International Journal of Information Science and Computing 3(1): June, 2016: p. 21-29
DOI : 10.5958/2454-9533.2016.00003.X

Quantum Information Science: Current Scenario and Future Prospects with Possible Academic Potentiality in Indian Educational Context

P.K. Paul[1], D. Chatterjee[2], A. Bhuimali[3], M. Ghose[4], Poovammal. E[5], R. Rajesh[6] and R. Senthamarai[7]

[1,] FBAS, Indian Institute of Engineering Science and Technology (IIEST), Shibpur- An Institute of National Importance, WB, India

[2]Vice Chancellor, Seacom Skills University, West Bengal, India

[3]Vice Chancellor, Raiganj University, Raiganj, West Bengal, India

[4]Dean (Academics), Sikkim Manipal University, Gangtok, Sikkim

[5]Professor, Dept. of Computer Science &Engineering, SRM University, Tamilnadu, India

[7]HOD, Department of Mechanical Engineering, Noorul Islam University, Tamilnadu, India

[7]HOD, Department of Computer Applications, Vinayaka Missions University, Tamilnadu, India

Corresponding author: PK Paul, prancloud@outlook.com

Abstract

Quantum Information Science [QIS] is an important interdisciplinary domain with much potential in industry, institution, educational sector, health and medical sector and so on. Quantum Information Science is a result of integration of Quantum Science and Information Science. Quantum Information Science is a new field which is responsible for faster and advanced communication system powered by QBit. Quantum Information Science is a combination of many other domains also. The periphery is increasing day by day. Today's super computer as well as in future computing, Quantum Information Science has great potentials. Academic programmes on Quantum Information Science are still limited than that of its requirement. Thus design and development of academic programme on Quantum Information Science becomes important. This hectic process is to be completed with high quality collaborative educational strategies. This paper illustrates many aspects of Quantum Information Science including role, need, characteristics and especially academic potentials in Indian Universities.

Keywords: Quantum Science, Information Science, Quantum Computing, QBit

The emerging discipline of Quantum Information Science is actually providing profound new insights into fundamentals problems related to both computation and Physical Science. Quantum Information Science is an interdisciplinary domain and combination of many domains such as computer science, management

science especially operation research, information science, quantum science and mechanics and so on. Information Science is an Applied Science field responsible for activities on information. It mainly involves information collection, selection, organization, processing, management and dissemination with several tools and technologies. Day by day the traditional role and importance of Information Science is changing and thus Information Science is affiliated with the advancement of Quantum Computing during late of 1990's. In many academics Quantum Information Science emerged as an important Applied Science and Technology field. Quantum Information Theory, Quantum Information Processing are some basic gradients of Quantum Information Science (See Fig: 1: Depicted the core gradients of QIS).

Objective

The main aim and objective of this study includes but not limited to the following:

- To know about Quantum Information Science, its characteristics, features and importance briefly
- To find out the academic programmes available in the domain of Quantum Information Science
- To identify the main advantages of Quantum Information Science in the academic world. And also to analyze about this in the research world as well.
- To mitigate any issues involved and to find the possible strategy and way to introduce Quantum Information Science on specialized programme as full-fledged study or as a specialization.
- To visualize the future potentials of Quantum Information Science programme in Indian Universities.

