toward content that aligns with their beliefs, interests and social circles reinforcing engagement patterns that drive visibility and influence (Hussin, Chin, Sondoh, & Choo, 2024; Islm *et al.*, 2021). The interactivity and algorithm-based nature of social media platforms (Oliveri & Carpenter, 2024) also encourages users to keep updating, responding and reacting to information (Purnama, Ulfah, Machali, Wibowo, & Narmaditya, 2021), making social media not just a communication tool but a powerful mechanism for knowledge dissemination and public discourse formation. In this context, universities, scholars and professionals leverage social media not only to share insights but also to shape institutional narratives, promote expertise and strengthen their influence within academic and industry network.

Since this study focuses on how digital learning discourse forms and spreads on social media, SNA is appropriate for identifying key actors, clusters and information pathways. SNA is a methodological approach that focuses on analyzing nodes (actors or entities) and edges (connections or interactions) to map the structure of relationships in a given network (Biddix *et al.*, 2023; Khor & Darshan, 2022; Miller, 2023). This makes it possible to see which actors are central, how groups form and how information moves across the network (Miller, 2023; Tabassum, Pereira, Fernandes, & Gama, 2018).

In this study, SNA helps identify which actors (universities, educators, scholars and institutions) function as central nodes in knowledge dissemination. These actors shape

educational discourse by amplifying content, taking part in discussions and promoting institutional expertise. The degree of centrality, betweenness and closeness in a network reflects how influential an actor is within the system (Freeman, 1978; Saqr, Elmoazen, Tedre, López-Pernas, & Hirsto, 2022; Scott, 2002). High-centrality actors can serve as source of information, ensuring that digital learning, research findings and policy discussions reach a broader audience. Through retweets, citations, mentions, and engagement metrics, SNA helps trace how digital learning narratives gain traction and shape public perception (Biddix *et al.*, 2023; Ghahramani, Prokofieva, & de Courten, 2025; Logan *et al.*, 2023). In the study of Ghahramani *et al.* (2025), where they employed co-occurrence network analysis and association rules mining to investigate how hashtags interconnect in health promotion campaigns, it was revealed that highly engaged hashtags such as #AmericanHeartMonth and #OurHearts served as central nodes in public health discourse. The findings suggest that hashtags function similarly to high-centrality actors in digital learning networks, connecting diverse audiences and structuring knowledge dissemination pathways.

To contribute to the body of research on SNA in digital learning, this study explores how digital learning is perceived and influenced by examining user interactions, content dissemination and discussion structures on social media.

Research methodology

This study employs an SNA approach to investigate digital learning discussions on Platform X (formerly known as Twitter) in selected Southeast Asian countries, namely the Philippines, Malaysia, Indonesia and Thailand. The research focuses on analyzing the perception and influence of digital learning in Asia on social media by studying the user interactions, content dissemination and the structure of discussions surrounding digital learning.

Data collection

Data were collected using systematic search queries with relevant keywords, including "Digital Learning," "Philippines," "Malaysia," "Indonesia" and "Thailand." The study identified and extracted tweets from 745 Platform X users who recently engaged with these keywords or were mentioned in relevant tweets. The data collection period spanned from February 2022 to February 2025.

To ensure data quality and relevance, specific inclusion and exclusion criteria were applied. The inclusion criteria considered only active users who posted tweets, were mentioned, or otherwise participated in conversations related to digital learning. Conversely, accounts that had been inactive for more than six months or had fewer than 100 followers were excluded. These criteria were adopted to minimize noise in the dataset and to focus the analysis on users with a broader potential reach and more consistent engagement.

Data analysis

Social network analysis. A network graph was generated using NodeXL, a social network analysis tool integrated with Microsoft Excel that allows users to import, visualize, and analyze complex network data (Hansen, Shneiderman, & Smith, 2011). NodeXL is particularly useful for identifying key actors, detecting clusters and measuring network centrality, making it a valuable tool for studying user interactions and content dissemination patterns in digital learning environments. This is a social network analysis tool integrated with Microsoft Excel that allows users to import, visualize and analyze complex network data. Previous studies have applied similar approaches to hashtag-based datasets. For example, Biddix *et al.* (2023) used #highered, while Smith-Mutegi *et al.* (2025) used #STEM in searching for words and also reported #AI4ALL as a trending topic Ellis (2024) likewise used NodeXL to visualize and analyze the discourse network around #nutrition on X). The current

study examines how digital learning discussions take shape by analyzing how information spreads between users and how engagement influences the exchange of ideas.

Table 1 presents the key network metrics analyzed in this study. The dataset includes 745 users (vertices) and 953 connections (edges), representing interactions within the digital learning discourse. The network is divided into 505 connected components, showing various sub-communities within the discussion. The maximum geodesic distance, which measures the longest shortest path between any two users in the network, is 8, indicating the reachability of users within the discourse. The graph density is 0.000454644, reflecting a sparsely connected network where most users engage in limited interactions. Lastly, the modularity value is 0.445458, which suggests that the network has distinct communities. This may indicate that conversations are clustered by topic and that users engage mainly within specific groups.

The study identified 98 distinct groups, with the eight most prominent groups examined in detail. Group 1 emerged as the largest, highlighting concentrated interactions among specific users.

User influence metrics

To evaluate user influence within the network, three key indicators were applied. First, betweenness centrality was used to identify users who served as bridges between different clusters of discussion. Second, in-degree and out-degree centrality measured the frequency of interactions and overall engagement of users within the discourse. Finally, follower count was considered to capture the potential reach of each user and their capacity for information dissemination.

