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ORIGINAL PAPER

Migration pattern analysis of faculty members based on scientific disciplines: the case of the University of Tehran

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Abstract

Choosing the right field of study is a crucial moment that can determine an academic's professional future. While it is typically recommended for those at the start of their scientific career to carefully select their field of study, studies in the field of field migration have shown that it often involves the transfer of knowledge and ideas between different fields. This research focuses on understanding the migration patterns of faculty members at the University of Tehran during the period from 1980 to 2022, specifically examining interdisciplinary shifts among academics. Data on faculty members' academic backgrounds was collected, and 309 individuals with dual degrees were identified. VOS viewer and Node XL were used to illustrate their field mobility. With disciplines classified based on the International Standard Classification of Education (ISCED). The classification of disciplines was based on the International Standard Classification of Education (ISCED). The findings revealed that 74% of faculty members migrated to a completely different scientific field, while only 26% engaged in intra-field migrations. This indicates that most individuals crossed rigid boundaries between broad scientific fields rather than opting for neighboring fields within the same discipline. The study concludes that the pattern of field migrations highlights the artificiality of

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field borders and reflects researchers' desire to foster communication and collaboration across various disciplines underscoring the importance of increased interdisciplinarity in scientific endeavors.

Keywords Boundary crossing · Field migration · Social sciences · Field mobility · Interdisciplinary · Migration patterns

Introduction

Choosing a field of study is a critical moment for every professional. Therefore, it is usually recommended that those who are at the beginning of their scientific career choose their field of study with sufficient information. Since the earliest times, university departments have been organized by disciplines (Veysey 1965); disciplines and universities have mutually influenced each other (Sá 2008). In this regard, the policy of discipline-oriented universities expects academics to choose a field based on the existing divisions, to work within specific boundaries, and to participate in conferences and associations related to their field of study. The existence of these rigid boundaries between disciplines has hindered the circulation of people and the creation of free communication and interaction between different disciplines. However, despite the rigid boundaries between scientific disciplines, many have changed their disciplines during their professional life; in fact, studies have shown that individuals in various scientific communities do not spend all their time in one field but rather may switch their field of activity more than once throughout their career path.

Switching fields of study means that a student does not continue in their prior field of study but instead migrates to another field. For example, a person with a bachelor's degree in biology may pursue a master's degree in sociology. Ziman (1987), identifies there are three methods through which researchers can move between scientific disciplines and scientist-field transitions: Diversification: A researcher may opt not to focus exclusively on a single specialized area within their field. Floating: Scientists engage with multiple fields but do not fully abandon their initial discipline. Migration: Researchers either voluntarily or involuntarily shift entirely away from their existing field and begin working in a new domain. These shifts contribute to distancing scientists from further depth in their original areas while also allowing them to acquire knowledge beyond their initial scope (Ziman 1987).

This phenomenon of changing scientific disciplines is referred to as "field mobility" (Le Pair 1980; Van Heeringen and Dijkwel 1987) and can be studied by observing the scientific activities of researchers while passing through different scientific fields. This concept has also been discussed in other studies as Field Switching (van Houten et al. 1983; Seymour and Hewitt 1997), and Field Migration (Hargens 1986).

Some researchers have also emphasized that a change in the field of study can lead to the transfer of knowledge and the circulation of scientific and technical human capital between remote scientific fields. The concept of

"scientific and technical human capital" borrowed from the concept of "social capital" was introduced into scientific evaluation by Bozeman et al. (2001) from the field of sociology. According to Bozeman et al. (2001), scientists acquire education and training in schools and universities, collaborate with other researchers, communicate with members of the scientific community, and establish a scientific network throughout their scientific careers. Through this process, they bring a set of behaviors, resources, and ideas into their field of study, which affects the ways of producing science and their scientific performance. This process leads to the development of skills, knowledge, and specialized abilities and the creation of scientific and technical human capital (Bozeman et al. 2001). The scientific capital, skills, and knowledge offered by individuals with different educational backgrounds will vary significantly. Therefore, it can be claimed that degrees obtained in a particular field of study from different universities are not equivalent. In fact, there will be differences in the scientific capital of two individuals who obtained their degrees from different universities. Similarly, there will be differences between the skills and scientific capital of an individual who received all their education in one field compared to someone to someone who migrated between two or three scientific disciplines and so has different bachelor's and master's degrees (Bozeman et al. 2001). This will affect their understanding of science and all their future scientific endeavors.

Literature review

Some studies have mainly focused on the causes and factors of leaving a scientific discipline: (Le Pair 1980; Seymour and Hewitt 1997; Ohland et al. 2008; Marra et al. 2012; Pramanik et al. 2019). According to these studies, factors, and motivations for changing disciplines are very diverse. The quality of relationships between university members, mutual relationships between students and professors, and structural and cultural characteristics of universities (Seymour and Hewitt 1997) are some of the mentioned reasons for field migration.

Other studies have pointed their attention to the effect of field migration on interdisciplinary scientific relations (Mulkay 1974; Hargens 1986; Rinia et al. 2002). Mulkay (1974) believed that scientists are "knowledge bearers". The movement of scientists from one discipline to another is one of the most effective activities to communicate and circulate knowledge between various scientific fields" (Bordons et al. 2004). As the new mode of science production suggests: "*The more a scientific system allows its members to move, the more powerful science production will become*"(Gibbons et al. 1994). Numerous studies have focused on the amount of knowledge transfer amongst scientific fields (Cronin and Davenport 1989; Lockett and McWilliams 2005; Goldstone and Leydesdorff 2006; Hessey and Willett 2013) and many efforts have been made to draw Map of relationships between scientific domains using publication data (Boyack et al. 2005; Rafols and Meyer 2010); or citation data (Moya-Anegón et al. 2004; Liu and Wang 2005; Porter and Rafols 2009).

An academic individual by moving between disciplines can gain new skills, and ideas and learn new methods, principles, and theories (Laudel 2003). For this reason, scientific mobility is considered one of the most important conditions for enriching scientific disciplines. As the knowledge and skills acquired by scientific migration can significantly influence the field.; Mulkay (1974) views inter-disciplinary migrations as equal to "displacement of concepts" where scientific concepts can be transferred by field migration. In fact, Mulkay showed that knowledge, ideas, and methods of one's original discipline will be transferred to the new field and will create a new application (Mulkay 1974). The study of such migrations gives us information about how concepts move, which in turn increases our understanding of how scientific concepts grow and develop

From the summary above, the following conclusions were reached:

- Scientists moving from one scientific network to another will usually be accompanied by the transfer of concepts;
- The movement of scientists from one scientific network to another will usually be accompanied by the transfer of concepts;
- Entering a new field, on the one hand, can solve previous problems, and on the other hand, it can direct the attention of former members to newer problems. Additionally, it has the potential to create new scientific networks.

Later studies regarding the migration of scholars between scientific fields confirmed the results of Mulkay (1974) and showed that migrations usually take place based on the conceptual and cognitive affinity of scientific fields with each other; Hargens (1986) pointed out that the primary reason for migration between disciplines is the existence of common concepts and the number of common topics between those disciplines. Moreover, many migrations of scientists show the importance of that discipline for the recipient fields; some sciences are considered as the basic fields for other disciplines and lead to a better understanding of difficult scientific concepts, and in this sense, they have high scientific value and competence (Le Pair 1980). Le Pair (1980) investigated the transfers made by faculty members between different scientific fields within an institution in the Netherlands. Considering the fact that every educated person can be a transmitter of knowledge and ideas, he acknowledged that specifying the fields of giving and receiving in order to show the flow of ideas among scientific fields can indicate the degree of influence of disciplines on each other. Le Pair (1980) highlighted that the fields of physics and chemistry are among such fields. Three years later van Houten et al. (1983) examined immigrant physicists in the same institution studied by Le Pair (1980). According to van Houten et al. (1983), over half of the physicists in the institute worked in departments outside of physics, they demonstrated that the former physics members believed their prior studies significantly influenced their new work. Van Houten concluded that physics serves as a foundational field for astronomy and chemistry whereas mathematics does not hold the same role. Finally, many physicists particularly those who made a significant impact in their new field, still identify themselves as physicists and maintain their affiliation to their original (previous) field.