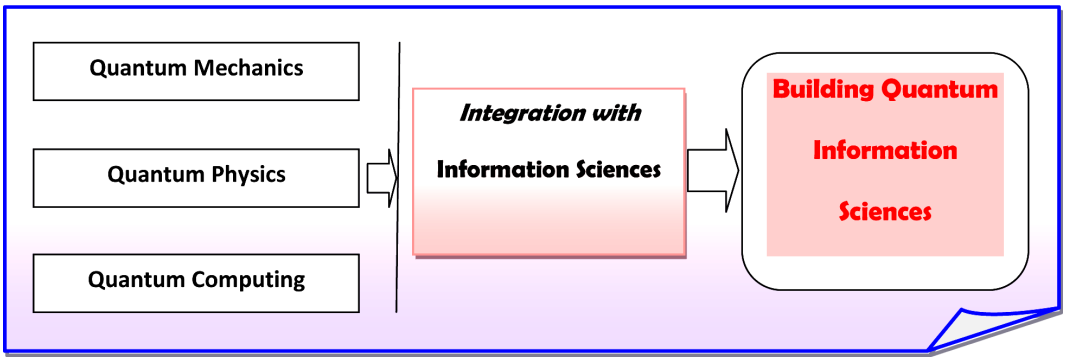

Fig. 1: Components and gradients which help in building Quantum Information Science

Quantum Information Science: Basic and Fundamentals

Quantum Information Science is actually an extension of Quantum Computing. Quantum Computing depends on Quantum Mechanics and Quantum Science. Quantum Information Science is mistakenly treated as Quantum Information Theory, though it has some difference with Quantum Information Science. Quantum Information Science is actually an academic cover on Quantum Information Technology [01, 02,05].

Quantum Science is based on the Physical Information that is held in the state of a Quantum Systems. As Quantum Information Science is powered by QBIT, it is dedicated to higher speed and processing of information. It is also responsible for healthy and sophisticated Information Infrastructure Building.

Quantum Information Science originated as Quantum Computing and then the domain grows as Quantum Information Technology. During last decade of 1990, the nomenclature of Quantum Information Science was evolved. Though the domain is big enough than other domain, Quantum Information Science is responsible for information collection, selection, processing, management and dissemination with QBIT and Quantum Processing. Some of the domains which help in Quantum Information Science are Quantum algorithm, Quantum Computing, Quantum Cryptography, Quantum Dense coding, Quantum Computational Complexity, Quantum Communication and so on [06,09].

Quantum Information Science: Role in faster Information Transfer

Quantum Information Science or QIS is actually enriched with Atom, Molecules, Optical Physics which are mainly responsible for faster and advanced communication between the processors. (*Fig: 2- Showing the relationship of Quantum and Information Science)*. Quantum Information Science comes with much potential and features.

- It is based on large scale computer and thus performs calculation, manipulation and processing of billions of data within a second or moment to get useful information.
- Quantum Information Science may build quantum powered Information Networks. Thus such networks enable speedy inter and intra communication of data, audio and video files with higher speed than the conventional.

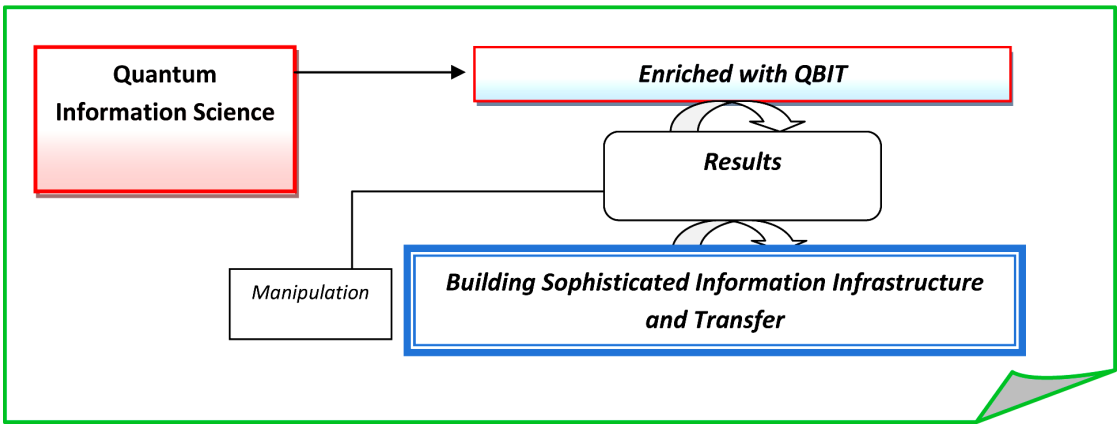

Fig. 2: QBit and its ultimate role in Information Science practice

- Quantum Information Science is based on optical cable and thus it plays an important role for quantum data processing (*Fig: 3 for speedy transfer)*.
- Data in digitized form is increasing day by day and its amount is getting tripled each year. Hence, future data mining and retrieving of information will be possible with Quantum enriched Information Systems.