The top 10 influential users were ranked based on their betweenness centrality scores, comprising organizations, government agencies, educational institutions and technology companies that actively promote digital learning.

Hashtag and URL analysis

This study identified the top 10 hashtags used in tweets, revealing key digital learning themes. The most frequently used hashtags included #digital (44 occurrences), #learning (37 occurrences) and #Indonesia (24 occurrences). Additionally, the study examined the top 10 URLs shared in tweets, which linked to news publishers, educational institutions and technology platforms that actively promote digital learning initiatives. These findings provide insights into the thematic focus of discussions and the primary sources of information within the digital learning network.

Ethical considerations. This study adhered to ethical guidelines for digital research by analyzing only publicly available tweets and ensuring user anonymity. Data were used strictly for research purposes, with no alteration or misrepresentation of user-generated content.

Table 1. Summary of the search queries “Digital Learning,” “Philippines,” “Malaysia,” “Indonesia” and “Thailand”

Graph metric	Value
Number of vertices	745
Total edges	953
Connected components	505
Maximum geodesic distance	8
Graph density	0.000454644
Modularity	0.445458

Limitations

While this study provides valuable insights into digital learning discussions, it is limited by its reliance on Platform X as the sole data source, which may exclude discussions occurring on other social media platforms. Additionally, the study excluded users with fewer than 100 followers, potentially omitting contributions from niche communities that engage in digital learning conversations but have lower visibility.

Results and discussions

As shown in Figure 1, the network graph visualizes interactions and discussions surrounding digital learning accounts on X, which are operated by both organizations and individuals to share information. The clusters signify various groups engaged in interconnected discussions, each focusing on specific digital learning topics across the Philippines, Malaysia, Indonesia and Thailand. The size of the nodes and the density of their connections indicate the influence and activity level of these accounts in facilitating conversations.

The analysis identifies the graph cluster as brand clusters. It explains that the uses within the network are relaying the messages (Ellis, 2024; Kustudic, Xue, Zhong, Tan, & Niu, 2021) of certain institutions or persons over the topic of digital learning without exchanging extra ideas or information. The results also indicate that the subject matter of digital learning is discussed widely on X among many disconnected participants. Hence, brand clusters focus on participants who mention brands when they discuss digital learning, but they likely do not connect to each other.

The NodeXL-generated network graph identifies a total of 98 distinct groups, with eight major groups being the most prominent, and Group 1 emerging as the largest. Visual

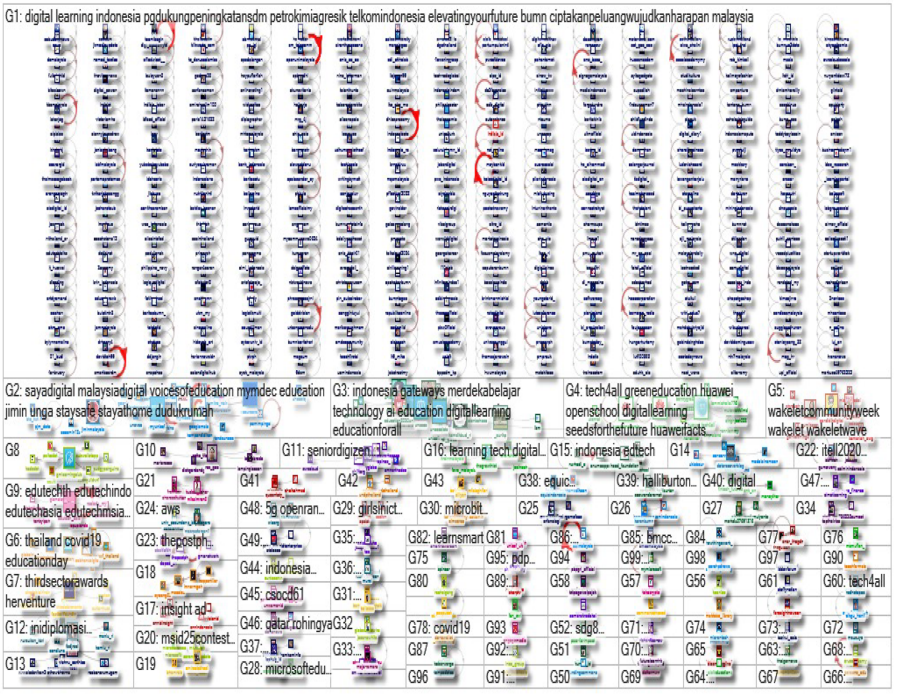

Figure 1. NodeXL graph for digital learning-related account on X

representations of social media connections display various network structures, which help explain group dynamics revolving around digital learning. These structures reveal how individuals connect across different Asian countries and explain the phenomenon within the network.

Overall graph metrics

The overall graph metrics were presented in Table 2. The analysis indicated that there were 745 X users in the entire network. The study reported the top 10 key players among all X users based on the magnitude of the in-degree centrality (see Table 2). The findings revealed different perspectives on digital learning as the topic of conversation focused on different areas with digital learning as the central theme.