As a result, individuals who have changed their fields of study actively engaged in two or more different fields instead of just one. Consequently, they are more multidisciplinary compared to those who have worked in a single field. Given that a multidisciplinary approach is an advantage in today's academic world some institutions such as the National Academy of Sciences (2005) have encouraged their members to study in more than one field (Kim 2006) With the belief that studying in several disciplines provides communication between different scientific fields and equips individuals with multidisciplinary skills (Rinia et al. 2002).

Being multidisciplinary not only enhances communication and cooperation among individuals but also plays a crucial role in scientific activities. For instance, when someone transitions from sociology to biology, they not only establish a connection within sociology but also come across researchers from their previous field of biology. This expands their communication networks and fosters their scientific collaboration (Kim 2006). Hargens (1986) conducted a study on the structure and migration patterns of scientists, focusing on the flow of ideas and knowledge between science disciplines, and highlighted the migration of researchers in and out of physics, emphasizing cognitive similarities as the basis for interdisciplinary migrations. Hargens (1986) noted that these migrations involve knowledge transfer, making them valuable for studying knowledge flow across scientific fields alongside citation analysis. Urata (1990) later supported Hargens's findings.

Research objectives

Research in the area of field migration has shown that field migration is accompanied by the transfer of knowledge and ideas from one field to another. This allows researchers to use the data on field migration to analyze and interpret the level of flow of knowledge between scientific fields. (Le Pair 1980; Rinia et al. 2002; Ackers 2005). One of the benefits of moving between scientific fields is the opportunity it provides for the circulation and transfer of knowledge from one scientific field to another, which is known as a crucial factor for the advancement of science and scientific knowledge (Urban 1982). Given the significant role of field migration in the scientific community, this paper aims to examine the migration pattern of faculty members at the University of Tehran from 1980 to 2022. Specifically, we will explore the following:

To display the percentage of field migrations of University of Tehran faculty members
To create a map of migrations between broad fields of science;
To create separate scientific maps of faculty member migrations from in and out of narrow scientific disciplines for each of the eleven broad fields.
To compare scientific migration between and within the fields.

Methodology

Research context

This study was undertaken at University of Tehran, the oldest and most prominent Iranian university located in Tehran, Iran. The University of Tehran offers its educational services through more than 100 educational units and has 1720 faculty members. The reason for selecting the University of Tehran among other universities in Iran was its comprehensive coverage of scientific disciplines across all 9 broad fields required for this study.

Data description

We needed information about those faculty members who obtained their PhD degrees in a field different from their Bachelor's and Master's, in scientific literature they are called field switchers or double degrees. In order to obtain this data, we had to study the resumes of all faculty members in all scientific departments. This data about the faculty's academic background was gathered from the University of Tehran's database in March 2022. Out of all faculty members, 309 (18%) were identified as double degrees. Some of them had changed their disciplines twice. These groups of faculty members were moved to the next step to be analyzed by our visualization tools.

Tools

VOS viewer and Node XL were used as our tools to illustrate the field mobility of 309 faculty members. Node XL is an open-source add-in toolkit within Microsoft Excel that can be used to discover, explore, and visualize network data (Smith et al. 2009). This software apart from being very flexible and easy to use, provided the possibility to show in-degree and out-degree edges which was a crucial factor for us to choose an illustration tool. In addition to Node XL, we also utilized VOS viewer to create additional illustrations as it generates clustered maps which enhances our understanding of the data being analyzed.

It is worth noting that our discipline classification was based on the International Standard Classification of Education (ISCED) which was developed in 1976 by the United Nations Educational, Scientific and Cultural Organization (UNESCO) (UNESCO 2012)

Results

Our data indicates that 18% of faculty members of the University of Tehran have changed their field of study at least once. This means that they obtained a bachelor's or master's degree in a different field than their doctoral degree. The percentage of scientific field migration among faculty members is presented in Table 1.

Table 1 Percentage of migrations to different fields

Broad field	Percentage of migrations from a field	Percentage of migrations to a field	Percentage of total migrations
Education	2	6	4
Arts and humanities	14	10	12
Social sciences, journalism and information	11	21	16
Business, administration and law	6	13	10
Agriculture, forestry, fisheries and veterinary	6	3	5
Engineering, manufacturing, and construction	21	13	17
Health and welfare	11	11	11
Information and communication technologies	6	4	3
Natural sciences, mathematics, and statistics	23	19	22

The percentage of total migrations reveals that the majority of University of Tehran faculty members (22%) migrated within the field of Natural sciences. Conversely, the lowest number of migrations occurred in Education, Information and Communication Technologies, Agriculture, Forestry, Fisheries, and Veterinary sciences. Social sciences received the highest percentage of immigrants at 21%. Additionally, Natural Sciences (23%) and engineering (21%) were the primary fields contributing immigrant donors to other fields.

Our second objective was to draw a comprehensive map of migrations to illustrate the migrations that happened between broad fields; to achieve this we utilized two illustration software programs, VOSviewer and NodeXL. In both maps clusters are represented by colors and nodes are labeled with their narrow field category names (Figs. 1 and 2)

Figures 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 show field migrations that occurred within each broad scientific field. Each node represents a narrow field and each narrow field is distinguished by shape and color. Directed edges indicate migrations in and out of each narrow field. According to Figs. 5 and 6, natural sciences experienced the highest influx of immigrants. While a large number of faculty members migrated within Natural sciences (e.g. from biology to physics), it also attracted immigrants from other broad fields, like engineering and medicine. Significant migrations took place from physics to management, philosophy, education, mechanical and electrical engineering. Within Natural Sciences, Physics and Chemistry were the primary disciplines sending migrants, while biology was the main recipient.

Figures 7 and 8 show that a large number of faculty members have migrated from Mathematics and Physics to engineering. Engineering has also lost a large number of faculties who mostly migrated to management. There are also migrations to information science, political science, language and literature studies, and