Quantum Information Science - Academic Opportunities and Possibilities

Quantum Information Science is offered in many educational institutes around the world. However, the number and type of the programme is still limited in this field. This programme is mainly offered in

western countries such as US, UK, Australia and some Universities in Japan and South East Asia [09]. As far as India is concerned, Quantum Information Science is still not offered in any of the institution. India has the best and largest educational systems in the world. Yet, still programme on Quantum Information Science as a part or module is not offered in any of the institutions in India. India has 42 central universities, 15+ IIT's, 30+ NIT's, 5+ IISER and in more than 5000+ Technical Institutions and thus India has many possibilities to offer Quantum Information Science programme [18]. In the following academic units and academics, Quantum Information Science is possible as far as computing and allied faculty is concerned.

- Computer Science/ Computer Science and Engineering
- Information Technology
- Communication Technology
- Information Science
- Electronics and Communication Engineering

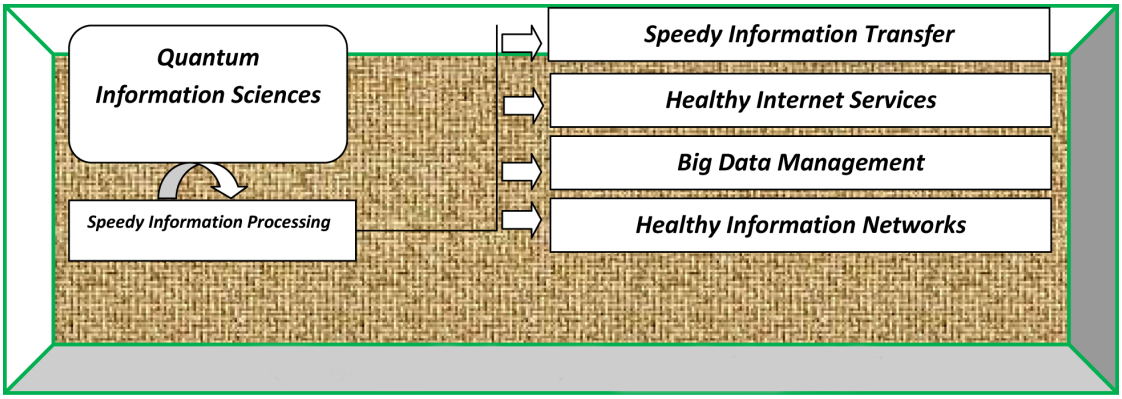

Fig. 3: Speedy Information Infrastructure building with QIS

However, to offer Quantum Information Science in such academics and departments, some skilled and interdisciplinary knowledgeable faculty members and researchers are needed. They should be comfortable in dealing / analyzing / teaching the courses related to Physics particularly in Quantum Science and mechanics [22]. However, apart from conventional programme, such departments may offer many degrees with Quantum Information Science as specialization like:

- MCA [Quantum Information Science/IST].
- BSc/MSc-Computer Science [Quantum Information Science/IST].
- BSc/MSc-Information Technology [Quantum Information Science/IST].
- BSc/MSc-Information Science [Quantum Information Science/IST].
- BSc/MSc-Informatics [Quantum Information Science/IST].
- BTech/MTech-Information Technology [Quantum Information Science/IST].
- BTech/MTech-Computer Engineering [Quantum Information Science/IST].
- BTech/MTech- Communication Engineering [Quantum Information Science/IST].
- BTech/MTech- Electronics and Communication Engineering [Quantum Information Science/IST].