User analysis

Table 3 presents a ranking of influential users based on their betweenness centrality and provides a description of their accounts. Users are ranked according to their betweenness centrality scores, while the account description outlines the type of account. The betweenness centrality column displays the raw score for each user, whereas the follower column indicates the number of followers associated with each account (Blumenschein & Hannisdal, 2024; Clifton & Webster, 2017; Wasserman & Faust, 1994). Additionally, the group cluster column categorizes users into specific groups, as shown in Figure 1. The follower count reflects the number of followers each user had during the specified period. Among the accounts at the top of the list, five (5) are international organizations or global tech firms (Huawei Tech4All, UNESCO Digital Learning, UNESCO Bangkok, Education2030UN, and Google Malaysia), while the rest represent government ministry (Kementerian Pendidikan Dasar dan Menengah), local organizations, and educational initiatives (Malaysia Digital Economy Corporation (MDEC), Resilience Development Initiative (RDI), GM Learning Club and Philippine Information Technology Organization (Phil-IT Org) from Southeast Asia.

The findings reveal the top 10 users were distributed across several cluster groups, with Group 4 (Figure 1) accounting for the highest number of influential users. Notably, Group 3 includes four key users: UNESCO Digital Learning, UNESCO SDG4, Kementerian Pendidikan Dasar dan Menengah (Indonesian Ministry of Basic and Secondary Education) and the Resilience Development Initiative (RDI), which together suggest a regional concentration of discourse among Southeast Asian educational stakeholders and global

Table 2. Overall graph metrics

Graph metric	Value
Vertices	745
Unique Edge	581
Edges With Duplicates	372
Total Edges	953
Self-Loops	663
Reciprocated Vertex Pair Ratio	0.016129032
Reciprocated Edge Ratio	0.031746032
Connected Components	505
Single-Vertex Connected Components	408
Maximum Vertices in a Connected Component	31
Maximum Edges in a Connected Component	55
Maximum Geodesic Distance (Diameter)	8
Average Geodesic Distance	2.105586
Graph Density	0.000454644
Modularity	0.445458

Table 3. Top 10 influential users with betweenness centrality score

Rank	Description	Followers	Betweenness centrality	In-degree centrality	Out-degree centrality	Group cluster	Tweet
1	Huawei – Tech4all	1,586,889	592	12	3	4	4,184
2	Malaysia Digital Economy Corporation	27,625	350	4	10	2	18,172
3	UNESCO Digital Learning	12,589	344	1	5	3	3,915
4	UNESCO's #SDG4 Global Education Cooperation Mechanism	54,961	344	0	4	3	12,957
5	Kementerian Pendidikan Dasar dan Menengah, Indonesia	128	216	3	0	3	32
6	Google Malaysia	36,005	66	1	5	2	5,191
7	Resilience Development Initiative, Indonesia	613	58	0	2	3	2,607
8	GM Learning Club, Thailand	2,086	30	0	6	8	694
9	UNESCO Bangkok	11,920	16	1	1	6	30,441
10	Philippine Information Technology Organization	542	14	0	3	11	4,587

actors. These users were relatively low in in-degree and out-degree centrality values (ranging between 0 and 5), indicating that while their structural position as intermediaries is strong, direct interactions with other users may be limited. This aligns with the findings of Ellis (2024), where users with high betweenness centrality acted as important bridges within the network despite having relatively low reciprocal engagement.

The findings also revealed that the X account, which owns the highest follower count (1.5 million) and the highest betweenness centrality score (592), emerged as a global actor promoting digital inclusion and literacy through initiatives such as digital training that bridge gaps and create new opportunities for all. Huawei Tech4All maintains high engagement and visibility, particularly in conversations centered on equity, infrastructure and ICT integration. Their high centrality and activity indicate a significant influence on shaping global conversations about access to education and technology. SNA techniques such as degree centrality, betweenness centrality and community detection are used to identify influential nodes within social networks and are particularly effective in bridging disparate clusters within a network (Ellis, 2024; Freeman, 1978; Hansen *et al.*, 2011; Rodríguez-Ibánez *et al.*, 2023). Their digital advocacy likely contributed to their visibility in multiple clusters, demonstrating how corporate-led initiatives can shape narratives and influence digital learning policy conversations through social media while improving brand awareness.

Notably, Huawei Tech4all account also shows consistent support for global digital learning initiatives. It actively collaborates with international partners such as UNESCO and several ministries of education, as evidenced by the appearance of co-branded content and global campaign hashtags (Table 3). Their collective efforts aim to improve digital access in underserved areas, many of which include public K-12 schools. While the #tech4all hashtag appears prominently within Cluster 4 (G4) of the network, the Tech4All account engages in multiple country specific partnerships that likely involve hashtags distributed across different modularity clusters. Interestingly, many of these initiatives are now linked to sustainability and green education, especially in Malaysia and Indonesia, where digital innovation is widely embraced. It appears that Huawei Tech4All's messaging has evolved from focusing on digital access during the pandemic to supporting long-term, sustainable education. For instance,

a September 2022 post promoting the event "Tech for a Sustainable Future" used the hashtag #tech4nature, indicating a growing link between digital learning and environmental themes in Asia. This direction is further supported by a December 7, 2023 X post announcing a partnership between Huawei, UNESCO and Thailand's Ministry of Education to launch the Green Education Initiative, aimed at promoting environmental education and contributing to Thailand's carbon neutrality goals. Recent research brought back the discourse on digital sustainability after the COVID-19 pandemic. Certomà, Iapaolo, and Martellozzo (2024) explain that digital tools can help promote equity, protect the environment, and improve governance. However, they also warn that digitalization can worsen inequality and create new challenges. This shows the need to carefully examine how digital efforts, like online education and green technologies, truly support sustainability goals (Certomà *et al*., 2024). By analyzing data from long-running industry surveys such as Society for Information Management (SIM), Gartner, UBS, Deloitte and the International Data Group (IDG), the study of Ben-Zvi and Luftman (2022) found that companies are increasingly using digital technologies to support environmental sustainability by creating platforms and products focused on green goals. This growing emphasis on sustainability and visibility is also evident in initiatives like Huawei Tech4All.