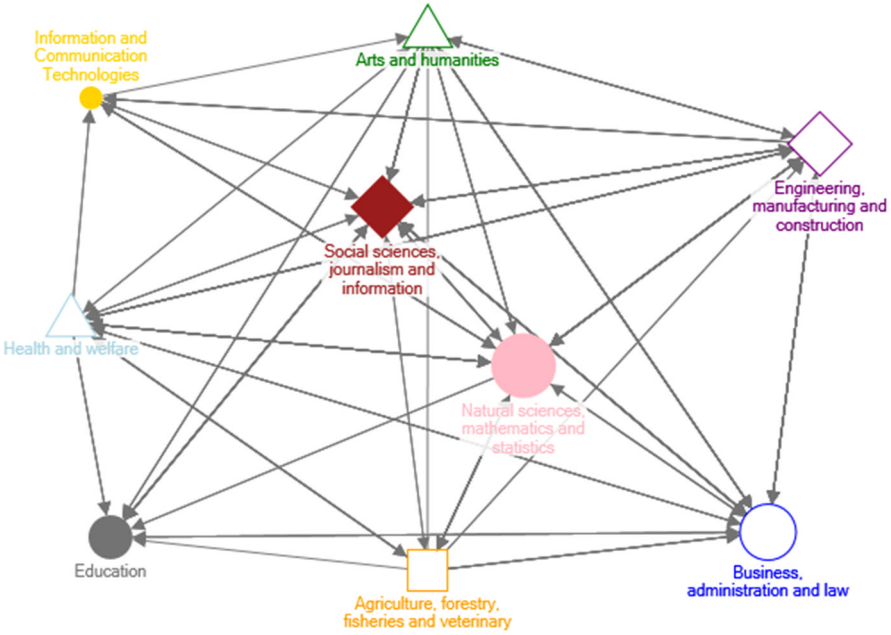

Fig. 1 Directed map of migrations of University of Tehran faculty between broad fields, drew with NodeXL

philosophy. Figures 9 and 10, show the migrations within and out of social sciences. The number of people who have left the social sciences is much less than those who have entered this field. As shown the number of migrations from management to other disciplines is less than migration to it. Management has accepted a large number of immigrants from engineering; mostly from chemical engineering, electrical engineering, mining, mechanics, and industrial engineering. In Arts and Humanities

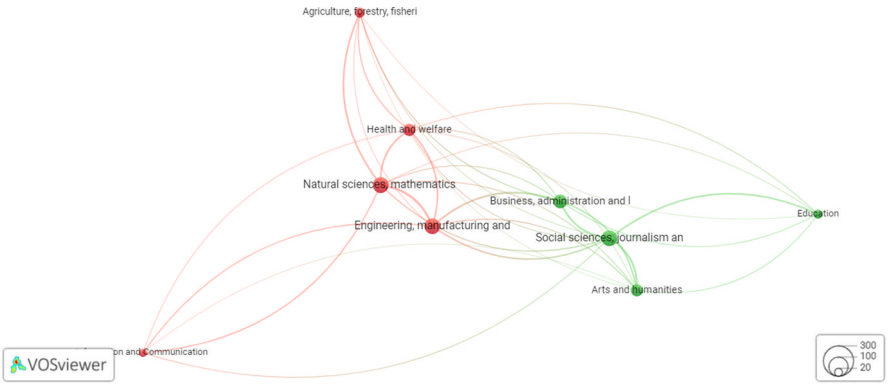

Fig. 2 Map of migrations of University of Tehran's faculty members between broad fields with VOSviewer. Larger circle indicates more migration to the field

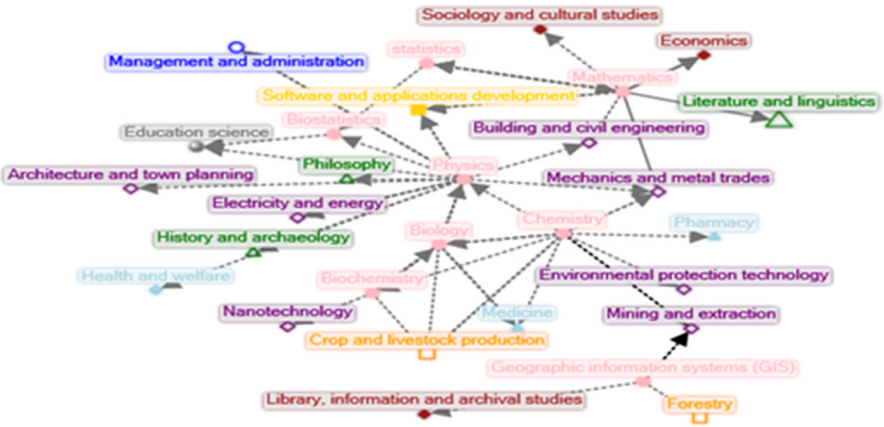

Fig. 3 Migrations from natural science disciplines to other disciplines

(Figs. 11 and 12) Linguistics, Religious, and theology have accepted a large number of migrants. Figures 13 and 14 show a directed map of academic migrations in and out of Health and Welfare. As it is shown there are many faculty exchanges between medicine, biology, pharmacy, and chemistry. Figures 15 and 16 show that crop and livestock production from agriculture, forestry, fisheries, and veterinary is the main

