CHAPTER FIVE

CONCLUSIONS AND DISCUSSIONS

For this study, bibliographic data was collected from three international CD-ROM databases to ascertain the publication behavior, authorship trends and subject distribution of publications contributed in the field of computer science and information technology. The data analysis provided answers to questions posed in Chapter One. The discussion of the answered to the research questions follows.

Findings and Discussions

What were the total number and spread of Malaysian publication in computer science and information technology?

A total of 389 publications were published between 1990 and 1998 of which 229 (58.9%) were conference papers, 159 (40.9%) were journal articles, and 1 (0.2%) was a monograph chapter. Malaysian research publication productivity in the fields of computer science and information technology in the first nine years of 90's indicated two stages of development, i.e., the exploration period from 1990 to 1994 with 136 (35.0%) publications, followed by the rapid growth period during 1995 to 1998 with 253 (65.0%) publications. The average publication productivity was 43.2 per annum. The most productive year of research publication was 1997 with 83 (21.3%) publications. An upward trend for both annual and cumulative amount of publication production was expected to continue in the future. However, the negative effect of the age of research groups on productivity must be seriously noted. A decline signal was probably sent in

1998. Shepard (1956) found that creativity of research teams in industrial laboratories was highest during the first 16 months of its existence and declined thereafter. Wells (1962) and Wells and Pelz (1966) investigated 83 research groups and suggested that the general scientific contribution of their groups tended to decline with increasing age. They studied 172 randomly selected Swedish academic research groups from the fields of natural science and technology and found that the output per scientist seemed to increase during the first 10 years of a group's existence, after that output either stabilized or declined. In the Malaysian context, although an upward trend in publication productivity was generally indicated, the size of research groups and how this affects productivity could be a useful future study.

Who were the active Malaysian contributors?

A total of 458 unique Malaysian authors contributed the 389 publications in computer science and information technology during 1990 to 1998. This figure makes up 0.5 per cent of the total number of 87,000 IT workers in Malaysia by the end of 1998 (*Mid-Term Review of the Seventh Malaysia Plan 1996-2000*, 1999). Each author shared an average of 0.85 publication. More than one forth (136 or 29.7%) of the 458 authors contributed two or more papers/articles, while an overwhelming majority of researchers (322 or 70.3%) just wrote one publication. In general, Malaysian individual authors in the fields of computer science and information technology had various interests of research. Few scientists dedicated themselves to a single subject. The most Malaysian contributors were Mashkuri Yaacob and Mohd Ali Borhanuddin. The very common characteristics of these authors were the various interests of research. Mashkuri Yaacob had the widest breadth

of research interest. His 11 publications dealt with 8 fields according to *The Malaysian Research and Development Classification System (MRDCS)*, while Mohd Ali Borhanuddin covered across 5 areas. This result also hold true for Subramanyam (1984) who suggested that computer scientists had a more diversified research interest within their own field than environmental scientists who tended to work consistently in a well-defined subfield of their discipline and research productivity appeared to be directly related to breadth of research interest of computer scientists.

Out of the 389 publications, eighty per cent (312 or 80.2%) were jointly-author, while only about one fifth (77 or 19.8%) was single-authored works. The proportion of multiple authorship in this current study was higher than that of an investigation of zoology literature by Vimala and Reddy (1996) who found that 75% of works were co-authored. Two authored works was the dominant authorship pattern in the fields of computer science and information technology. Solo authored works and more than three-authored publications were not common. Scientific research was becoming an increasingly collaborative endeavor. The significance for modern scientific practice was mainly based on networking just as much as it was the collection of data or writing of texts. Melin (1997) suggested that the sole researcher was no longer the relevant producer of ideas and discoveries, it was instead the team or possibly an individual operating within a network. Bordons, Gomez, Fernandez, Zulueta and Mendez (1996) found a positive correlation between productivity and international and domestic collaboration at the author level. The 9-year Malaysian practice indicated that research in computer science and information technology in this country was in line with the above general findings on

collaborative activity. Moreover, the majority of the most productive researchers exactly profited from various academic collaborations. Among the first thirty-eight most active authors, few published all works singly. Mohd Ali Borhanuddin cooperated with others in all his publications, and Mashkuri Yaacob co-authored 10 out of 11 to his publications. However, the author position patterns of the productive authors displayed a different pattern. P. Raveendran, Hassan Basri, N. A. Rahim and R. Nagarajan were respectively the first author of all their publications. Ahmed Sohail was the first author five times. Mashkuri Yaacob, Mazlan Abbas, S. M. Rezaul Hasan and M. H. Selamat were leading authors for 4 times each. Very few productive authors were placed first in most of their published works. Further studies need to be carried out to ascertain whether authors' position is correlated to publication productivity.