UNESCO Digital Learning, UNESCO Bangkok, and UNESCO's Education 2030 accounts are in top 3, 4 and 9, respectively and appear prominently in Cluster 3 (G3). Their clustering suggests a coordinated effort to engage in digital education discussions that focus on policy and development, especially around the Sustainable Development Goal 4 framework, where digital learning is a central theme. These user accounts frequently retweet each other, amplify similar hashtags and share thematic content on policy advocacy, lifelong learning, inclusive access and digital transformation. This is in cognizance with a multilayer network approach in the study of Logan *et al.* (2023), where discussions that focus on specific topics in a social networks, such as X reveal highly influential users and well-connected groups who play a crucial role in shaping public discourse and driving engagement within their communities. The combined activity of these UNESCO-related accounts reflects a strong policy orientation that likely reaches ministries of education and school-level decision makers. Their consistent messaging on digital equity (Gottschalk & Weise, 2023) and teacher training contributes to shaping the digital transformation agenda (Memon, Memon, Memon, & Memon, 2025; Parveen *et al*., 2024) at the school level, especially in low- and middle-income countries across Asia. The content they generate that focuses on access, inclusion, and infrastructure translates to practical implications for K-12 classrooms, particularly in relation to teacher digital capacity and student access to learning technologies.

Additionally, Kementerian Pendidikan Dasar dan Menengah (Ministry of Basic and Secondary Education) in 5th rank and the Resilience Development Initiative (RDI) in rank 7th are positioned within Group 3. Their association in the same cluster highlights how institutional messages, such as Indonesia's national digital education strategies and initiatives like *Learning From Home*, which RDI took part in with UNICEF (RDI, 2020), are being circulated widely, albeit through disconnected users rather than cohesive community conversations. The presence of Indonesia's Ministry of Basic and Secondary Education is especially significant because it is the only actor among the top 10 that explicitly represents the K-12 sector. Its inclusion in a high-centrality cluster underscores how digital education efforts in school are being embedded into broader national and regional digital learning conversations. The ministry's visibility, though not characterized by high interactivity, reflects strategic broadcasting behavior that is commonly used by institutional accounts to push educational reforms and public service announcements to school administrators, teachers, and policy stakeholders. The account of the ministry also shows consistent collaboration with top influencers such as UNESCO and RDI, often through shared campaign messaging and retweeted content. Notably, RDI, which has more followers than the ministry, has assisted various national sectors, including education. This visibility and association may

help explain the ministry's high centrality score, as its presence is boosted through the content shared by other influential actors.

In a social network analysis during the COVID-19 time, it was found that government accounts, politicians, and major media outlets consistently formed a group on Twitter showing a collective effort to promote the national initiative across different data sets (Hasanuddin, Akbar, & Farid, 2022). Interestingly, the mentions of Indonesia in other clusters, including Group 1 (Figure 1), further suggest that its digital learning advocacy is being echoed in broader conversations across the network, indicating a strong brand presence with cross-cluster reach. The cross-cluster presence of Indonesia suggests that school-focused digital learning narratives are not isolated within education-specific discussions but are integrated into broader public discourses on national progress and innovation. This reflects a normalization of school-level digital transformation as a strategic priority across sectors, with implications for funding, implementation and curriculum development.

This aligns with existing patterns as Kustudic *et al.* (2021) study identifies that in Twitter (now X) communication groups, users can share similar patterns even if they do not connect directly. In social network analysis, clusters on Twitter can exhibit common patterns even among users who lack direct connections. Research indicates that groups can be categorized into fixed or variable types based on node degree and betweenness centrality (Ellis, 2024; Freeman, 1978; Miller, 2023), revealing common communication trends among users (Kustudic *et al.*, 2021). Building on this idea, Hasan, Bakar, and Yaakub (2024) argue that traditional friend and follower relationships are often insufficient for identifying communities. Instead, their study introduces a more refined approach to community detection by evaluating user similarities based on profile attributes, tweet topics and sentiments. This offers a better way to detect how online communities are formed around specific issues like digital learning.

This study also reveals that Malaysia demonstrates a strong presence through both governmental and corporate representation. Malaysia Digital Economy Corporation (MDEC) ranks at two (2) and Google Malaysia ranks at six (6) as shown in Table 3, suggesting robust alignment between national digital strategies and private sector support. MDEC, with a betweenness centrality score of 350, ranks second (2nd) among influential users in the digital learning discourse. This private sector organization is also known for its #mydigitalmaker initiative, which targets primary and secondary school students. Although the hashtag #mydigitalmaker does not appear in this dataset, the organization is recognized for its digital upskilling programs that have been integrated into the national curriculum. In a specific X post on August 6, 2023, MDEC highlighted the #mydigitalmaker carnival, where students participated in activities related to digital technology. The post stated that the event featured digital skills experiences, including virtual reality, robotics and coding. Thus, it can be inferred that its presence in the network reflects continued support for foundational digital learning in Malaysian classrooms.