However, apart from such departments, in the Faculty of Basic and Natural Science also Quantum Information Science programme may be offered in Indian Universities. These departments are as follows:

- Physics.
- Chemistry.
- Mathematics.
- Statistical Science and allied departments.

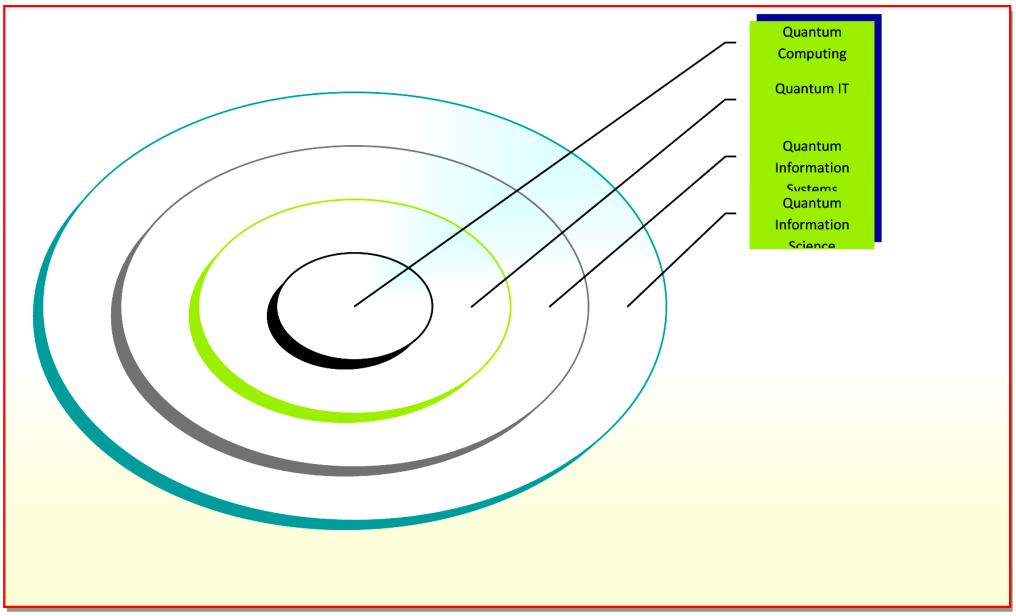

Fig. 4: Depicted QIS and its smaller knowledge gradients at a glance

Now look such possible degree in Indian Scenario with three years BSc and two years MSc course work and research work:

- BSc/MSc-Physics [Quantum Information Science//IST].
- BSc/MSc-Chemistry [Quantum Information Science/IST].
- BSc/MSc- Mathematics [Quantum Information Science/IST].
- BTech/MTech- Quantum Physics [Quantum Information Science].
- BTech/MTech- Quantum Mechanics [Quantum Information Science/IST] and so on.

Thus, by this approach, any basic university may offer such programme mentioned above. Such specializations are easy to adopt with existing Physics, Chemistry, Mathematics programme. Here any few Quantum Computing or Quantum Informatics faculty members may serve the whole programme efficiently [04, 09].

Quantum Information Science: Future Potentials

Quantum Information Science comes with much potentials and possibilities. Virtually Information carried by a Quantum Science flouts such common sense principles. Normal computing and information

systems is run on small scale computing but by QIS it will be so speedy, faster, transparent and able in healthy information infrastructure building with proper information transfer cycle.

In general, in information systems and information science practice, to find out a particular item in general computer, will take time in the order of *N* to search where as in Quantum Information Science, computer will take time in the order of square root *N*. Thus, Quantum Computing Information Science becomes much more inter and intra connected and sophisticated in Information Processing. During mid of 1990's some computing organizations were moved towards Quantum Computing for speedy Super Computer building. Today many Information Scientists are doing several information related activities for building complete Quantum enriched Information World [09, 10,15]. In such cases, Information Science professionals are proposing to introduce Quantum Computing and Information System enriched Information Foundation and facts:

- Data Centre.
- Information Centre.
- Information Systems.
- Information Networks.