What was the affiliate status of Malaysian authors?

The first unique authors of the 389 publications were affiliated to 49 organizations in Malaysia which covered three major sectors namely: government agencies and research institutes (GRIs), institutions of higher learning (IHLs) and the private sector. Each institution contributed an average of 7.94 publications. The minority (18 or 36.7%) of institutions contributed the majority (358 or 92.0%) of publication. This result indicated that Malaysian research production in the fields of computer science and information technology was highly concentrated to a few institutions. The three most productive institutions were Universiti Teknologi Malaysia (UTM), Universiti Sains Malaysia (USM) and Universiti Malaya (UM) which together account for a total of 222 (57.1%) publications. Blume and Sinclair (1973) reported a modest positive association between

individual productivity and group size among a large sample of British university chemists. Stankiiewicz (1979) studied 173 Swedish academic groups and found that group size was significantly related to the output of published papers. The relationship of group size to performance was curvilinear especially when group age was controlled. The bigger the group the larger the output till a certain size was reached when it began to decline. The optimum group size in this case was about 5 to 7 scientists. Fitschi et al (1980) found a relationship between productivity and department size in their Swiss sample but observed that for chemistry, physics and mathematics a significant productivity peak was indicated when the department size was between 9 to 22 researchers and assistants. The three above-mentioned Malaysian universities were among the oldest universities with a distinctive size of researchers who were productive as a group. According to *1996 National Survey of Research and Development (Revised Version)*, Universiti Sains Malaysia recorded the highest count both for number of local researcher and total research effort (266 and 125.12), followed by Universiti Teknologi Malaysia (230 and 102.4), Universiti Malaya (188 and 83.89), Universiti Kebangsaan Malaysia (170 and 79.75) and Universiti Putra Malaysia (144 and 73.96). This result verified the positive correlation between the size of the research group and productivity in this current study.

What were the main channels of Malaysian research publication?

Research in the natural science depended primarily on serial literature, especially on a small number of core journals published in the field. Fussler (1949) examined the high dependence on journals among chemists and physicists in USA. He pointed that the

scientists cited more than 90% of their references from serials. Print journals provided the most research support in the field of business management (Popovich, 1975). However, journal articles played the secondary role in humanities disciplines. Budd (1986), Heinzkill (1980) and Stern (1983) found that the percentage of the use of journal articles in American literature, English literature and literary scholarship were 26.7%, 20.0% and 15.1% respectively. The distribution analysis of the present study revealed that conference paper was the primary channel of research communication used by Malaysian authors to publish the majority of research findings in the fields of computer science and information technology during 1990 to 1998. The secondary channel used was journals. The finding might be unique for the field of computer science and information technology. Even though the majority of article of Malaysian researcher was published in a few journals, the distribution of such publication was rather dispersed. The expected core journals were not indicated. However, an increase trend of journal article publication was revealed.

The above-mentioned 229 papers were distributed in 148 conferences. Approximately, 1.5 papers were submitted to each conference. Over fifty per cent (55.0%) of total conference papers were published in less than one third (30.4%) of proceedings. Among the 148 conference proceedings, 19 (12.8%) core proceedings covered 74 (32.3%) papers, 41 (28.3%) moderate proceedings contributed 67 (29.3%) papers, and 88 (60.7%) low productive proceedings accounted for 88 (38.4%) papers. The productivity of conference paper peaked in 1997 and indicated an upward tendency.

The first authors of the 229 conference papers were affiliated to 35 institutions during 1990 to 1998, with an average of 6.5 papers per corporation. Universiti Teknologi Malaysia (UTM), Universiti Sains Malaysia (USM) and Universiti Malaya (UM) were the top corporate providers of conference paper, with 63 (27.5%), 44 (19.2%) and 28 (12.2%) titles each and totaled to 135 (59.0%). The total of conference papers from eight IHLs was 187 (81.7%). The most productive conference paper individual contributor was Mohd Ali Borhanuddin who submitted 9 papers.

