Global-level relationships of international student mobility and research mentions on social media

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Abstract

This paper explores the structural connectedness and associations of international student mobility and scholarly communication on a global scale. First, it examines the exchange of international students. Next, it investigates network structures of international student mobility and scholarly communication on two social media platforms, *Twitter* and *Mendeley*. It also determines which social media platform predicts more inter-country student exchange networks than the other and their statistical relationship. Data are obtained from *Unesco* for student mobility networks and *Altmetric.com* for scholarly communication on social media. Scholarly communication activities are measured by two factors: *Mendeley*-based research citations and *Twitter*-mediated research mentions. As a result, China and the USA exchanged most international students. The network structures of student mobility and online scholarly communication followed the ideas of World System Theory that describes core, periphery, and semi-periphery areas. The network analyses showed that the USA hosted the largest number of overseas students and was positioned at the center of student mobility and scholarly communication on *Mendeley*. The UK was in the central position on *Twitter*. Furthermore, research citations on *Mendeley* had a higher statistical correlation with international student mobility than research mentions on *Twitter* had. More importantly, a greater number of research citations on *Mendeley* predicted an increase in student mobility, and the *Twitter* network showed the highest density and shortest geodesic distance. The findings of this research may suggest that social media can be used effectively to spread academic ideas in the real and online worlds while considering the features of social media and related policies in different countries. Besides, worldwide intellectual mobility may enhance decentralization and co-development of the global academic society, which would be better assisted by proper utilization of social media.

Keywords

Student mobility; *Twitter*; *Mendeley*; Altmetrics; Social network analysis; SNA; Network structures; World system theory; Global academic society; Scholarly communication; Spreading academic ideas; Exchange of international students; Inter-country student exchange; Online communication.

1. Introduction

The contemporary world system places value on the interrelationship among diverse subsystems across countries. Diversity and change in different societies in terms of economy, culture, and demography have influenced the form of globalization (**Chase-Dunn**, 1992). Despite the increasing emphasis on globalization, stratification at the global level by country or continent still results in increased disparity in various social contexts (**Shannon**, 1989). Differences in economic level and power relations likewise exist in the academic sector (**Ayhan**, 2020). Educational policies are formed and reformed differently in different continents and countries (**Green**, 1999), which affects the flows that transfer human resources. Although the configuration of such exchange of human resources among countries has been studied by looking

at international student mobility from the perspectives of economy, policy, and international relations (**Barnett**; **Wu**, 1995; **Cummings**, 1984; **McMahon**, 1992), the scope of investigation on intellectual flows must be expanded to include a broader range of channels in not only the real but also virtual worlds. Moreover, the connectedness of human resources between diverse areas is becoming essential in the digital age (**Park**, 2020).

To tackle this problem, this study investigates the worldwide mobility of students and scholarly communication across both online and offline worlds. It explores the structural connectedness of student flows among countries on a global scale in recent years and further examination of the statistical association between student exchange and scholarly communication in terms of volume and pattern. By doing this, this study unveils whether there is stratification in terms of intellectual mobility by type of channels and discusses the potential to better disseminate knowledge by exploiting social media effectively. The research questions address:

(a) How do countries exchange international students?

(b) How similar is the network structure in international student mobility with that in scholarly communication on *Twitter* and *Mendeley*? How are the network structures statistically related to each other?

2. World System Theory and student mobility

Shedding light on the ideas of World System Theory (**Shannon**, 1989; **Wallerstein**, 1974), social systems have been developed under the change in components of societies. Social, political, and economic aspects in history have constituted the world system through their interdependence, which has been geographically divided into core, peripherical, and semi-peripherical areas according to the level of dominance and ownership of countries. Core countries maintain stronger power and ownership with higher state-of-the-art resources and capital than peripherical areas, while semi-peripherical areas fall between them (**Shannon**, 1989).