Finding

- Quantum Information Science is enriched with Quantum Information Systems and thus Quantum Information Science is bigger domain than Quantum Information Technology or Quantum Computing.
- QBIT is the main stakeholder in Quantum Information Science and allied knowledge and professional field.
- Quantum Computing, Quantum Encryption, Quantum Mechanics, Quantum Communication are the main stakeholder for Quantum Information Science building.
- Still Academic programme on Quantum Information Science is limited around the world and not a single University is offering such programme in India.

Table 1: Depicted general and popular courses related to Quantum Computing and Information

QIS and related programme	Universities and Institutes
MSc in Quantum Technologies -	School of Physics and Astronomy, University of Leeds, UK
MSc-Quantum Information	Institute of Quantum Computing, University of Waterloo, CA
MEngg (ECE) with Quantum Computing	Duke University, Durham, US
Short term work shop, Training etc.	Centre for Quantum Information and Quantum Computation, IISc, Bangalore, India
MSc-Quantum Information and Computing	Department of Physics, Loughborough University Leicestershire, UK

Suggestion

- Quantum Information Science and its real utilization is needed for the growth of society. Thus Government step, project and mission is essential for faster process.
- Quantum Information Science is an interdisciplinary thus, Computing, Information Science, Communication and other professionals need to work together for better result.
- Indian academics, universities may start Quantum Information Science as full-fledged or specialization programme in Computer Science, Information Science or Physical Science departments by some marginal arrangement.

Conclusion

Availability of digital data is increasing day by day. Thus this proliferation of information results in many tools, techniques and domain. Out of these, Big Data Management is treated as important one. In Big Data Management also, Quantum Information Science utilization is possible. Like Information overload, the www is also increasing day by day the internet overload and information overload are common problem now a days. Here implementation of Quantum Information Science may be a wonderful solution from Future Internet [09, 13]. Thus, academics, universities and departments of other domain but relate to Quantum Information Science may involve to do academic and R/D activities in Quantum Information Science for sophisticated Information Infrastructure development.

References

1. Centre of Quantum information science and technology 2013. Home Page, retrieved from http://cqist.usc.edu/ retrieved date-12-09-2013

2. Cohen, E.B. 2004. Applying the Informing Science Framework to Higher Education: Knowledge Development, Management, and Dissemination. Konferencja Pozyskiwanie wiedzy i zarządzanie wiedzą (Proceedings of the Knowledge Acquisition and Management Conference) May 13-15, 2004 Kule, Poland.

3. Cohen, Eli B. and Nycz Malgorzata 2006. Learning Objects and E-Learning: an Informing Science Perspective. *Interdisciplinary Journal of Knowledge and Learning Objects,* **2**.

4. Viola, L. *et. al.* 2001. 'Experimental realization of noiseless subsystems for quantum information processing' Science, retrieved from http://www.sciencemag.org

5. Martin, S.B. 1998. Information technology, employment, and the information sector: Trends in information employment 1970–1995. *Journal of the American Society for Information Science,* **49**(12): 1053–1069.

6. Michael Buckland and Ziming Liu 1995. History of information science. *Annual Review of Information Science and Technology,* **30**: 385-416.

7. NSF 1999. Workshop QIS: An Emerging Field of Interdisciplinary Research and Education in Science and Engineering, Arlington, Virginia, NSF, US.

8. Paul, P.K. 2011. "Quantum Information Science: Emerging Basic Science Focused Information Science domain." in Abhinav *National Journal of Science and Technology,* April, 2013, Vol. 2, No. 09, ISSN-2277-1174, Page-07-14, Impact Factor - 0.1210(2011), 0.2807(2012), GISI.