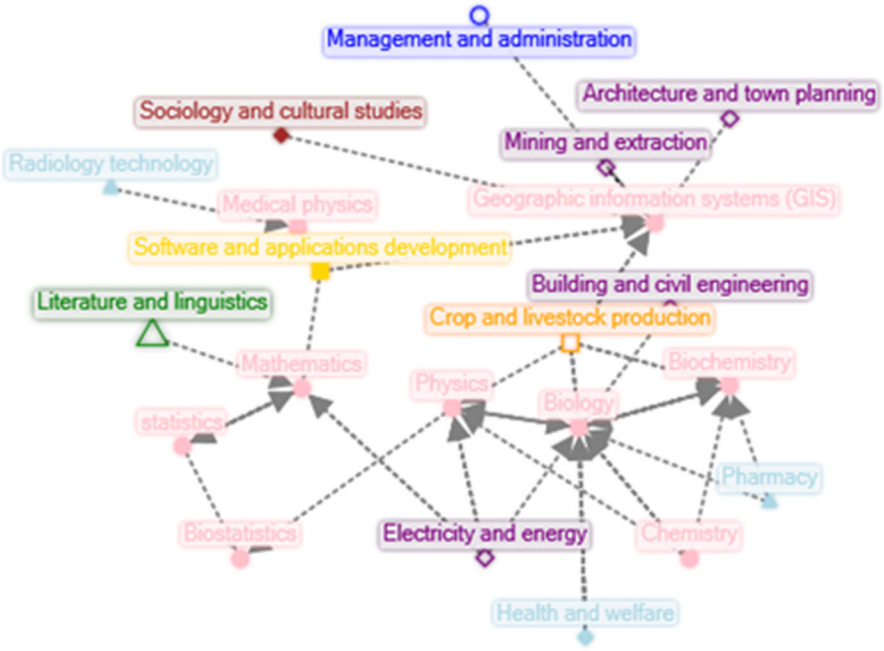

Fig. 4 Migrations to natural sciences from other disciplines

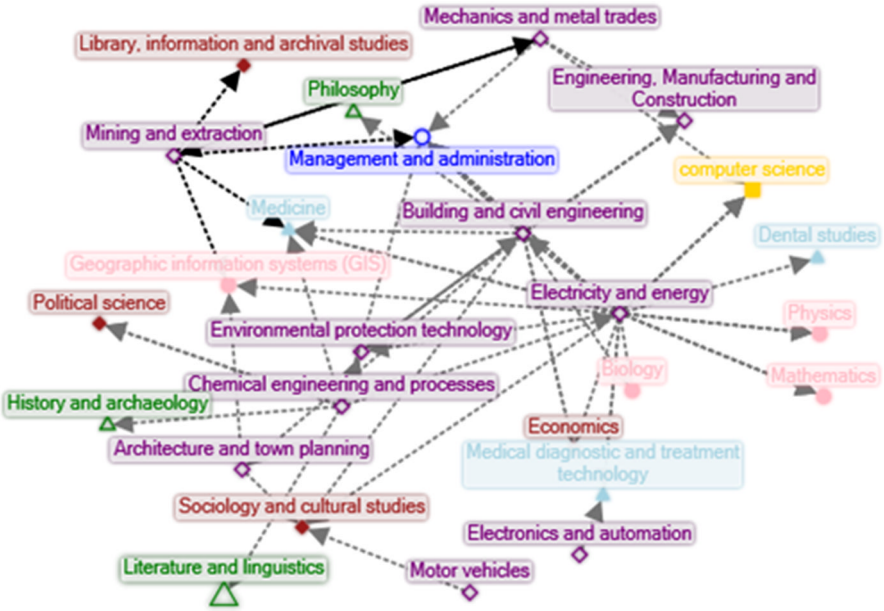

Fig. 5 Migrations from engineering to other disciplines

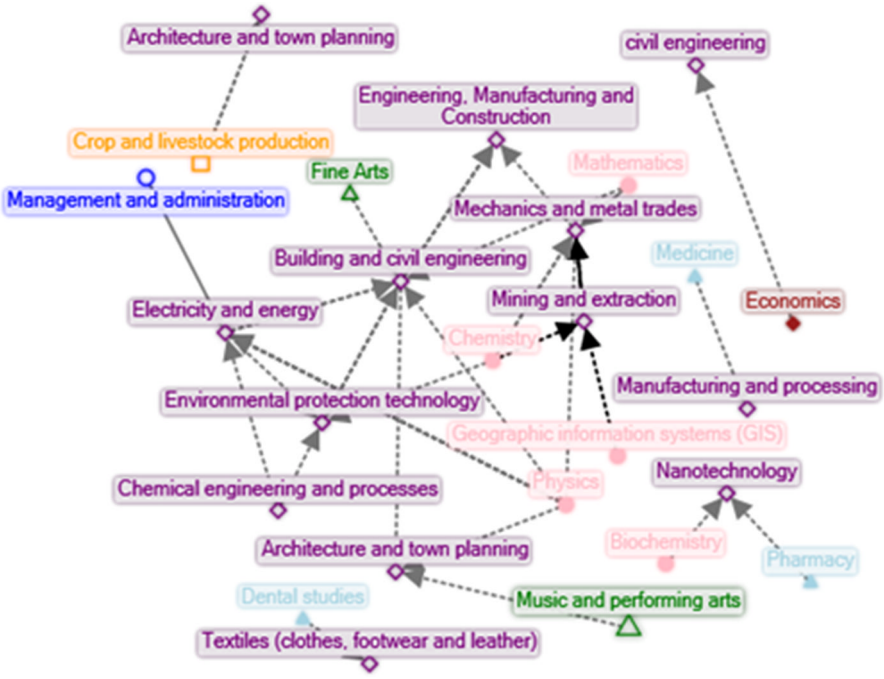

Fig. 6 Migrations from other disciplines to engineering

Fig. 7 Migrations from social sciences to other disciplines

giver of the migrants, and it has also received some migrants from natural science disciplines. Figures 17 and 18 show academic migrations to Education. Education has attracted many migrants from physiology, management, and biology. Figure 20 shows that computer science has also accepted faculty members from medicine, physics, mathematics, and engineering.

The percentage of 26 of the total field migrations occurred within the same broad field, meaning that individuals changed their disciplines while remaining in the same broad field. An example of this would be migration from Medicine to Pharmacy, both falling under the field of health and welfare. On the other hand, approximately 74% of migrations occurred between broad fields. For instance, an individual may have migrated from one field of health and welfare such as nursing to a humanities field like philosophy (Fig. 21).

Key findings include:

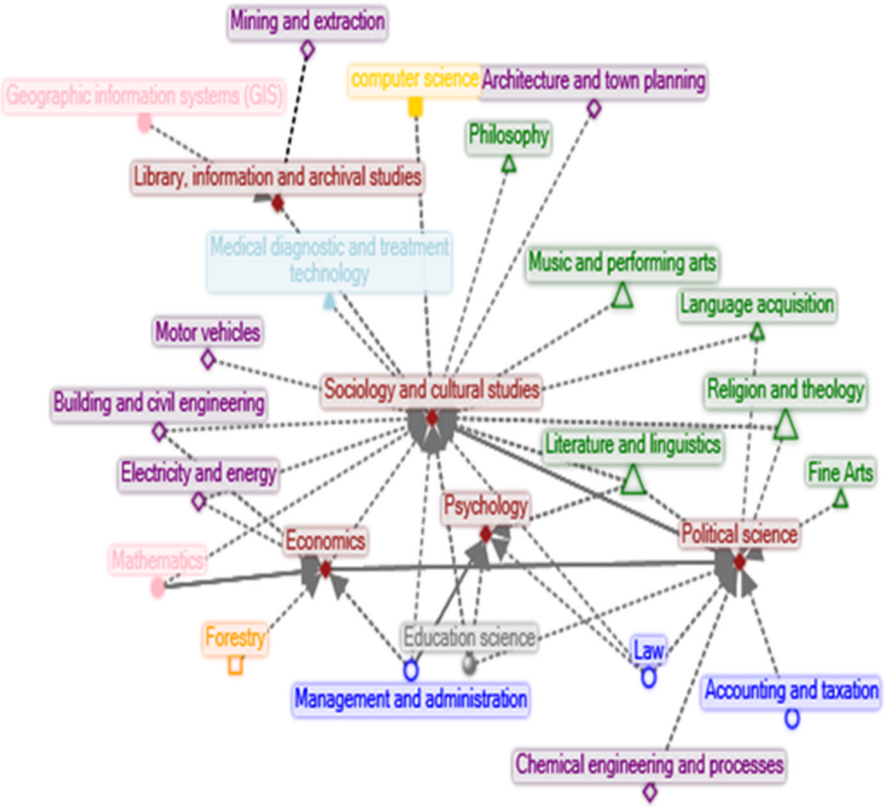

Fig. 8 Migrations from other disciplines to social sciences

Approximately 18% of the faculty members studied held dual degrees.
Field migration occurred predominantly across broader scientific fields (74%), compared to intra-field migrations (26%).
Faculty members tended to move into fields that were distinctly separate from their original fields, indicating a desire to communicate and cooperate with different disciplines.
These trends suggest that the boundaries between scientific fields may be artificially constructed and highlight the importance of interdisciplinarity in modern science.

Discussion

The network of natural science migrations shows a high level of discipline diversity. Kim (2006), unlike our research, showed that migrations from other fields to natural sciences were only from engineering. It seems that migration in and out of diverse fields of natural sciences is more common in our data. Despite mathematics being considered a hard science, it has a good faculty exchange with

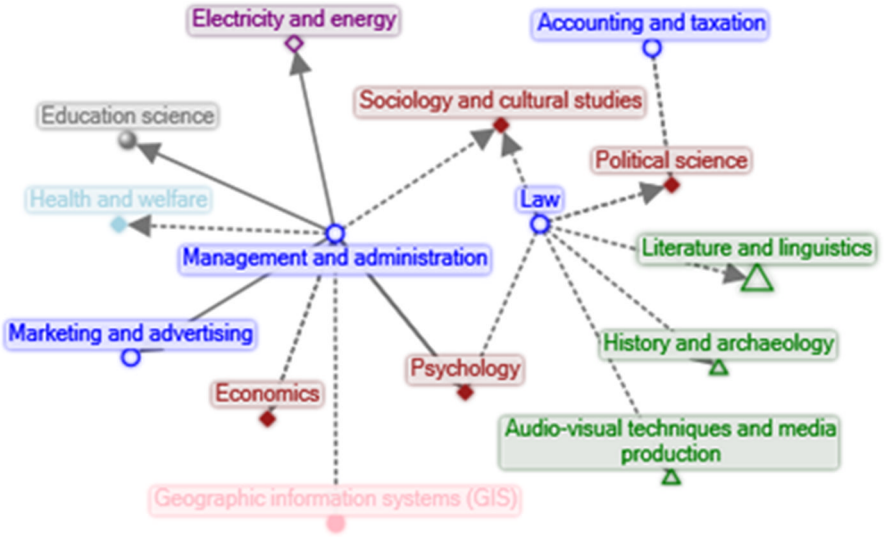

Fig. 9 Migrations from business, law, and administration to other disciplines

social sciences. Such a connection between hard and soft science was also seen in previous studies on science mapping, i.e., Porter and Rafols (2009). They pointed out that despite mathematics being classified as a hard science; it has relationships with other disciplines, especially with social sciences.