With the differentiated power relations among core, periphery, and semi-periphery countries (**Shannon**, 1989), researchers have discussed the economic factors that influence academic stratification globally. The developing countries' ability to sustain a stable economic situation was strongly related to sending their students to overseas countries, along with their interests in international trade and education (**McMahon**, 1992). **Barnett** and **Wu** (1995) also talked about the economic development of countries as a critical factor for more international student exchange with other countries. They found that well-developed Western countries were more likely to be in a central position in worldwide international student mobility. Among Asian countries, China emerged as a central country in line with its economic development. Japan, a developed country, was a critical country in student mobility, although its centrality was relatively lower compared with other industrialized countries. Similar results were uncovered in the study by **Chen** and **Barnett** (2000), revealing that the core countries in international student mobility were Northern American countries, such as the USA and Canada, and European countries, including France, Germany, and the UK. They also found that Japan and China were semi-core countries, while Latin American and African countries remained in the peripheral section.

3. Student mobility and web hyperlinks

Studies have expanded the scope of transactions among countries, looking at information exchange in the virtual world. Social networks have been analyzed to explore the interconnections and interrelationships among countries. These social relationships are defined as when a country exchanges its properties with another country. The objects they provide and receive are either visible or invisible, as the objects' range can be extensive. **Jiang** (2014) conducted preliminary research using Social Network Analysis (SNA) to investigate the social relationships among 23 different countries that exchange international students and how the flow of international students is related to hyperlinks on the Internet and telecommunication. The study found that the worldwide flow of international students from the countries was predicted based on hyperlink connections. A similar study (**Barnett** *et al.*, 2016) examined student migration flow among 210 countries and found that web hyperlinks and telephone minutes predicted the inter-country student migration relationships. They also discovered the existence of a center–peripheral configuration of relationships among the countries.

> "In order to understand the relationship between communication and international student flow in the information society, it is imperative to investigate the effects of Internet use"

Still, the research on international student mobility demands a more comprehensive and expansive area of study when investigating the links and communicative impact on the Internet and the configuration of international students' migration (**Barnett**; **Wu**, 1995; **Jiang**, 2014). In particular, student migration is related to a country's web indexes. With their measurement indicators, web indexes calculate a country's contributions to the information society. Countries with high web indexes attract international students from other countries. Further study needs to examine the points of connection between the development levels of Internet use, infrastructure, and student exchange among countries (**Barnett** *et al.*, 2014; **Jiang**, 2014; *Web Index*, 2020).

4. Student mobility and social media

To understand the relationship between communication and international student flow in the information society, it is imperative to investigate the effects of Internet use. Connections between actors on the Internet are made through small groups constructed according to common features shared between actors (**Barnett**; **Park**, 2014). Moreover, actors or organizations from different countries build virtual relationships in an online network by exchanging information with one another, which is analyzed using the hyperlinks connecting global webpages (**Barnett**; **Ruiz**; **Park**, 2015; **Meier**, 2016).

Research items linked by social media platforms have been investigated as a supplementary measurement of traditional research evaluation to discover research trends, popular topics or disciplines, and flow or features of transferring research ideas in the virtual world (**Bornmann**, 2014a; **Hassan** *et al.*, 2017; **Holmberg**; **Vainio**, 2018; **Thelwall**, 2008). The discussion of research items on social media platforms has also been examined, unveiling the interconnection between different countries (**Park**; **Youn**; **Park**, 2018).

Altmetrics is an emerging indicator to assess research impact on social media. While traditional research evaluation is conducted through a peer review process, altmetrics is more open, encompassing public behavior beyond the academic range. Since citing a research item on social media is more instantaneous than the traditional research evaluation method, altmetrics conducts research evaluation in a time-saving manner, which is beneficial in facilitating the spread of research influence (**Maggio**; **Meyer**; **Artino**, 2017; **Thananusak**; **Ansari**, 2019; **Thelwall**, 2018). Although researchers have been attentive when using altmetrics in research evaluation, as it may not thoroughly cover the highly influential research, it is still valued as an alternative approach to complement the traditional research evaluation method by proving its statistical association with the research impact of the real world (**Bornmann**, 2014b; **Sugimoto**, 2015; **Thelwall**, 2018).

