

DISSEMINATION OF CLASSROOM TEACHING IDEAS AND METHODS THROUGH SOME SOCIAL NETWORKS: THE SOCIOLOGICAL STRUCTURE OF THE COLLABORATION NETWORKS OF PHYSICS TEACHERS

By extracting all authors of articles published in the 3 most popular international journals of physics education for a period of ten years, some collaboration (co-authorship) networks have been constructed based on the criterion that if any two authors have published a paper together, they are labelled as connected or linked by research collaboration in physics education. We have then obtained numerical values for the average number of collaborators, size of clusters formed between physics teachers as well as values of the clustering coefficient. On comparison with the co-authorship networks of scientists in physics, high-energy physics, biomedical science and computer science, our results show that the physics teaching communities are highly fragmented on a global scale by forming many small clusters (or local groups) around the world. However, the internal collaboration within each cluster is astonishingly strong. In this paper, we shall furthermore discuss the implications of those differences on the world-wide dissemination of new or innovative teaching ideas and practices from one physics teacher or educator to the rest in this teaching profession.

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Introduction

Many science educators or teachers around the world often have developed some innovative ideas or methods of excellent practices from their own classroom science teaching. Apart from publication in some international journals or presentation in some international conferences, could they effectively disseminate their theories and practices through other sort of interpersonal linkage or relationship? From a teacher educator's point of view, it is educationally important or meaningful to have some sort of sharing of those educators' or teachers' classroom experience with other practitioners in this professional field. The study on the "small-world problem" by the social psychologist Stanley Milgram (1967) revealed a very famous result of "six degrees of separation" (see e.g. Buchanan, 2002 and Watts, 2003) which states that any two persons on Earth are connected through their friends or friends of friends and the number of those intermediate persons needed for building up the linkage is often just six or less. However, a mere friendship or acquaintance has a rather little likelihood that these two persons will do any effective sharing of ideas or practices on science education. To examine the probable paths, connection and extent of sharing on science education between science educators or teachers, we need an easy and objective way to identify the interpersonal linkage between them and some quantifiable indicators to measure the extent of collaboration.

The Method

By adopting the Newman's (2001) social network analysis approach (see, e.g. Scott, 2000 and Wasserman & Faust, 1994), some collaboration networks are constructed for all authors of the 3 international journals on physics teaching - Physics Education, The Physics Teacher and the American Journal of Physics. The interpersonal linkage is taken to be the co-authorship of a paper published in any one of those 3 journals during the years 1993 to 2002. This linkage could be easily and objectively found from the lists of author indices usually provided in the year-end issue of each journal. This linkage also represents a very deep level of sharing on science education between two authors who would not write a paper on physics education together if they have not really collaborated to do some research on science education. In essence, a network is defined to be a set of nodes (for example, persons/members, plants/animals, computer routers, web pages, cities/towns, airports, power stations/substations, and patients) that are connected by social/physical ties or links (for example, friendship/kinship/professional affiliation, food chain, cables, URLs, highways, airline flights, high voltage transmission lines, and sexual relationships). A famous branch of mathematics called graph theory is used to describe and analyze the structure of these networks in which nodes and links are represented by vertices and edges, respectively. Details of the network construction procedures and underlying mathematical theory have recently been formulated by Yeung, Liu & Ng (2005) in a systematic way. Apart from some programs specifically developed by us for conversion for data format and for special calculations, we have mainly employed the two well-known shareware/freeware for social network analysis - UNCNET version 6 (Borgatti, Everett & Freeman, 2002) and PAJEK (Batagelj & Mrvar, 1999) to draw the network graphs and extract various network statistics/parameters for studying the extent of collaboration between those authors.

Findings and discussion

The preliminary results of our present study could be concisely summarised in Table 1 and depicted in Figure 1 below.