Further examination of Google Malaysia's inclusion in the list reveals that their digital learning initiatives come in partnership with the Ministry of Education, which has deployed platforms like Google Classroom to nearly all public school teachers and students. According to Google, this collaboration provided digital learning tools to over 4.8 million students and 500,000 teachers across 10,000 schools in Malaysia (Google Cloud, 2023). Its inclusion in this network reinforces its role in supporting digital learning in Malaysian schools.

Meanwhile, GM Learning Club in Thailand and Phil-IT Org in the Philippines represent grassroots movements in digital learning conversation. Although their betweenness centrality and follower counts are comparatively lower, their inclusion in the top 10 influential users signals the importance of community-driven digital learning efforts (Hasan *et al.*, 2024; Mayger & Provinzano, 2025). GM Learning Club is active in organizing school teachers' training and providing professional development programs in Thailand, while Phil-IT Org leads edtech events and forums in the Philippines. Their account is notably active in organizing digital education forums, connecting private sector partners with school-related events, and highlighting digital learning technologies, making them a visible and influential actor in

conversations around K-12 digital education. Their visibility within the network underscores the idea that influence in digital learning conversations is not solely defined by size or centrality but also by relevance and consistency in local engagement (Bokányi *et al.*, 2023; Hasan *et al.*, 2024; Kustudic *et al.*, 2021).

Top 10 hashtags

The ten most frequently used hashtags in the network are shown in Table 4. The most used hashtag is #digital, which appeared 44 times, followed by #learning, with 37 mentions. These keywords are consistent with the main theme of the dataset, which centers on digital learning. The hashtag #indonesia ranks third with 24 occurrences, indicating a notable presence in the conversation. At the fourth spot is #tech4all ($n = 17$), a hashtag associated with Huawei's digital inclusion campaign with four domains: education, environment, health and development. Two related hashtags tied at fifth and sixth places ($n = 16$), #pgdukungpeningkatansdm and #petrokimiagresik, which refer to a fertilizer producer in Indonesia that produces various types of fertilizers and chemicals for agro-industrial solutions. #malaysia also appeared 16 times, suggesting its relevance in the network discourse. The remaining hashtags #telkomindonesia, #elevatingyourfuture, and #education had 15 mentions with the 8th and 9th ranks closely related with an Indonesian Telecommunication entity. These entries complete the top 10 and represent various actors or themes circulating within the broader conversation on digital learning initiatives.

The analysis of the top 10 most frequently used hashtags in the network reveals key geographic and thematic patterns related to digital learning discourse. Among the top hashtags mentioned are #Malaysia and #Indonesia, which signal the visible presence and active engagement of these two Southeast Asian countries in the conversation. Asian countries have historically shared a common lineage and numerous cultural commonalities, especially among the three Southeast Asian countries of Indonesia, Malaysia and the Philippines (Marta, Supina, Rashid, Karolina, & Naseer, 2022). Malaysia and Indonesia appear as top X mentions because both nations share cultural and linguistic traditions that shape their online discourse (Suhardjono, 2012). This is why e-commerce, social media marketing initiatives overlap with Malaysian and Indonesian audiences (Marta *et al.*, 2022).

In the context of social network analysis, keywords and hashtags help categorize and retrieve information, with hashtags functioning as user-generated tags that improve discoverability and content relevance within the network (Devika & Subramaniyaswamy, 2022). The hashtag #Malaysia, which appeared 16 times in the dataset, was prominently used by both governmental and private sector accounts advocating for national digital education strategies. Influential users such as the Malaysia Digital Economy Corporation (MDEC) and

Table 4. Summary of top hashtags

Rank	Top hashtags in Tweet in entire graph	Entire graph count
1	#digital	44
2	#learning	37
3	#indonesia	24
4	#tech4all	17
5	#pgdukungpeningkatansdm	16
6	#petrokimiagresik	16
7	#malaysia	16
8	#telkomindonesia	15
9	#elevatingyourfuture	15
10	#education	15

Google Malaysia likely contributed to this visibility through campaigns that support primary and secondary education, including teacher training, digital content development and access to learning platforms like Google Classroom. Maintaining an active presence on social media is a growing trend among private entities, government actors, including politicians who use platforms like X to disseminate policy agendas and engage the public (Nazareth, 2023). Additionally, the strategic use of hashtags to associate initiatives with wider discourse has become a standard practice in digital communication (Ghahramani *et al.*, 2025; Omena, Rabello, & Mintz, 2020). This study reveals that through such messaging, Malaysia's educational discourse on digital learning in the school sector is made more visible and networked within the regional digital learning ecosystem.

Similarly, #Indonesia, with 24 mentions, reflects the country's strong engagement in digital learning. The hashtag #Indonesia is frequently used by actors such as the Kementerian Pendidikan Dasar dan Menengah, which translates to Ministry of Primary and Secondary Education in Indonesia and the Resilience Development Initiative (RDI). These accounts frequently contribute posts aligned with national education strategies (Jamil, Idris, Zalli, Rakami, & Putra, 2024) and digital upskilling efforts (Pasquel-López *et al.*, 2022; Perez *et al.*, 2023). Notably, related hashtags like #petrokimiagresik and #pgdukungpeningkatansdm, which are linked to Indonesia's fertilizer and agro-industrial sectors, show that digital learning conversations extend beyond formal education into industry-specific contexts. These hashtags are often used in conversations that tie digital innovation to agriculture, green and sustainable initiative (Ben-Zvi & Luftman, 2022; Certomà *et al.*, 2024) and human resource support for skill development and lifelong learning within key economic sectors (Dwi Lestari & Riatun, 2024; Priyanto & Suhandi, 2022). The inclusion of these in the digital learning network creates new opportunities for schools to engage in sustainability efforts, especially as governments in Southeast Asia increasingly promote community-wide green initiatives. Their appearance in Clusters 1 and 3 (Figure 1) also suggests these sector-based narratives are part of broader regional discussions around digital transformation and not isolated efforts. By using digital technologies as a tool (Ben-Zvi & Luftman, 2022), schools can take part in climate education, environmental awareness, and digital innovation, which are becoming key priorities in K-12 education systems (Pilařová, Balcarová, Pilař, & Kuralová, 2024).