However, research citations on social media have yet to be deeply examined regarding their relationship to the flow of scholarly communication and international student mobility. Despite previous studies on international student mobility and hyperlinks (**Barnett** *et al.*, 2016; **Jiang**, 2014), patterns of citing research items on social media need to be understood along with traditional settings of intellectual mobility across countries, which would provide insights to develop educational strategies for disseminating knowledge. The present research tackles this problem by investigating international student mobility and research citations on social media. It will utilize altmetrics data as a source for analyzing scholarly communication on social media.

> “Patterns of citing research items on social media need to be understood along with traditional settings of intellectual mobility across countries, which would provide insights to develop educational strategies for disseminating knowledge”

5. Methods

5.1. Data for analysis

For the analysis, three datasets were used. First, two datasets of research citations on *Twitter* and *Mendeley* were provided by *Altmetric*, a company offering altmetrics data (*Altmetric*, 2018). The altmetrics data used in the study by **Park** *et al.* (2018) was adopted in this research. In their study, the authors investigated the impact of research publications worldwide in 2016. They obtained research citations defined by the “first seen on” and “pubdate” categories, which were captured by *Altmetric* in 2014 and 2015. The authors calculated how many times research publications were cited on the two social media platforms and refined the altmetrics data through an extraction process to build undirected matrices of 242 countries. In the matrices, countries were nodes, and the number of citations between the countries was indicated in cells. We borrowed these matrices to investigate scholarly communication patterns on social media for this research. The datasets from *Altmetric* (2018) were used because they provide log data of digital citation tools and information about social media use for academic purposes, demonstrating the citation behavior of social media users. *Mendeley* and *Twitter* were chosen because they have extensive altmetrics data coverage and high research citation rates (**Robinson-García** *et al.*, 2014). As the present study explores its novel contribution to the comprehensive examination of the transmission of intellectual human resources and academic ideas across both the real and virtual worlds, data of international student mobility between 212 countries were downloaded from the *Unesco Institute for Statistics* website (*UIS Statistics*, 2018). The same two-year period was selected in the altmetrics data.

To prepare the three datasets for SNA, a critical method to examine the relationship among components (countries in this study) on a network (**Giuffre**, 2013), international student mobility data were converted to an undirected network matrix. The countries in the three datasets were compared, selecting 207 coinciding countries for the data analysis.

5.2. Social network analysis

SNA quantitatively investigates the complicated, interconnected relations between components within or across groups. It enables researchers to analyze a network structure consisting of *nodes* (or vertices) and *links* (or edges). Nodes are elements that constitute a network, and links refer to connections between nodes (**Cross**; **Borgatti**; **Parker**, 2002). As links indicate the relationship between the connected nodes, investigating links between nodes uncovers unseen insights into the network (**Giuffre**, 2013). Conducting SNA helps researchers to examine the configuration of nodes and their interactive connections on a network through statistical methods and mapping (**Cross** *et al.*, 2002). SNA (a) promotes “effective collaboration within a strategically important group,” (b) supports “critical junctures in networks that cross-functional,

hierarchical, or geographic boundaries," and (c) ensures "integration within groups following strategic restructuring initiatives" (**Cross** *et al.*, 2002, p. 28). In this study, SNA was conducted to analyze the interactive relationship among countries in the three datasets. The features of international students' mobility across different countries were examined, and the citation behavior patterns of *Twitter* and *Mendeley* users were tracked. Regarding the citation behavior on these two social media platforms, mentions of research items on them were examined.