Fig. 10 Migrations from other disciplines to business, law, and administration

Fig. 11 Migrations from arts and humanities to other disciplines

Our illustrated data reveals that physics, biology, biochemistry, chemistry, and medical sciences are inter-connected through crop and livestock production. These findings align with previous studies by Porter and Rafols (2009) and Leydesdorff and Rafols (2009). The map drawn by Leydesdorff and Rafols (2009) also demonstrated a link between chemistry, biology, Biomedical Sciences, environmental science, and agriculture.

There are also migrations from physics, math, engineering, and medicine to computer science. This part of our results is again in line with Porter and Rafols (2009) as well as Leydesdorff and Rafols (2009) citation data. In all maps drawn by them to examine the degree of interdisciplinarity, the interdisciplinary relationship between physics, medical science, math, engineering, and computer science has been established which is also seen in the networks illustrated in the present study.

Many migrations happened within and between engineering, but, with low discipline diversity. Previous research on field mobility, Le Pair (1980) and Van Heeringen and Dijkwel (1987) also indicated a high number of migrations from engineering to other disciplines. In the engineering network shown in this study, the field of management is the only discipline from humanities that engineering faculties have moved in and out of. Interestingly, a significant number of current University of Tehran's faculty of management, have a background in engineering. The majority of migrations from engineering

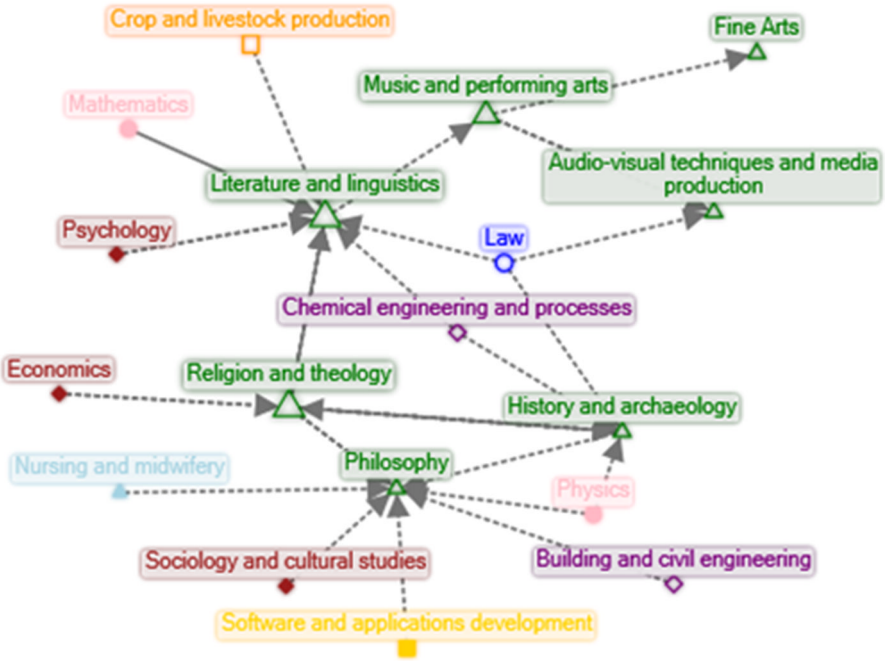

Fig. 12 Migrations from other disciplines to arts and humanities

in Iran can be attributed to its social context. Because engineering is given high value and credit leading individuals choose it as a profession regardless of their interests and talents (in Iran). Moreover, according to Enayati Novinfar et al. (2013); the unsuitable labor market in Iran and the lack of sufficient facilities to promote this industry in Iran can be reasons for this large number of faculty members transitioning from engineering to other careers.

Social sciences received a wide range of immigrants from humanities and engineering, which means that a large number of professors in the social sciences hold degrees in areas such as information science, literature, philosophy, electrical, and civil engineering. This confirms the research conducted in 2008 (Javaheri 2008). This research revealed that 71% of Iranian master's graduates in social sciences had academic backgrounds other than social sciences. There has been a significant exchange between information and sociology. The relationship between information science and sociology has been explored in two studies Small (1999), and Leydesdorff (2007). This connection exists because information science is closely intertwined with social activities.

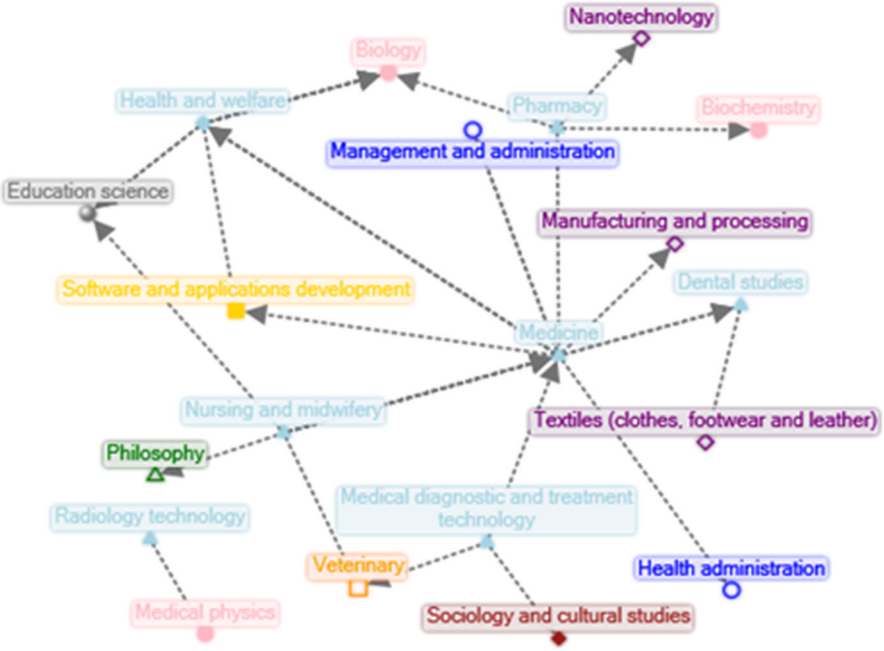

Fig. 13 Migrations from health and welfare to other disciplines

Conclusion

Data on interdisciplinary migrations contain interesting information to explain the formation of interdisciplinary relationships (Mulkay 1974; Hargens 1986; Urata 1990; Rinia et al. 2002). It is believed that researchers facilitate the flow of knowledge by moving between scientific fields, and as carriers of knowledge, they facilitate the transfer of knowledge between scientific disciplines. Maps of migrations depicted in this study show high disciplinary diversity and network coherence. Rafols and Meyer (2010), argued that the network diversity is an indication of the degree of interdisciplinarity, this subject, occurred in this study, among all migrations, within the nine broad fields that were illustrated by figures. Natural sciences alongside engineering showed a great degree of interdisciplinarity.