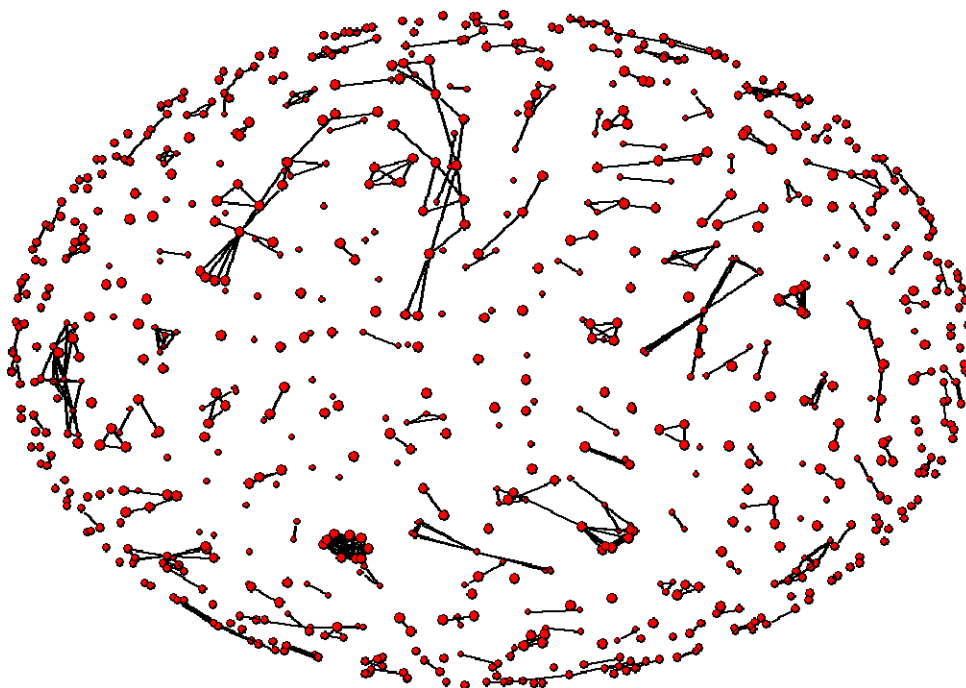
Table 1. Key collaboration statistics for the collaboration networks as derived from the 3 international journals on physics teaching.

Network name	PE	PT	AJP	All
Data source	Physics Education	The Physics Teacher	American Journal of Physics	3 physics teaching journals
Size of the network	826	1,810	3,019	5,271
Mean no. of collaborators per author (std. dev.)	1.3 (1.6)	1.2 (1.7)	1.7 (1.8)	1.6 (1.8)
Size of the largest cluster	11	25	38	62
As a percentage	1.33%	1.38%	1.26%	1.18%
Clustering coefficient	0.745	0.680	0.863	0.816

The size of the network could roughly tell us the total number of researchers on physics teaching during the last ten years. On comparing with the results from Newman (2001), we found that our total number is roughly about 1/300 of that in the medicine field, 1/10 in the physics field and slightly less than a half in the computer field. It is remarked that many researchers published both on physics teaching and on the physics field and some researchers had never published any articles in those journals covered by our database. Regarding the number of collaborators per author, 32% of the authors in our networks have no collaborator at all and the number of collaborators for the most collaborative author is 17. On average, each

author on physics teaching research has only 1.6 collaborators in this field which is much less than 9.7, 3.95 and 6.4 in Newman's (2001) physics, computer and medicine collaboration networks, respectively. The size of the largest cluster (i.e. the giant component) in our "All" collaboration network is 62 (or just 1.2% of the whole collaboration network) which is much smaller than that given in Newman's 4 sets of collaboration networks (57 to 92.6%). As shown in Figure 1, our networks are indeed highly fragmented with 32% of isolated nodes and 20% of researchers having a single collaborator. However, when we look at the cluster coefficient which represents the probability that an author's two collaborators are linked, we are much surprised to note that our values are higher than those found in Newman's collaboration networks – 0.066 in biomedical science, 0.43 in physics, and 0.496 in computer science. The difference can be attributed to the fact that our collaboration networks contain clusters of mostly very small size in which all authors may have co-authored with one and other in the same cluster. The main limitations/errors for our approach come from the fact that authors of those articles published in local (usually non-English) physics education journals or international science journals have been excluded from our collaboration networks. Besides, our database includes authors in the years 1993 – 2002 and so all earlier authors and their interconnection have been ignored, giving rise to another source of errors in our analysis.