The distribution of Malaysian conference papers was concentrated in a few proceedings published in seventeen countries or regions. A total of 149 (65.1%) papers were published in USA, followed by 23 (10.0%) in Singapore and UK respectively. The proportion of conference publications of the three countries reaches 85.2 per cent. Other proceedings were published in Australia, Austria, Belgium, Canada, China, Czech, Egypt, Hong Kong, India, Italy, Japan, Netherlands, Switzerland and Turkey.

Out of the 159 journal articles mentioned above, about half (48.4%) were published in one forth (24.1%) of 108 publishing journals. In other words, a sum of 102 (94.4%) low productive journals contributed a total of 122 (76.7%) articles. This phenomenon indicated that the distribution of Malaysian journal articles in the fields of computer science and information technology during 1990 to 1998 was widespread. Nath and Jackson (1991) obtained the similar results. In these cases, Lotka's Law relating to the number of authors of papers written by each author did not apply. Malaysian author of research publication in the fields of computer science and information technology during

the years from 1990 to 1998 published in various channels. The annual rate in journal article publication was 17.7 and the most productive year for journal articles was 1997. *Malaysian Journal of Computer Science* was the most productive journal relative to other journals. Mashkuri Yaacob was the most productive researcher with 7 (4.1%) journal articles during 1990 to 1998.

The publishers of the 108 journals were located in 15 countries, i.e., Australia, Bangladesh, Canada, France, Germany, India, Japan, Malaysia, Netherlands, Singapore, Slovenia, Switzerland, Taiwan, UK and USA. UK has the maximum of journal publications, i.e., 63 (39.6%), followed by USA with 32 (20.1%).

A total of 371 publications cited 4,223 references. About 11.4 references were attached to each publication. The most common number of reference in one single publication was eight. Journal article showed the maximum of references in a single publication and the sum of publications citing most references. On the contrary, conference paper had more items with the least quantity of references.

What were the areas researched upon?

The whole 389 publications were involved to 39 fields of research area in accordance with *The Malaysian Research and Development Classification System (MRDCS)*. Simulation system attracted the most interests with a sum of 85 (21.9%) publications. The most active subject areas in which 10 or more publications were simulation system, control engineering, computer assisted instruction (CAI), programming techniques,

expert system, asynchronous transfer mode (ATM), image processing, software engineering and digital signal processing & applications.

Universiti Teknologi Malaysia had the most achievements in the fields of control engineering, computer assisted instruction (CAI), digital signal processing & applications and digital systems. Universiti Sains Malaysia stood head in programming techniques, neutral network and computer graphics, undertook the all completed projects of integrated circuits, and shared the quantity of production in parallel processing with Universiti Putra Malaysia equally. Universiti Malaya played the leading role in the fields of simulation system, image processing, software engineering, computer aided system, compression techniques and antenna technology, as well as jointly dominated over the researches of artificial intelligence (AI), simulation system, image processing and CAD/CAM systems with others. Universiti Kebangsaan Malaysia and Universiti Putra Malaysia displayed the extraordinary successes in expert system, knowledge base and asynchronous transfer mode (ATM) respectively.

Some individual authors stood out as very active in research with most number of contributions in specific fields of computer science and information technology. They were: Mohd Ali Borhanuddin, Ahmed Sohail, Mazlan Abbas and R. Mukerjee in asynchronous transfer mode (ATM), K. L. Lo and Abdul Halim Mohd Yatim in simulation system, and Marzuki Khalid, Rubiyah Yusof, Shamsudin M. H. Amin and Zainol Anuar in control engineering.

Conclusion

The results of this study have indicated four viewpoints. Firstly, Malaysia has achieved remarkable successes in research in some fields of computer science and information technology, such as simulation system, computer control engineering, computer-assisted instruction (CAI), expert system, asynchronous transfer mode (ATM), and image processing. The institutions of higher learning played a leading role in these areas of research. Secondly, the collaborative activities have dominated and further promoted the continuous development in national computer science and information technology research. Thirdly, the cooperation environment has nurtured an increasing number of local researchers of whom productive authors from academic institutions were not rare. Finally, Malaysian computer science and information technology researchers were more inclined to publish in the form of conference paper which was the primary channel for communication of research findings.

The current study has only focused on Malaysian publications listed in three international databases and, therefore, admits limitations. Further studies covering local contributions from local database and indexes could greatly complement this study. Further study can also take into account citation count to the publication identified from the three databases to ascertain which paper achieved the most impact internationally. Furthermore, in view of the significant role of information technology for Malaysia's Vision 2020, an officially coordinative project for Malaysian computer science and information technology research should be necessary and feasible.