> "The present study explores its novel contribution to the comprehensive examination of transmission of intellectual human resources and academic ideas across real and virtual worlds"

Diverse measurements were tested in this research to investigate the social and statistical relationships between students' mobility, research mentions on *Mendeley*, and those on *Twitter*. To investigate the frequency or proportion of direct, immediate connections among countries in the three network datasets, *density* and *degree centrality* were tested. Density refers to the ties divided by all possible ties. It demonstrates how fast information is disseminated on the network by nodes that play a critical role in spreading the information to other nodes (**Wassink**, 2018). Degree centrality measures the number of direct links with a node. It measures the frequency or proportion of direct ties that a node has (**Borgatti**, 2005). In accordance with the direction of a direct link, degree centrality is sorted into *outdegree centrality* and *indegree centrality*. Outdegree centrality measures the number of ties that go outward to other nodes; on the other hand, indegree centrality calculates the number of ties that come inward to a node from other nodes (**Jiang**, 2014). In addition to the measurement of the degree centralities, country population data (*Population Reference Bureau*, 2015) were used to calculate the ratio of students per capita of countries that sent most students overseas and that of outdegree centrality and indegree centrality per capita, which is to show the further results in comparison with the country size.

While degree centrality figures out direct connections outward from or inward to a node, *geodesic distance* indicates the shortest path from one node to another. In the matrix, the geodesic distance among nodes manifests the measurement of cohesion in a social network. The pathway between nodes links them, and the number of the links to pass through to reach a different node represents the distance length (**Borgatti**; **Everett**; **Freeman**, 2002). One of the indicators in investigating geodesic distance is *betweenness centrality*. Betweenness centrality measures the statistical value of a node regarding how central it is in the network. It measures the value of a node positioned in the geodesic paths that connect nodes or groups (**Freeman**, 1978) and calculates the "frequency of arrival" to pass a particular node (**Borgatti**, 2005, p. 70). If a node has a high betweenness centrality, it is in the network's central position as it connects different nodes or groups of nodes. Nodes transfer information to others in different groups by crossing the nodes with a high betweenness centrality. That means those with high betweenness centrality have authority as a broker in social networks to build the intellectual connections between different groups (**Giuffre**, 2013).

The statistical relationships between networks were tested through Quadratic Assessment Procedure (QAP) correlation and QAP multiple regression (**Borgatti** *et al.*, 2002). According to **Krackhardt** (1987), "QAP is a nonparametric, permutation-based test that preserves the integrity of the observed structures (i.e., explicitly retains the interdependency among the dyads)" (p. 174). QAP correlation and QAP multiple regression measure the similarity of multiple matrices by matching the equivalent dyadic cells in those matrices. The two methods can be conducted based on nonparametric assumptions for testing the social relations among nodes (**Barnett** *et al.*, 2016).

In the present paper, student mobility and research citation patterns on *Mendeley* and *Twitter* were analyzed by measuring outdegree centrality, indegree centrality, betweenness centrality, geodesic distance, and density. QAP correlation was conducted to test the statistical relationships between the three network datasets, and QAP multiple regression was tested to predict international students' mobility based on research mentions on *Twitter* and *Mendeley*. *Ucinet 6.666* (**Borgatti** *et al.*, 2002) was utilized for the analysis.

6. Results

6.1. Student mobility among countries

Looking at the interrelationship between countries that sent and received students, China and the USA had the largest exchange, with China sending their students to the USA the most (see Table 1). India was the next country with a strong interrelationship with the USA. In general, China sent numerous students to other countries on diverse continents such as Europe (e.g., the UK, France, and Germany), Asia (e.g., Japan, Republic of Korea, and China-Hong Kong Special Administrative Region), North America (e.g., Canada), and Oceania (e.g., Australia). In addition, when it comes to the ratio of students per capita of the sending countries, Slovakia sent their students to the Czech Republic the most (0.863% of the population), both located in Central Europe.