According to Hargens (1986) and Urata (1990), the migration flow of researchers between scientific fields is equal to the flow of citations between fields, indicating that the results of migration and citation patterns of scientists are interchangeable. By implementing Hargens and Urata's results in our study, it can be concluded that the citation network of the University of Tehran faculty will be as dense as their migration data.

Moreover, analyzing the donor and recipient disciplines can provide us insights into the characteristics and structures of various scientific disciplines (Le Pair 1980). This study revealed that natural science disciplines were the primary source

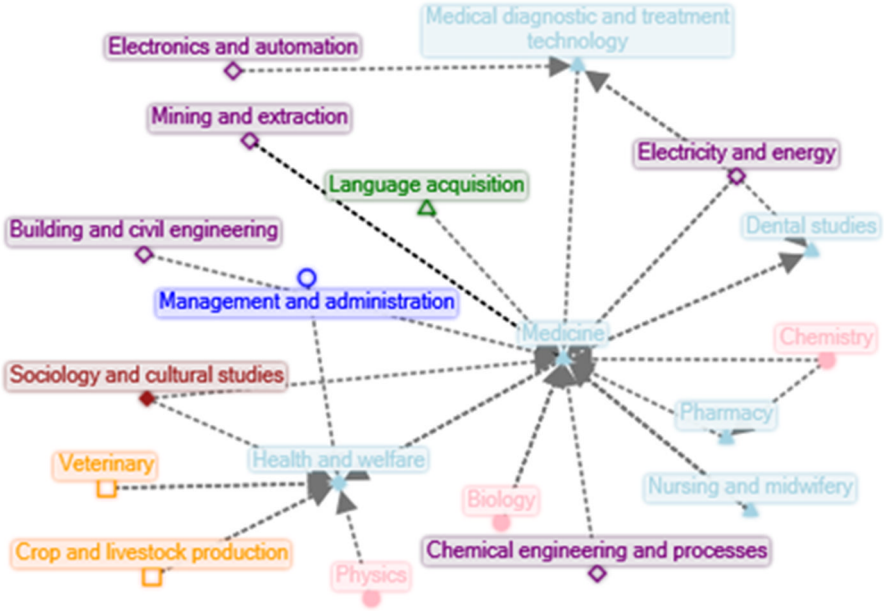

Fig. 14 Migrations from other disciplines to health and welfare

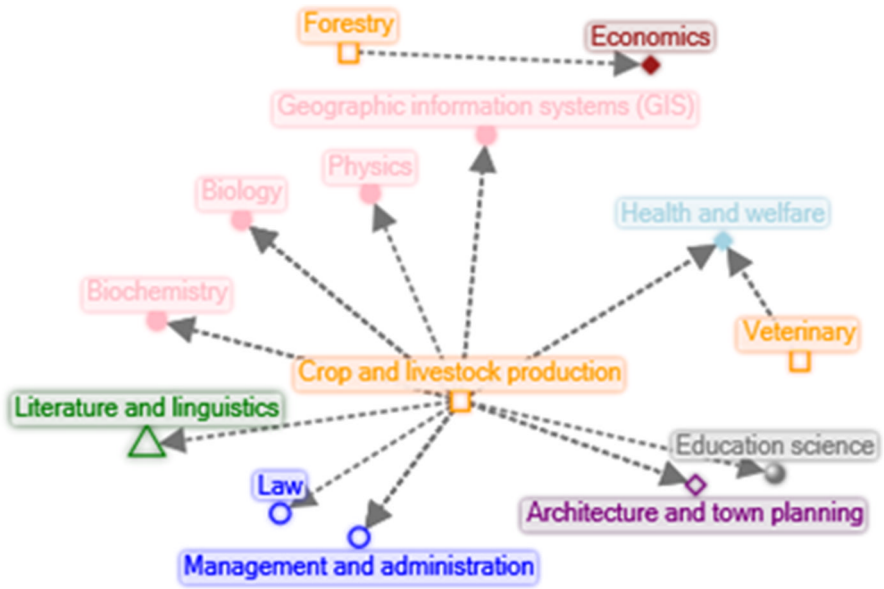

Fig. 15 Migrations from agriculture, forestry, fisheries and veterinary to other disciplines

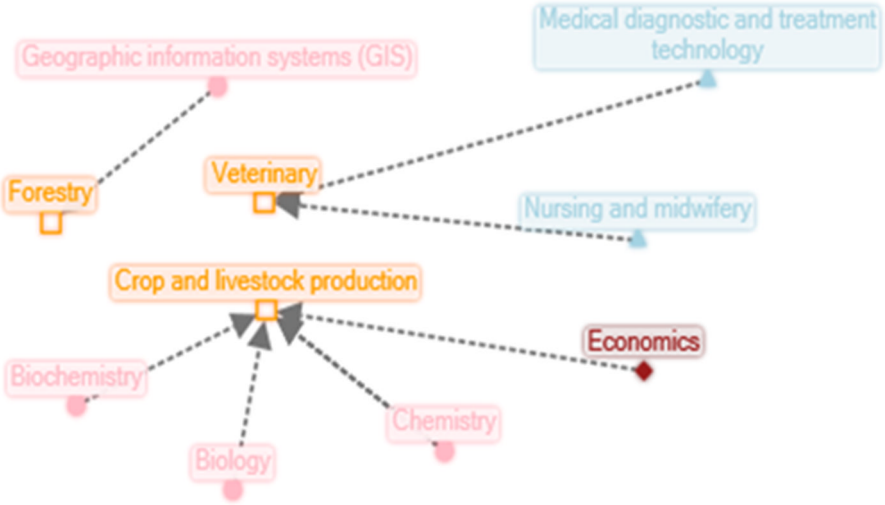

Fig. 16 Migrations from other disciplines to agriculture, forestry, fisheries, and veterinary

of migrants to other disciplines. Previous research has shown that scientific fields that attract a large number of immigrants tend to place less emphasis on their own contents and instead rely heavily on other scientific fields for advancement (social sciences being a prime example). On the other hand, fields that send immigrants to others are more independent than other fields. Moreover, the contents of these fields can be considered as a basis for other disciplines (Le Pair 1980; Cronin and Davenport 1989), physics and mathematics can be mentioned as an example for giver disciplines. it is worth mentioning that physics and mathematics have been classified as hard sciences (Becher and Trowler 2001)., which means that people working within these disciplines tend to isolate their selves from other disciplines, have the least connection and communication with others and as a result think less to change their disciplines. Therefore, it seems that concerning interdisciplinary migrations, the pre-determined classifications in relation to soft and hard sciences have no precedent.