Another prominent hashtag, #tech4all, appeared 17 times and is directly linked to Huawei's global campaign to promote inclusive digital access. While not tied to a specific country in the hashtag itself, its frequent mention alongside country-specific hashtags such as #Malaysia and #Indonesia suggest overlap between global corporate initiatives and national implementation efforts. A critical reading of this pattern indicates that their initiatives center on facilitating access to infrastructure support that aligns with the technology they provide (Chen, 2021; Hasija & Nupur, 2024) such as access to network connection, mobile technologies, capacity building and community-based digital literacy programs. Thus, it is safe to say that in bridging digital divides, Tech4All contributes to more than just hardware deployment. It becomes part of the evolving discourse and practice of digital learning in K-12 education. This is consistent with literature that highlights the role of information technology in strengthening corporate accountability and social responsibility, particularly during public crises such as the COVID-19 pandemic (Amar, Nordin, Ismail, Hadi, & Arifin, 2021; Chen, 2021).

Given Huawei's active presence in many Asian countries, this also raises the potential for similar programs to be introduced or scaled in other contexts, particularly in countries like Thailand and the Philippines, where #Tech4All did not prominently appear in this dataset. This absence raises important questions about whether such initiatives are underrepresented in these countries or if they are present but not widely communicated through social media platforms. The results point to an opportunity for broader regional engagement, suggesting that countries with Huawei branches could benefit from stronger collaboration in advancing school-based digital learning efforts aligned with national goals. A related study by Hasija and Nupur (2024), which analyzed the advent and growth of the edtech industry during and post-pandemic through quantitative and qualitative methods, found that tech companies'

investments in education addressed urgent learning needs while also strengthening their market position and reputation. This reflects the reciprocal value of programs like Huawei's Tech4All, which, though underrepresented in countries like the Philippines and Thailand, could offer mutual gains when aligned with national education goals.

Hashtags like #telkomindonesia and #elevatingyourfuture, both with 15 mentions, show a visible role of Telkom Indonesia in the digital learning discourse. The association between these two hashtags is particularly noteworthy, as #elevatingyourfuture serves as the company's official campaign tagline, reflecting its commitment to promoting digital learning and communication. This result supports the earlier findings of Amar *et al.* (2021), which emphasized how telecommunications and tech companies contribute to STEM-related educational initiatives as part of their corporate social responsibility efforts. Furthermore, the strategic use of these hashtags may point to the effectiveness of branding and messaging in strengthening online presence and aligning corporate identity (Ghahramani *et al.*, 2025; Omena *et al.*, 2020).

Finally, #education, with 15 mentions, appears at the lower end of the top 10 hashtag list. While it directly aligns with the central theme of this study, its relatively modest frequency suggests that users may prefer more specific or branded terms (e.g. #digitallearning, #tech4all) when engaging in discussions about educational initiatives. Its presence in Group 2 and Group 3, which consist mainly of institutional and policy-focused actors, indicates that the hashtag is still relevant in formal discourse, especially in relation to policy goals and inclusive access. This suggests that while it is used in broader digital learning narratives, it is shaped by organizational or campaign-driven initiatives (Ghahramani *et al.*, 2025; Hasija & Nupur, 2024).

This study interprets the roles of key actors based on their behavior and position in the network. Central users like UNESCO Digital Learning and Google Malaysia act as policy promoters, sharing structured content and events linked to digital learning. In contrast, actors like GM Learning Club and Phil-IT Org share local training and engagement content, placing them closer to grassroots communities. Their presence in smaller clusters suggests their conversations focus more on localized school issues.

The analysis of the top hashtags further reveals how different user groups frame digital learning in different ways. Hashtags such as #tech4all and #mydigitalmaker were commonly used by high-influence users and reflect themes of innovation and digital skills in schools. More general hashtags like #digital, #education and #learning were used across all groups, indicating broad relevance. Country-specific tags like #Malaysia and #Indonesia supported national campaigns, while others like #telkomindonesia and #elevatingyourfuture, found in user timelines, showed how digital learning connects with industry and career goals. These patterns highlight how hashtag use aligns with the goals of different actors. Ministries and NGOs focus on reform and training. Companies promote digital skills and employment opportunities. Community users highlight school-level practice. This variety of hashtag use reveals how digital learning is shaped by different needs and contexts within the network.

Top 10 URLs

The top 10 URLs shared in the network reflect a mix of institutional, educational and media-related content that reveals the diverse sources surrounding the digital learning discourse. The majority of these links point to news articles, institutional portals, higher education resources and organizational announcements, which highlight the integration of external information sources in user-generated digital learning content.