Figure 1. A graph for the collaboration network of 826 authors (denoted by circles) in the Physics Education journal during the years 1993 – 2002.



Implications and conclusions

By examining the co-authorship on physics teaching papers, we have objectively constructed the collaboration networks for physics educators or teachers. We have then made use of the social network analysis approach to find some quantifiable indicators, to wit, average number of collaborators per author, size of the largest cluster and the clustering coefficient which can measure the extent of linkage for the effective dissemination of exemplary practice on classroom physics teaching. Our results show that the physics teaching research community around the world forms many small clusters (or local groups) of which the internal

collaboration within each cluster is very strong. One probable reason for this phenomenon can be ascribed to the fact that there are many authors who only occasionally write a single paper, frequently without co-authorship. As our collaboration networks are highly fragmented on a global scale, so those researchers on physics teaching around the world are not so easily or directly connected through research collaboration. Of course, there are some other channels (e.g. international conferences or online discussion forum on physics/science teaching) available to compensate for this deficiency but they are much more difficult to study in an objective and quantitative way with reliability comparable with the present approach. Besides, those other channels are probably less effective in communicating the details of the classroom hands-on experience on science teaching. We should promote research collaboration in science education across different science departments (within an institution) and across institutions or schools for more effective dissemination of exemplary teaching methods or ideas around the world. In future, it should be interesting and worthwhile to check if similar pattern of research collaboration networks also happens in the biology and chemistry teaching communities as well as various communities for cross-disciplinary/inter-disciplinary science teaching. On the other hand, this kind of social network analysis has recently been adopted to study the social interaction of students in classrooms (see, e.g. Cho, Stefanone, and Gay, 2002; Martinez and co-workers, 2003). Hence, there is a growing research interest in studying the sociological structures of both the teachers' networks and students' networks with the aim to improve the effectiveness of teaching and learning.

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References

- Batagelj, V. & Mrvar, A. (1999). Pajek – Program for Large Network Analysis. [Online] <http://vlado.fmf.uni-lj.si/pub/networks/pajek/>.
- Borgatti, S.P., Everett, M.G. & Freeman, L.C. (2002). *Ucinet for Windows: Software for Social Network Analysis*. Harvard: Analytic Technologies.
- Buchanan, M (2002). *Nexus : small worlds and the groundbreaking science of networks*. New York: W.W. Norton
- Cho, H., Stefanone, M. and Gay, G. (2002). Social network analysis of information sharing networks in a CSCL community. In G. Stahl (Eds.) *Proceedings of the Computer-Support for Collaborative Learning (CSCL) 2002 Conference*, pp. 43-50. Boulder Colorado, NJ: Lawrence Erlbaum Associates.
- Martinez, A., Dimitriadis, Y., Rubia, B., Goomez, E., and de la Fuente, P. (2003) Combining qualitative evaluation and social network analysis for the study of classroom social interactions. *Computers & Education*, 41, 353–368.
- Milgram, S. (1967). The small world problem. *Psychology Today* 2, 60-67.
- Newman, M.E.J. (2001). Scientific collaboration networks. I. Network construction and fundamental results. *Phys. Rev. E64*, 016131-8.
- Scott, J. (2000). *Social Network Analysis: a handbook*. (2nd ed.) London: SAGE Publications.
- Wasserman, S. & Faust, K. (1994). *Social Network Analysis: methods and applications*. Cambridge: Cambridge University Press.
- Watts, D.J. (2003). *Six Degrees: The science of a connected age*. New York: W.W. Norton.
- Yeung, Y.Y., Liu, T. C.Y. & Ng, P.H. (2005). A social network analysis of research collaboration in physics education. *American Journal of Physics*, 73(2), 145-150.