The data of the present research, like many previous studies (Le Pair 1980; Rafols and Meyer 2010) showed numerous migrations between fields that are

Fig. 17 Migrations education to other disciplines

Fig. 18 Migrations from other disciplines to education

closely related in terms of content, methodology, and concept. For example, many migrations happened from nursing (from Health and welfare) to veterinary medicine (from agriculture, forestry, fisheries, and veterinary), regardless of the fact that these two fields are completely separated by broad field boundaries. Therefore, a high frequency of faculty exchange between two or more disciplines indicates the presence of similarities in the foundational principles of those disciplines (Le Pair 1980). There are also, a large number of migrations from psychology to education (or vice versa). In Iran, generally, these two fields are placed together in one

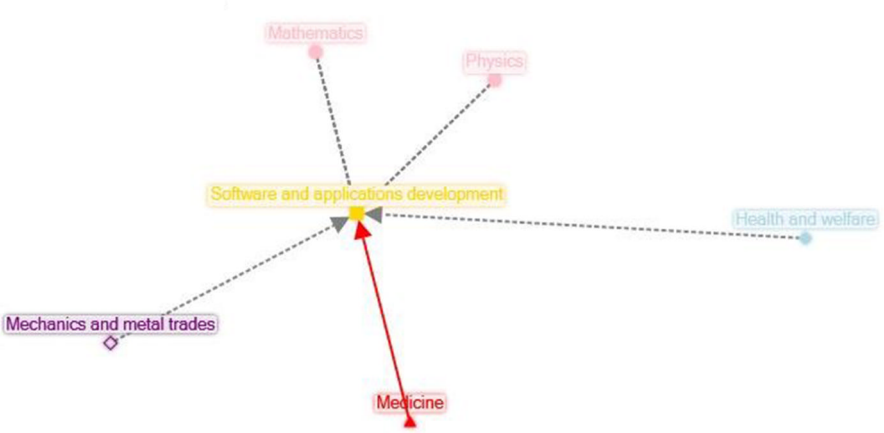

Fig. 19 Migrations from information and communication technologies to other disciplines

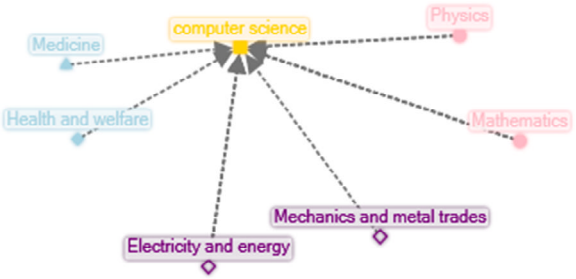

Fig. 20 Migrations from other disciplines to information and communication technologies

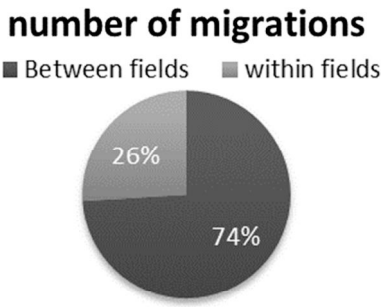

Fig. 21 Migrations have broad fields compared with migrations within a narrow field of migrations

organizational unit, and in terms of structure and education, they are in close connections. This indicates that the closeness of the organizational and situational structure of the two disciplines can also be a motivation for migration between disciplines. The other studies that have used the citation data showed psychology and education have always exchanged a lot of information with each other (Rosvall and Bergstrom 2008). Therefore, as Hargens (1986) pointed out forty years ago, the existence of similarities and commonalities in terms of problems and methods, in other words, cognitive similarities between fields, plays a significant role in creating migrations. This can be concluded that moving between scientific disciplines and making connections between different concepts tends to be more important than paying attention to the predetermined boundaries between scientific disciplines.

Overall, the map of migrations showed that leaving a scientific field and crossing a broad field (74%) occurs almost three times more than intra-field migrations (26%). This indicates that leaving a field does not typically involve simply transitioning to a related field within the same discipline; instead, the majority of migrants cross the rigid boundaries between broader scientific fields and move to fields that are completely distinct from their original field.

The conclusion of this study can be summarized as follows:

First, the pattern of scientific field migrations shows the artificiality of the borders between fields; also it is an indication of the closeness of subject areas of different disciplines. in general, it represents the desire and interest of researchers to establish communication and cross the boundaries between areas of science, which is itself a manifestation of the need for participation, communication, and

cooperation between various disciplines and more Interdisciplinarity in science and scientific activities.

Second, the most important contribution of this research is its facilitating role in the process of choosing a field for novice scientists. Selecting a field is very important and necessary to start a scientific activity; every scientist will undoubtedly go through this course. What this research showed is that people are not required to continue their education in their first choice and they can choose another discipline in their academic life. This study showed that changing a scientific degree and moving between fields does not create a disturbance or a blow to the process of producing science but also it reinforces and enhances the circulation of knowledge.

Study limitations and future research directions

This study has potential limitations. Our research was done in a quantitative approach, since results are gained by numerical data some important aspects of migrations might have been overlooks. It is obvious that many facets of field migrations remain undiscovered, yet they could be crucial. We suggest investigating the role of field migration on people's scientific activities by implementing qualitative methods. This form of research could involve more detailed observation of scientific activities and conducting in-depth interviews. The quality of interdisciplinary activities among migrating scientists is also significant. This can be assessed by analyzing factors such as the number of citations from outside the field, publishing articles in journals outside the researcher's scientific field, or the frequency of collaborations with people from different fields. Additionally, for more in-depth qualitative analysis, case studies could be conducted to examine the characteristics of high-frequency giver and receiver disciplines.

Overall, further research using qualitative methods and case studies could provide valuable insight into the impact and dynamics of field migration on scientific activities.

The aforementioned suggestions require a subjective understanding of the disciplines involved. For instance, to assess the level of interdisciplinarity of an individual who has transitioned from electrical engineering to industrial engineering one must have knowledge of the subject covered in both fields and the ability to differentiate between them. Future studies should be conducted on a case-by-case basis with a high level of knowledge and precision.

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Author contributions S.M. designed the research, analyzed data, and generated figures and tables, and writing the first draft of the manuscript. N.N. edited the manuscript in the English language and proposed the research questions. A.A.S. contributed to the data analysis and discussion of the manuscript. M.T., contributed in extracting data and updating data and converting from Persian to English language of the first draft of the manuscript. All authors read and approved the final manuscript.

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Data availability The datasets generated during and/or analyzed during the current study are available from the first author upon reasonable request.

Declarations

Ethical approval The core research was carried out at the time when compliance with the code of ethics governing human participants was not a requirement. The researchers had however followed a set of rules in compliance with pertinent Iranian law on privacy protection. The additional information was gleaned from in-house databases that had been properly anonymized.

Informed consent No personal information of the individuals under investigation has been disclosed in the figures and results of this research.

Conflict of interest There is no conflict of interest.

References

Ackers L (2005) Moving people and knowledge: scientific mobility in the European Union. Int Migr 43(5):99–131. https://doi.org/10.1111/j.1468-2435.2005.00343.x

Becher T, Trowler P (2001) Academic tribes and territories: intellectual enquiry and the culture of disciplines. McGraw-Hill Education, London

Bordons M, Morillo F, Gómez I (2004) Analysis of cross-disciplinary research through bibliometric tools. In: Moed HF, Glänzel W, Schmoch U (eds) Handbook of quantitative science and technology research. Springer, Dordrecht. https://doi.org/10.1007/1-4020-2755-9_20

Boyack K, Klavans R, Börner K (2005) Mapping the backbone of science. Scientometrics 64:351–374. https://doi.org/10.1007/s11192-005-0255-6

Bozeman B, Dietz JS, Gaughan M (2001) Scientific and technical human capital: an alternative model for research evaluation. Int J Technol Manag 22(7-8):716–740. https://doi.org/10.1504/IJTM.2001.002988

Cronin B, Davenport L (1989) Profiling the professors. J Inf Sci 15(1):13–20. Available via Pascal and Francis Bibliographic Databases. http://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail%26idt=6970782. Accessed 18 Oct 2023

Enayati Novinfar A, Durrani K, Karamdoost NA (2013) Comparative evaluation of effective factors in students major selection at Educational Sciences and Engineering Colleges in University of Tehran. Q J Res Plan High Educ 18(4):145–167. Available via Iranian Institute for Research and Planning in Higher Education. https://journal.irphe.ac.ir/article_702800_en.html?lang=fa. Accessed 18 Oct 2023 [In Persian]