As shown in Table 5, the most shared link, published by Medcom.id, reports on Telkom Indonesia's success at the 2024 BUMN (Badan Usaha Milik Negara) Learning Festival. This reflects the visibility of Indonesia's digital learning initiative, led by companies as part of their CSR. This is consistent with this study that Indonesia appears prominently in NodeXL dataset, such as hashtags, user clusters and influential actors. As part of the dataset retrieved from X,

Table 5. Top 10 URLs in entire graph

Rank	URL	Description	Count
1	https://www.medcom.id/teknologi/news-teknologi/5b2wVzVk-telkom-borong-5-penghargaan-di-bumn-learning-festival-2024	News publisher	7
2	http://bit.ly/VoicesOfEdu	Google form	5
3	https://www.oum.edu.my/wasap/	Higher education	5
4	http://GREENSTUDY.org	K-12 Education	5
5	http://cnnindonesia.com/tv	News publisher	3
6	https://www.prnewswire.com/news-releases/integrated-media-technology-limited-announces-memorandum-of-understanding-to-develop-sourcing-channel-of-halal-products-in-thailand-301565014.html	News publisher	3
7	https://bdaily.co.uk/articles/2022/03/03/uk-ai-digital-training-provider-expands-into-south-east-asia	Business news platform	3
8	https://fastrac.oum.edu.my/	Learner portal	3
9	https://mydigitalworkforceweek.my/	News publisher	3
10	https://challenges.adb.org/en/challenges/aiformsmes	Multilateral development finance institution	3

this URL reveals that the digital learning conversation is not limited to social media users but is actively supported and legitimized by media platforms. News publishers like *Medcom.id* provide an additional layer of visibility to digital learning events by circulating them through mainstream channels that interact with and benefit from viral digital discourse, thereby amplifying their reach and perceived relevance (Nanjundaiah, 2024). Furthermore, media outlets help sustain public interest and lend legitimacy (Aïmeur, Amri, & Brassard, 2023) to digital learning as a significant area of investment and transformation. From a social network analysis perspective, URLs to news articles serve as discursive anchors. They act as nodes around which conversation clusters form, shaping which topics gain visibility and how those topics are framed (Mattei, Pratelli, Caldarelli, Petrocchi, & Saracco, 2022).

The second most shared URL is a Google Form for registration to the "Voices of Education" livestream organized by Google Malaysia, which aligns with Malaysia's active participation in digital learning promotion. Notably, Google Malaysia is the only user in the Top 10 influential users that also appears in the Top 10 URLs. This is most likely because the link simply serves as a registration form for the livestream event, and many users are familiar with using Google Forms (Jaiswal, 2024). While it does not amplify content in the same way that media articles do, its widespread use still reflects how Google tools are in digital learning environments, especially tools within the Google Suite such as Google Classroom, Docs and Forms, which are familiar to many teachers and students in educational settings.

The third and eighth URLs link to Open University Malaysia (OUM), showing educational institutions are using social media to extend learning access and engage prospective learners (Oliveri & Carpenter, 2024; Purnama *et al.*, 2021). Notice that the links lead to a communication platform and an official site, so they function as gateways rather than simple references. They invite users to continue the conversation or access formal information. This is common in digital learning communication, where links guide audiences toward interactive or institutional spaces. In K-12 settings, schools can use the same approach to share updates and direct students, parents and educators to official platforms. Schools can use similar link-based strategies not only for sharing announcements or learning materials, but also for directing students, parents and educators to more structured or official platforms. A related study by Moore (2025), which applied the Shannon and Weaver communication model as a conceptual framework, emphasized the importance of choosing appropriate communication channels to ensure message clarity. While the study did not explicitly classify websites, it supports the idea

that official institutional sites can function as formal communication channels, particularly when designed to reduce noise and guide users effectively. However, younger users need appropriate digital guidance. As noted by Treves, Masud, and Faloutsos (2022), their studies revealed a concerning number of malicious users who collectively post malicious URLs and coordinated deceptive behavior.

Similarly, the fourth and fifth URLs, Green Study and CNN Indonesia, show that both nontraditional learning platforms and mainstream media are active contributors to the digital learning conversation. Green Study, in particular, is notable for its documented collaboration with schools in Malaysia and Indonesia. A review of its official website confirms its partnerships with schools and educators to promote environmental awareness and project-based learning. Green Study's visibility, therefore, suggests that the platform is intentionally engaging in the digital learning conversation with an advocacy for promoting sustainability (Ben-Zvi & Luftman, 2022; Certomà *et al.*, 2024; Pilařová *et al.*, 2024) among the K-12 sector. This may also help understand why hashtags #petrokimiagresik related to sustainability appeared among the highest in the rankings in this study and is linked to Indonesia, which indicates that digital learning discussions increasingly reflect cross-cutting conversations like climate education, civic responsibility, and school-community engagement.

Joining the CNN as a media outlet are the sixth (6^{th}), seventh (7^{th}) and ninth (9^{th}) links show cross-border interest and private sector involvement. Specifically, the sixth URL from PR Newswire discusses a Thai partnership around digital product sourcing, and the seventh article by Bdaily describes the expansion of an AI training provider based in the United Kingdom into Southeast Asia. While these links are typical news articles rather than instructional resources, their content still aligns with the broader digital learning conversation. Much like the Medcom.id URL article, these links report on events or initiatives that are externally led, particularly by industry actors, and present digital learning as a feature of national progress or innovation.