The analysis of outdegree and indegree centralities found that the majority of the top 20 countries that send out the most students overseas were located in Asia and Europe (Table 2). China was ranked top on outdegree centrality by sending its students to overseas countries the most, along with other Asian countries, such as India, Republic of Korea, Saudi Arabia, Kazakhstan, Vietnam, Malaysia, Bangladesh, Iran, Turkmenistan, Pakistan, and Turkey. European countries were Germany, France, Ukraine, Italy, and Russian Federation.

On the other hand, the USA was the major country that had a high indegree centrality and received international students the most. Another country in North America, Canada, had a high indegree centrality as well. Other related countries that received students from overseas countries were European (e.g., the UK, France, Russian Federation, Germany, Italy, Austria, the Netherlands, Ukraine, and Switzerland) and Asian countries (e.g., Japan, Malaysia, Saudi Arabia, United Arab Emirates, Turkey, Republic of Korea, and India). Two countries in Oceania, namely Australia and New Zealand, were also highly ranked.

Table 1. Countries that exchanged the most students during 2014 and 2015

Country (sending)	Country (receiving)	Students (ratio of students per capita of sending country in 2015, in parenthesis)
China	USA	551,978 (0.042%)
India	USA	210,327 (0.016%)
China	Australia	187,632 (0.014%)
China	UK	177,722 (0.013%)
China	Japan	164,401 (0.012%)
Saudi Arabia	USA	104,900 (0.332%)
China	Canada	104,692 (0.008%)
Kazakhstan	Russian Federation	108,547 (0.620%)
China	Republic of Korea	68,658 (0.005%)
India	Australia	62,454 (0.005%)
Bangladesh	Malaysia	59,575 (0.037%)
Canada	USA	55,363 (0.004%)
Germany	Austria	53,896 (0.066%)
China	China, Hong Kong Special Administrative Region	52,845 (0.004%)
Morocco	France	51,877 (0.152%)
China	France	50,685 (0.004%)
Germany	Netherlands	47,407 (0.058%)
Slovakia	Czech Republic	46,589 (0.863%)
China	Germany	45,502 (0.003%)
Belarus	Russian Federation	43,684 (0.460%)

Table 2. Outdegree and indegree centralities of student mobility (ratio of outdegree centrality and indegree centrality values per capita in 2015, in parenthesis)

Outdegree centrality		Indegree centrality	
Country	**Value**	**Country**	**Value**
China	1,576,561 (0.001%)	USA	1,708,084 (0.005%)
India	468,325 (0.000%)	UK	842,731 (0.013%)
Germany	228,060 (0.003%)	Australia	548,770 (0.023%)
Republic of Korea	215,711 (0.004%)	France	437,010 (0.007%)
Nigeria	167,785 (0.001%)	Russian Federation	384,254 (0.003%)
Saudi Arabia	165,915 (0.005%)	Germany	372,683 (0.005%)
France	158,095 (0.002%)	Canada	314,664 (0.000%)
Kazakhstan	142,138 (0.008%)	Japan	264,633 (0.002%)
Vietnam	124,820 (0.001%)	Malaysia	210,432 (0.007%)
USA	121,101 (0.000%)	Italy	176,691 (0.003%)
Malaysia	115,306 (0.004%)	Saudi Arabia	142,913 (0.005%)
Ukraine	111,073 (0.003%)	United Arab Emirates	136,436 (0.014%)
Bangladesh	108,736 (0.001%)	Austria	128,951 (0.015%)
Italy	102,472 (0.002%)	Netherlands	122,474 (0.007%)
Iran	100,275 (0.001%)	Ukraine	115,453 (0.003%)
Russian Federation	99,836 (0.001%)	Turkey	114,919 (0.001%)
Turkmenistan	98,538 (0.018%)	Republic of Korea	105,035 (0.002%)
Canada	94,914 (0.000%)	Switzerland	95,255 (0.011%)
Pakistan	90,788 (0.000%)	New Zealand	95,078 (0.021%)
Turkey	89,030 (0.001%)	India	79,715 (0.000%)

6.2. Geodesic distance among countries in student mobility and social media

Table 3 shows the means and standard deviations of international student mobility and research mentions on *Twitter* and *Mendeley*. The measurement of density showed that *Twitter* had the highest density, followed by student mobility and *Mendeley* in that order (Table 4), indicating that *Twitter* users mention research and diffuse academic information more quickly (**Wassink**, 2018). The average value of *Twitter* was over ten times greater than that of student mobility.