9. Paul, P.K, 2013. "Social Computing and Social Informatics: The stakeholders of Knowledge Society emphasizing similarities and dissimilarities at a glance" in Abhinav *National Journal of Science and Technology,* **2**(4): 25-32, Impact Factor - 0.1210(2011), 0.2807(2012), GISI.

10. Paul, P.K., Chaterjee, D., Bhatnagar, R., Uma Pricilda 2012. "Information Scientist: Contemporary innovative techno management roles with special reference to Information Scientist Vs Information Technologist: A Study", *Indian Journal of Information Science and Applications [IJISA],* **2**(1): 47-50 Jan-Jun-2012, Academic Research Publication, New Delhi, ISSN-2249-3689

11. Paul, P.K., Ashok Kumar, Dipak Chaterjee 2012. "Health Informatics and its Practice: Emerging Domain of Information Science-Indian Scenario" in *Current Trends in Biotechnology and Chemical Research,* **2**(2): 83-87, ISSN-2249-4073 *[Indexed in DOAJ, Index Copernicus, Google Scholar, CAS-USA]*

12. Paul, P.K, Chatterjee, D., Ghosh, M. 2012. "Medical Information Science: Emerging Domain of Information Science and Technology (IST) forsophisticated Health & Medical Infrastructure Building — An Overview" in *International Scientific Journal of Sports Science,* **1**(2): 97-104, ISSN-2277-2804, New Delhi Publisher, New Delhi.

13. Paul, P.K, Ghose, M.K. 2012. "Cloud Computing: Possibilities, Chalenges, and opportunitities with special reference to its emerging need in the academic and working area of Information Science", ICMOC, *Procedia Engineering,* **38:** 2222-2227, DOI-10.1016/j.proeng.2012.6.267, 1877-7058 C- Published by- Elsevier,USA,

14. Paul, P.K. 2011. " Service Science Nature in Information Science|: Overview" in *Abhinav National Journal of Commerce and Management*, **2**(4): 176-181, ISSN-2277-1166 Impact Factor 0.5051(2011), 0.9670 (2012) GISI

15. Paul, P.K., Rajesh, R., Chaterjee, D., Senthamarai, R., Kumar, A. and Chaterjee, S. 2013. "Usability Engineering: Contemporary Overview with specialreference to its possible & emerging utilisation in the academic and industrial field of Information Science (IS)" *Journal of Emerging Technology in Mechanical Science and Engineering,* **4**(1). ISSN-0976-2558, NI University, Kanyakumai, TN, India.

16. Paul, P.K. 2013. "Information Science and Technology [IST] and its comparision with Information Technology and Social Computing" in *Abhinav National Journal of Science and Technology,* **2**(3): 17-25, Impact Factor - 0.1210(2011), 0.2807(2012), GISI.

17. Paul, P.K. 2013. "Quantum Information Science- Domain of Future Information Management in Organization and Enterprises: Emerging Interdisciplinary Scenario" in *SIT Journal of Management,* **3**(2): 543-551, (Indexed by Google Scholar, IF-1.223 by IIFS).

18. Paul, P.K. and Chatterjee, D. *"Quantum Information Science and a Possible Domain for Future Information School"* in Encyclopedia of Information science and Technology, 3rd Edition, by IGI Global (Information Science Reference),USA, (ISBN 978-1-4666-5888-2 (hardcover) /ISBN 978-1-4666-5889-9 (eBook) /ISBN 978-1-4666-5891-2 (print & perpetual access) Page 2582-2590, IGI Global (Information Science Reference), USA.

19. Paul, P.K., Mrinal, K. Ghose, Minakshi Ghosh and Jhuma Ganguly, 2015. "*MSc Information Science (Quantum Information Science) Specialization: Its Requirement and Proposed Model for Future I-School Dedicated to Next Generation Information-Technology- Community Interaction"* in SRELS *Journal of Information Management,* (ISSN (Print): 0972-2467/ ISSN (Online): 0976-2477), Vol.52 No.2, April 2015, Page 9–15, DOI: 10.17821/srels/2015/v52i2/61940 (Indexed by Google Scholar, Research Gate, ILSA, Indian Citation Index)

20. Paul, P.K. 2013. "MSc-Information Science: A Five year proposed Multiple Exit programme for healthy Information Infrastructure Building" Global Research Analysis- *An International Indexed Journal,* **2**(11): 119-121. IF-0.2714.