Gibbons M, Limoges C, Nowotny H, Schwartzman S, Scott P, Trow M (1994) The new production of knowledge: the dynamics of science and research in contemporary societies. Sage Publications Inc, New York

Goldstone RL, Leydesdorff L (2006) The import and export of cognitive science. Cogn Sci 30(6):983–993. https://doi.org/10.1207/s15516709cog0000_96

Hargens L (1986) Migration patterns of U. S. Ph. D. s among disciplines and specialties. Scientometrics 9(3-4):145–164. https://doi.org/10.1007/bf02017238

Hessey R, Willett P (2013) Quantifying the value of knowledge exports from librarianship and information science research. J Inf Sci 39(1):141–150. https://doi.org/10.1177/0165551512442476

Javaheri F (2008) Transition of scientific discipline an approach to study of attitude toward majoring in sociology among non-sociology former graduates. Iran J Sociol 9(3.4):89–119. Available via Iranian Sociological of Association. http://www.jsi-isa.ir/article_21812.html?lang=en. Accessed 18 Oct 2023 [In Persian]

Kim E (2006) Impacts of discipline mobility on scientific productivity. MS Thesis. Available via ResearchGate https://www.researchgate.net/publication/33996298_Impacts_of_discipline_mobility_on_scientific_productivity_electronic_resource. Accessed 18 Oct 2023

Le Pair C (1980) Switching between academic disciplines in universities in the Netherlands. Scientometrics 2:177–191. https://doi.org/10.1007/BF02016696

Laudel G (2003) Studying the brain drain: can bibliometric methods help? Scientometrics 57(2):215–237. https://doi.org/10.1023/a:1024137718393
Leydesdorff L (2007) Mapping interdisciplinarity at the interfaces between the science citation index and the social science citation index. Scientometrics 71:391–405. https://doi.org/10.1007/s11192-007-1694-z
Leydesdorff L, Rafols I (2009) A global map of science based on the ISI subject categories. J Am Soc Inf Sci 60(2):348–362. https://doi.org/10.1002/asi.20967
Lockett A, McWilliams A (2005) The balance of trade between disciplines: do we effectively manage knowledge? J Manag Inq 14(2):139–150. https://doi.org/10.1177/1056492605276645
Liu Z, Wang C (2005) Mapping interdisciplinarity in demography: a journal network analysis. J Inf Sci 31(4):308–316. Available via Pennsylvania State Univ. https://citeseerx.ist.psu.edu/document?repid=rep1%26type=pdf%26doi=545e8f7399afac6ded4618634965645d17b0276a. Accessed 19 Oct 2023
Marra RM, Rodgers KA, Shen D, Bogue B (2012) Leaving engineering: a multi-year single institution study. J Eng Educ 101(1):6–27. https://doi.org/10.1002/j.2168-9830.2012.tb00039.x
Moya-Anegón F, Vargas-Quesada B, Herrero-Solana V, et al (2004) A new technique for building maps of large scientific domains based on the cocitation of classes and categories. Scientometrics 61:129–145. https://doi.org/10.1023/B:SCIE.0000037368.31217.34
Mulkay M (1974) Conceptual displacement and migration in science: a prefatory paper. Sci Stud 4(3):205–234. https://doi.org/10.1177/030631277400400301
National Academy of Sciences, National Academy of Engineering, Institute of Medicine, Committee on Science, Engineering, and Public Policy, Committee on Facilitating Interdisciplinary Research (2005) Facilitating interdisciplinary research. National Academies Press, Washington. Available via NAP. https://nap.nationalacademies.org/catalog/11153/facilitating-interdisciplinary-research. Accessed 19 Oct 2023
Ohland MW, Sheppard SD, Lichtenstein G, Eris O, Chachra D, Layton RA (2008) Persistence, engagement, and migration in engineering programs. J Eng Educ 97(3):259–278. https://doi.org/10.1002/j.2168-9830.2008.tb00978.x
Pramanik S, Gora ST, Sundaram R, Ganguly N, Mitra B (2019) On the migration of researchers across scientific domains. In Proceedings of the international AAAI conference on web and social media 13:381–392. https://doi.org/10.1609/icwsm.v13i01.3238
Porter AL, Rafols I (2009) Is science becoming more interdisciplinary? Measuring and mapping six research fields over time. Scientometrics 81:719–745. https://doi.org/10.1007/s11192-008-2197-2
Rafols I, Meyer M (2010) Diversity and network coherence as indicators of interdisciplinarity: case studies in bionanoscience. Scientometrics 82:263–287. https://doi.org/10.1007/s11192-009-0041-y
Rinia EJ, van Leeuwen TN, Bruins EEW, et al (2002) Measuring knowledge transfer between fields of science. Scientometrics 54:347–362. https://doi.org/10.1023/A:1016078331752
Rosvall M, Bergstrom CT (2008) Maps of random walks on complex networks reveal community structure. Proc Natl Acad Sci 105(4):1118–1123. https://doi.org/10.1073/pnas.0706851105
Sá CM (2008) 'Interdisciplinary strategies' in U.S. research universities. High Educ 55:537–552. https://doi.org/10.1007/s10734-007-9073-5
Seymour E, Hewitt NM (1997) Talking about leaving: why undergraduates leave the sciences. Westview Press, Boulder. Available via University of Michigan. https://dept.math.lsa.umich.edu/%7glarose/dept/teaching/resources/talkingAboutLeavingSeymourHewittOverview.pdf. Accessed 19 Oct 2023
Small H (1999) Visualizing science by citation mapping. J Am Soc Inf Sci 50(9):799–813. https://doi.org/10.1002/(SICI)1097-4571(1999)50:9%3C799::AID-ASI9%3C3.0.CO;2-G
Smith MA, Shneiderman B, Milic-Frayling N, Mendes RE, Barash V, Dunne C, Capone T, Perer A, Gleave E, (2009) Proceedings of the fourth international conference on Communities and technologies 255–264. https://doi.org/10.1145/1556460.1556497
UNESCO Institute for Statistics (2012) International standard classification of education: ISCED 2011. Comp Soc Res 30. Available via VOCED Plus. http://hdl.voced.edu.au/10707/240136. Accessed 19 Oct 2023
Urata H (1990) Information flows among academic disciplines in Japan. Scientometrics 18:309–319. https://doi.org/10.1007/BF02017767
Urban D (1982) Mobility and the growth of science. Soc Stud Sci 12(3):409–433. https://doi.org/10.1177/030631282012003003

Van Heeringen A, Dijkwel PA (1987) The relationships between age, mobility and scientific productivity. part I. Scientometrics 11:267–280. https://doi.org/10.1007/BF02279349

van Houten J, van Vuren HG, Le Pairs C, et al (1983) Migration of physicists to other academic disciplines: situation in the Netherlands. Scientometrics 5:257–267. https://doi.org/10.1007/BF02019741

Veysey LR (1965) The emergence of the American University. University of Chicago Press, Chicago. Available via University of Chicago. https://press.uchicago.edu/ucp/books/book/chicago/E/bo68084905.html. Accessed 19 Oct 2023

Ziman JM (1987) Knowing everything about nothing: specialization and change in research careers first edition Edición. Cambridge University Press, Massachusetts. Available via Amazon. https://www.amazon.com/Knowing-Everything-about-Nothing-Specialization/dp/0521323851. Accessed 19 Oct 2023