Table 5 demonstrates the frequency of geodesic distance among countries. As geodesic distance refers to the shortest path between different nodes, the numbers on the far left column indicate the length of the shortest paths, or the shortest links between two nodes (**Borgatti** *et al.*, 2002). As a result, *Twitter* had the most frequent cases of geodesic distance (82.3%), meaning that, when citing research items, the paths to different countries are shortest on *Twitter*. International student mobility data and *Mendeley* had 51.4% and 42.6% of missing paths, respectively; therefore, almost half of all possible interrelationships among different countries were not built from student mobility or *Mendeley*. Also, the geodesic distance among countries was greatest in international student mobility.

Table 3. Means and standard deviations of student mobility and social media

	Mean	SD
Mobility	793.206	7,756.059
Mendeley	275.265	4,458.998
Twitter	8,284.306	194,638.250

Table 4. Density of networks in student mobility and social media

	Average value	Total	SD
Mobility	793.206	7,609,224	7,756.059
Mendeley	275.265	11,737,870	4,458.998
Twitter	8,284.306	353,259,360	194,638.250

Table 5. Geodesic distance among countries in student mobility and social media

Geodesic distance	Mobility	*Mendeley*	*Twitter*
1	9,593 (22.5%)	12,738 (29.9%)	35,112 (82.3%)
2	10,787 (25.3%)	11,704 (27.4%)	7,118 (16.7%)
3	327 (0.8%)	50 (0.1%)	0 (0.0%)
N/A	21,935 (51.4%)	18,150 (42.6%)	412 (1.0%)
Sum	42,642 (207 countries x 206), (100%)		

Table 6. Betweenness centrality in student mobility and social media

Mobility	Value	*Mendeley*	Value	*Twitter*	Value
USA	930.212	USA	473.185	UK	279.653
UK	773.232	Spain	344.954	USA	75.653
Germany	551.832	Netherlands	283.509	Canada	75.653
Canada	543.010	UK	230.335	Colombia	71.502
Thailand	517.203	Germany	210.424	Japan	67.139
Brazil	494.627	Brazil	194.055	Chile	66.419
Italy	489.612	India	191.805	Netherlands	46.982
Japan	478.638	Italy	189.225	Germany	46.982
France	463.013	Canada	166.775	Italy	46.982
Morocco	413.275	Sweden	158.805	Sweden	46.982
India	373.013	Mexico	146.591	Australia	46.982
Turkey	366.353	Australia	145.820	Spain	46.982
Portugal	364.085	France	143.629	Finland	43.131
Switzerland	322.078	Denmark	125.049	Denmark	43.131
Netherlands	290.715	Colombia	115.537	Central African Republic	43.033
United Arab Emirates	289.171	Malaysia	110.552	India	43.030
Belgium	284.349	Belgium	110.486	Mexico	43.030
New Zealand	283.959	Switzerland	108.361	Norway	43.030
Republic of Korea	283.393	Portugal	107.324	Ireland	43.030
Ireland	279.061	Japan	106.118	Brazil	43.030

In terms of betweenness centrality, the USA had the most primary central position in international students' mobility and research mentions on *Mendeley*, while the UK occupied the most central position on *Twitter* (see Table 6). Of the top 20 countries with the highest betweenness centrality, nine countries (the USA, the UK, Germany, Canada, Brazil, Italy, Japan, India, and the Netherlands) were found all in student mobility and on the two social media platforms. The countries in the top betweenness centrality in student mobility, but not on the social media platforms included four Asian countries (Thailand, Turkey, United Arab Emirates, and the Republic of Korea), one country in Oceania (New Zealand), and one African country (Morocco). On the other hand, the countries that had high betweenness centrality on both social media platforms were two North/South American countries (Mexico and Colombia), three European countries (Spain, Sweden, and Denmark), and one country in Oceania (Australia).