21. Paul, P.K. 2013. "Cloud Computing Based Green Information Infrastructure: The Future of Eco Friendly Information Science Practice" *PARIPEX Indian Journal of Research,* **2**(11): 122-124.

22. Paul, P.K., Dipak Chaterjee, Sarangi, B.B., Kumar, A. and Chetri, R. 2012. "Information Management: Emphasizing its different angel and view with special reference to manpower development programme in India" *IJIDT International Journal of Information Dissemination & Technology,* **2**(2): 12-117, ISSN-2229-5984 [*Indexed*

in DOAJ,EISRJC, J-GATE, Ulrich Directory, Google Scholar, Proquest, Index copernicus and other major databases]

23. Paul, P.K. 2013. "Information Systems: From Meaning to its Changing Domain at a Glance" in *Abhinav National Journal of Science and Technology,* **2**(11)1-08, Impact Factor - 0.1210(2011), 0.2807(2012), GISI.

24. Paul, P.K. 2013. "Interactive Design: the pillar of Modern Information Systems" in *Abhinav National Journal of Science and Technology*, April, 2013, **2**(10): 15-22, Impact Factor - 0.1210(2011), 0.2807(2012), GISI

25. Paul, P.K. 2013. "Web Architecture and Information Architecture: Emerging tools of Information Science Emphasizing Relationship and Basic" in *Abhinav National Journal of Science and Technology,* April, 2013, **2**(10): 26-32, Impact Factor - 0.1210(2011), 0.2807(2012), GISI.

26. Reichman, F. 1961. Notched Cards. In R. Shaw (Ed.), The state of the library art04(01), pp. 11–55). New Brunswick, NJ: Rutgers, The State University, Graduate School of Library Service.

27. Saracevic, T. 1996. Relevance reconsidered. Information science: Integration in perspectives. In Proceedings of the Second Conference on Conceptions of Library and Information Science (pp. 201–218), Copenhagen, Denmark: Royal School of Library and Information Science.

28. Saracevic, T. 1975. Relevance: A review of and a framework for the thinking on the notion in information science. *Journal of the American Society of Information Science,* **26**(6): 321–343.

29. Saracevic, T. 1979a. An essay on the past and future of information science education. I. Historical overview. *Information Processing & Management,* **15**(1): 1–15.

30. Saracevic, T. 1979b. An essay on the past and future of information science education. II. *Unresolved problems of 'extemalities' of education Information Processing & Management,* **15**(4): 291–301.

31. University College London, UCL Quantum Technologies, retrieved from http://www.ucl.ac.uk/quantum retrieved date-12-09-2013

32. V Vedral 2006 Introduction to Quantum Information Science (Oxford Graduate Texts), retrieved from dl.acm.org

33. Vakkari, S.P. 1996. Library and information science: Content and scope. In J. Olaisen, E. Munch-Petersen, & P. Wilson (Eds.), Information science: From development of the discipline to social interaction. Oslo, Norway: Scandinavian University Press.

34. Vickery, B.C. and Vickery, A. 1987. Information science in theory and practice. London: Butterworths.

35. Wersig, G. and Neveling, U. 1975. The phenomena of interest to information science. *Information Scientist,* **9**: 127–140.

36. White, H.D. and McCain, K.W. 1997. Visualization of literatures. *Annual Review of Information Science and Technology,* **32**: 99–168.

Webpages

http://www.en.wikipedia.org/ Quantum Information Science

http://www.infosci.cornell.edu/

http://www.ischools.org

http://www.libsci.sc.edu/bob/istchron/iscnet/ischron.html