Building on these insights, users ultimately benefit by gaining immediate access to reliable information, often framed by trusted news sources, while these shared links help centralize conversations around recognizable actors and events. The result of this study also revealed that the top 10 links use official domain identifiers such as.id, .my, .uk, .org, .edu, which can indicate institutional credibility and help reduce exposure to malicious content (Treves *et al.*, 2022). This is especially important in the context of younger users in K-12 environments who may be more vulnerable to deceptive links. The consistent presence of these official domains among the top shared URLs in the dataset reflects how users tend to engage with content perceived as credible and trustworthy. A related study by Coe and Kuttner (2018), based on 35 years of television news content analysis, shows how media influence public discourse on education through agenda setting. News coverage not only informs but also shapes which topics gain attention and how they are understood. This supports the role of shared news links in this study, as trusted media sources help structure digital learning discourse and guide engagement through credible and recognizable narratives (Huang, 2022).

In line with cross-sector initiatives, the tenth URL from the Asian Development Bank (ADB) highlights an AI challenge for micro, small, and medium enterprises (MSMEs) in Thailand. Although it is not education-focused, its presence among the most shared links suggests it is seen as relevant to the digital learning conversation. It reflects broader priorities in digital transformation, workforce readiness and capacity building. For K-12, this points to a growing overlap between industry innovation and long-term education goals.

In addition to content amplification, URLs serve as discursive anchors that validate the topics being shared (Treves *et al.*, 2022). News articles from Medcom.id, PR Newswire and CNN Indonesia reinforce narratives around digital learning as an element of national pride or industry innovation. Their frequent inclusion suggests that users rely on formal media sources to lend credibility to their tweets. Links to Google Forms (e.g. for the Voices of Education livestream) show how users respond to and engage with organized, institutional activities. These links show which events and actors are seen as credible in online conversations. The

frequent use of recognizable links and official web domains suggests that users prefer to share content they see as trustworthy, which can influence how digital learning is understood by others.

Limitations and implications

This study offers a qualitative interpretation of digital learning discourse in Southeast Asia by analyzing actor roles, hashtag patterns, URL use and network fragmentation. While the findings provide meaningful insights into the structural and thematic nature of digital learning conversations on social media, several limitations must be acknowledged to contextualize the results and guide future research.

First, the dataset is limited to publicly available X content collected over a short period. It excludes private interactions, other platforms and offline contexts, which may contribute to the broader conversation. The results represent what was visible through NodeXL at the time. Second, although the structural metrics highlight how users cluster, they do not capture the nuances of message tone, sentiment or discursive intention. Without content-level coding or sentiment analysis, it is difficult to assess whether the conversations across clusters were collaborative, critical, promotional or passive. This limits interpretive richness and may oversimplify the perceived separation among actors.

Third, the absence of identified bridging users between key actor groups, such as ministries, grassroots organizations and corporate platforms raises questions about coordination, but this should not be equated with complete institutional disconnection. Actors may collaborate offline or through other digital platforms not captured by this dataset. Thus, the visible fragmentation may be more reflective of the communication behaviors typical of social media ecosystems rather than actual policy or practice gaps.

Despite these limitations, the study contributes critically to the understanding of how digital learning is framed, legitimized and distributed in the social media environment. It highlights that while digital learning is a shared concern, the actors promoting it often do so within their own thematic spaces, without converging narratives. This has implications for school environments, particularly in K-12 systems, where policy, infrastructure and pedagogy must intersect to support digital transformation.

Future research should consider integrating content analysis, longitudinal tracking and cross-platform comparisons to further understand how meanings around digital learning evolve and circulate across education systems. There is also a need to examine the roles of low-centrality actors who, while less prominent in the network, may be key enablers of change at the school or community level. Understanding these dynamics will enhance the value of social network analysis as a qualitative tool for exploring the complexities of education discourse in the Asian context.

Conclusion

This study examined digital learning discourse in Southeast Asia through social media network analysis, focusing on how K-12 school environments are reflected within the broader ecosystem of digital education. By using NodeXL to map user clusters, influential actors, hashtags and shared URLs from X (formerly Twitter), the study revealed that digital learning conversations are shaped by diverse stakeholders, including government agencies, international organizations, private technology companies, grassroots groups and media outlets. Each of these actors contributes uniquely to the public discourse, yet the analysis also showed significant fragmentation in their interactions.

The findings highlight that, while digital learning has become a prominent agenda in many Southeast Asian countries, its promotion and implementation often occur in isolated spheres. Clusters were found to be structured around specific institutional or sectoral boundaries, with limited cross-sector communication. This has implications for how schools interpret, adapt

and benefit from national and regional digital learning efforts. For school environments to fully engage in and benefit from digital transformation, stronger coordination and dialogue among all stakeholders are essential.

This study shows how social media network analysis can reveal the structure and flow of digital learning discourse. Although the data did not show clear collaboration between national and grassroots actors, the limited interaction across clusters, especially among ministries, private tech companies and community-led organizations, suggests that digital learning discussions take place in separate spheres. This structural separation, as revealed in the NodeXL-generated modularity clusters, suggests a fragmented communication pattern across sectors, which may limit the broader reach and impact of digital learning discourse on school-level practices. While the findings did not explicitly identify concrete gaps, the limited interaction among user groups observed in the network suggests areas where stronger coordination may be beneficial. This highlights the value of fostering more connected networks within the social media environment, where digital learning is a central topic of discussion. Moving forward, understanding how discussions around digital learning unfold on social media can help inform more inclusive and coordinated educational discourse. While this study does not prescribe strategies, the patterns revealed through network analysis suggest that fostering stronger interactions between diverse actors could contribute to a more cohesive and equitable digital learning environment for K-12 education.

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