6.3. Network relationships between student mobility and social media

QAP correlation and QAP multiple regression were conducted to test statistical relationships between international student mobility, research mentions on *Twitter*, and research mentions on *Mendeley*. Table 7 presents the statistically weak positive correlations between student mobility and research mentions on *Twitter* (r = .120, n = 207, p < .01), weak positive correlations between student mobility and research mentions on *Mendeley* (r = .212, n = 207, p < .01), and strong positive correlations between research mentions on *Twitter* and those on *Mendeley* (r = .833, n = 207, p < .01). Thus, student migration patterns to overseas countries were correlated to research mention patterns on *Twitter* and *Mendeley*. At the same time, the relationship between the two social media platforms was much stronger than that. The research mentions on *Mendeley* had a higher statistical correlation with student mobility compared with those on *Twitter*.

Table 8 presents the result of the QAP multiple regression, calculated to predict international student mobility based on mentions on *Twitter* and *Mendeley*. Both social media platforms were the significant predictors of international student mobility, with R^2 = .0531. More specifically, *Mendeley* had a positive relationship with student mobility (β = .366, p < .01), while *Twitter* had a negative relationship (β = –0.004, p < .01). Thus, the increase in research citations on *Mendeley* predicted the increase of student mobility, while the increase of research mentions on *Twitter* predicted the decrease in student mobility, which explains 5.31% of the total variance in student mobility.

Table 7. QAP correlation between student mobility and social media

	Mobility	***Mendeley***	***Twitter***
Mobility	1.000	0.212**	0.120**
Mendeley		1.000	0.833**
Twitter			1.000

**Significant at p < .01 (two-tailed)

Table 8. QAP multiple regression to predict student mobility based on social media

	Unstandardized coefficients	**Significance**
Intercept	574.10712	0.00000
Mendeley	0.36640	0.00050
Twitter	–0.00403	0.00100

7. Conclusions and discussion

The aim of the present study was to comprehensively investigate the movement of intellectual resources and academic ideas across countries in both the real and virtual worlds, exploring the potential means of knowledge dissemination. Our findings addressed the structural connectedness of student flows and scholarly communication across 207 countries and examined the inter-country relationships regarding the volume and pattern of international student mobility. We also tested the correlation and prediction of network structures in international student mobility by comparing research citations on *Mendeley* and *Twitter*. The analysis revealed notable international student mobility between China and the USA. The USA was in the central position in student mobility flows and scholarly communication on *Mendeley*, and the same can be said for the UK's position on *Twitter*. Scholarly communication on *Mendeley* had a higher statistical correlation with international student mobility than that on *Twitter* did. Furthermore, more active scholarly communication on *Mendeley* predicted the increase in international student mobility among countries, while the communication on *Twitter* predicted the decrease in international student mobility. Despite the limited data coverage *Altmetric.com* (**Holmberg**; **Park**, 2018), our results confirm that citation behavior on social media differs by user group and purpose. *Mendeley* users tend to exist in academic circles, while *Twitter* users are made up of more general public. That is, *Mendeley* focuses more on reference management and promotion of users' research, while *Twitter* is a channel for everyday social conversation using short messages called tweets. The different features of the two social media platforms may influence the opposite prediction of international student mobility in the real world (**Haustein** *et al.*, 2014; **Holmberg**; **Vainio**, 2018), as demonstrated by previous studies that addressed international student mobility and web hyperlinks (**Barnett** *et al.*, 2016; **Jiang**, 2014).

The network structures of student mobility and online scholarly communication echoed the ideas of World System Theory that is the core, periphery, and semi-periphery, each of which influences one another (**Shannon**, 1989). From our findings, it was revealed that China sends numerous students to Western countries. However, scholarly communication on social media often revolves around research items published in Western countries, particularly the USA and UK. For instance, students from other countries most commonly study in the USA, but not many American students choose to study overseas, as evidenced by other studies (e.g., **Barnett** *et al.*, 2016; **Barnett**; **Wu**, 1995). Moreover, considering the predicted high student migration rate to the USA, based on the research mention rate on social media, the USA is a significant actor in the global diffusion of academic knowledge both in the real and virtual worlds.

> "This result resonates that citation behavior on social media differs by user group and the purpose of using it"

One of the most important factors for high human resource exchange is stable economic status. Industrialized countries that hold advanced educational resources and technology receive more attention from other countries located in a core position in the world system, while the countries in the opposite situation rarely experience the same (**Barnett**; **Wu**, 1995; **Chen**; **Barnett**, 2000; **McMahon**, 1992; **Seok**; **Barnett**; **Nam**, 2020). This stratification was also observed on social media in our findings. Countries that receive more attention on the Internet and that contribute to the information society have higher prospects in terms of receiving international students (**Jiang**, 2014).

Although *Mendeley* positively predicted the international student mobility rate, *Twitter* negatively predicted this, possibly due to its different purpose as a social media platform and its user groups (**Haustein** *et al.*, 2014). Furthermore, *Twitter* still has the potential to activate scholarly discussion in diverse disciplines (**Holmberg**; **Thelwall**, 2014; **Thelwall**, 2018). Our results reveal that *Twitter* had the highest density and shortest geodesic distance, meaning that *Twitter* users mention research articles and spread academic ideas quickly to many other users in different countries in a tight relationship network (**Wassink**, 2018). This idea mirrors the interconnectedness found on *Twitter* across continents, whereas *Mendeley* users rarely built relationships with those from other countries (**Park** *et al.*, 2018). Therefore, the use of *Twitter* for diffusing research items is valuable in the sense that *Mendeley*, but not limited to, is used by a smaller range of users, and some countries do not provide information about international student mobility. Nonetheless, it should be noted that a strategy for adopting social media to enhance the dissemination of academic ideas and resources is designed in light of the policies and restrictions found in different countries (**Wilford**, 2017). For instance, although many Chinese students study in English-speaking nations (**Barnett** *et al.*, 2016), China has rarely appeared at the top of the list of traditional and digital academic activities, which requires careful interpretation, as indicated in other literature (e.g., **Jiang**, 2014).

Despite this limitation, the academic world has seen the growing involvement of developing countries. One example of this is the rapidly increasing participation of developing countries in the peer review process, although their participation rate is still lower than that of major developed countries (*Publons*, 2018). It thus becomes necessary to properly design tactics in order to form part of the hub of global education and academia by exchanging human intellectual resources with other countries within and beyond one's own continent (**Lee**, 2015). Active interaction with intellectual resources from diverse educational, cultural, and economic backgrounds will enhance the decentralization and co-development of a global academic society. High-quality human resources are needed to contribute to academic knowledge improvement across national borders for global intellectuality. The proper utilization of social media will accelerate knowledge diffusion and support learners who benefit from this worldwide knowledge mobility.

For further study, a more precise investigation needs to investigate the research areas popular on social media and compares them with international student mobility. Moreover, further study could compare the intellectual mobility of different groups, as well as classify social media types by country to predict intellectual mobility, particularly since different nations have their own preferred social media and online channels (**Danowski**; **Park**, 2020; **Park**; **Park**, 2018). Finally, other relevant indicators should be included when examining the relationship between scholarly communication and student mobility among countries (**Barnett**; **Park**, 2014).

> "The use of *Twitter* for diffusing research items is valuable in the situation that *Mendeley*, but not limited to, is used by a smaller range of users than *Twitter* and some countries do not provide information about international student mobility"

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