

**TEACHING AND LEARNING SPACE ALLOCATION IN HIGHER EDUCATION
INSTITUTIONS**

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**TEACHING AND LEARNING SPACE ALLOCATION IN HIGHER
EDUCATION INSTITUTIONS**

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ABSTRACT

Allocating space for teaching and learning is one of the facility management main elements in universities. Increased in the number of students, courses and programmes are the main contributing factors that generate teaching and learning space allocation. Lack of management will reduce the effectiveness of teaching and learning process. The faculty's administration also does not have any computerized system that may help deliver information about teaching and learning space. A computerized system is needed for space allocation information to help the faculty to make good decisions. Thus, this research has three objectives. The first objective is to develop a conceptual framework for teaching and learning space allocation according to user's requirements. The second objective is to develop a prototype system for teaching and learning space allocation information based on the conceptual framework of user's requirements. The final objective is to test run the system based on the user's requirements analysis. In developing the prototype system, firstly, this research analyses user's requirements in teaching and learning space allocation. Next was the process for developing the system consisting of data management, analysis and presentation of teaching and learning space allocation information system. Finally, the system underwent a test run incorporating user's teaching and learning requirement that has been determined earlier. In conclusion, the system is capable of helping the faculty's administration in delivering the information about teaching and learning space as systematic manner. Recommendations for future research includes consideration of other aspects of user's requirements of teaching and learning facilities, system's technical improvement, method of determining the user's requirements and more advanced spatial analysis for development of a better system.

ABSTRAK

Pengagihan ruang pengajaran dan pembelajaran merupakan salah satu elemen utama pengurusan fasiliti di kebanyakan universiti. Peningkatan bilangan pelajar, kursus dan program, merupakan penyumbang utama kepada pengurusan pengagihan ruang pengajaran dan pembelajaran. Pengurusan yang lemah boleh mengganggu proses pengajaran dan pembelajaran yang efektif. Pihak pengurusan fakulti juga tidak mempunyai sistem berkomputer untuk membantu penyampaian informasi ruang pengajaran dan pembelajaran. Sistem berkomputer diperlukan untuk pengagihan maklumat ruang bagi membantu pihak fakulti dalam melakukan keputusan yang baik. Lantaran itu, kajian ini mempunyai tiga objektif. Objektif pertama ialah membentuk sebuah konsep rangka kerja untuk pengagihan ruang pengajaran dan pembelajaran berdasarkan keperluan pengguna. Objektif kedua ialah membangunkan sebuah model sistem bermaklumat untuk pengagihan ruang pengajaran dan pembelajaran berdasarkan rangka kerja keperluan pengguna. Objektif terakhir adalah untuk menguji sistem berkenaan berdasarkan kajian keperluan pengguna. Dalam membangunkan model sistem berkenaan, pertama, kajian ini menganalisis keperluan pengguna terhadap pengagihan ruang pengajaran dan pembelajaran. Seterusnya adalah proses membangunkan sistem dengan mengambilkira pengurusan data, analisis dan persembahan sistem maklumat pengagihan ruang pengajaran dan pembelajaran. Akhir sekali, sistem tersebut diuji berdasarkan keperluan pengajaran dan pembelajaran yang telah dikenalpasti pada peringkat awal. Rumusannya, sistem ini berkemampuan membantu pihak pengurusan fakulti dalam menyampaikan maklumat terhadap ruang pengajaran dan pembelajaran secara bersistematik. Cadangan kajian masa hadapan yang diutarakan termasuklah mengambilkira keperluan-keperluan lain pengguna terhadap fasiliti pengajaran dan pembelajaran, meningkatkan keupayaan teknikal sistem, kaedah mengenalpasti keperluan pengguna dan analisis spatial lanjutan untuk pembangunan sistem yang lebih baik.

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CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

“Good planning comes from good information and good information comes from a good system”

Calkins, (1972) in Hamid B. Hj. Mar Iman, (2006)

Considerable development in IT can bring benefit to the FM industries especially in business support process (Mawson 1994; Hinks 2002). Facilities managers are now looking forward for information technology (IT) due to the potential of IT in delivering good decision making, better support for core objective, greater control of the assets base, reducing overhead cost, increasing facilities performances, improving transparency in monitoring and competitiveness (Lunn & Stephenson 2000; Swift 2000; Pitt & Hinks 2001; Wan & Chan 2007). The role of IT has turned the data in FM to be important for the users and its management as it enhances innovative businesses through the management of the operations, supply chains, business supports and customer satisfactions.

In higher education institution, educational facility is the attractive key to encourage research as well as to fasten knowledge creation (Price et al., 2003). Facilities managers should not only aim to optimize the running cost of building but also to increase the efficient use of its assets and facilities. The question is how to link the needs of the users to the space management within the existing physical environment? Grimshaw (1999) argues that for a change towards a better facilities management system, organization, employees and information must be linked together. This is further supported by Alexander (2003) that adaptation to change in management and measurement issues in FM is a key for effective facilities implementation of future organization. Thus, efficiency can be created by linking the organization with its physical environment in which it operates (Amaratunga & Baldry, 2000). Therefore, this research carried out a combination of user requirements on facilities issues and the needs of information technology on helping the management process.

Research focus is the resource service in higher education environments which the scope is the teaching and learning (T&L) space allocation. The research will gathered out the requirements from the user's perspective on allocating the T&L space. With the result and finding on the user requirements analysis (URA), it will lead to a development of a conceptual framework. This result will be success factor of the research which will explain what the requirements on users view are. After the conceptual constructed, these will be the basis of the information system developments which the second focus of this research. The system may focus on delivering and display the information to its users as the purpose of allocating the teaching and learning space in the university. Therefore, with the system develop it will help the administration as decision making for managing the T&L space systematically and ultimately satisfying the need of the users.

1.1 RESEARCH PROBLEM STATEMENT

“The distribution of the available areas of space among a number of objects with different sizes so as to ensure the optimal space utilization and the satisfaction of additional requirements and/or constraints” (Burke et al., 2001)

Marmolejo (2007) cite that two of ten critical higher education facilities issues from the APPA (Association of Higher Education Facilities Officers, 2006) are the resource scarcity and affordability and the information technology. The main resource in higher education institutions is their teaching and learning (T&L) space. T&L space must be managed properly by the facilities manager. The reasons for managing and planning the space are to optimize its physical resources, to assist in time table planning, as well as to support the teaching and learning of subjects (Fauzi A. Wahab, 2005). Therefore, space strategies have to get involved in facilities management, thus, the quality of the space can be achieved and influences the performance of the people (McGregor, 2000).

Space allocation problem is not a new issue within higher education environment. It has been discussed and researched, by many researchers from all over the world including Sharma & Kumar (1985) - issues on space allocation in academic departments high rise building, Burke & Varley (1998)- issues on higher education requirements, Beynon (1997)– issues on physical higher education facility requirements, Schaerf (1999)– issues on automated time table for higher educational institutes, Burke & Varley (1999) - issues on automating space allocation, Burke et al. (2001)– issues on space allocation process, Silva & Beng (2003) – issues on Meta heuristic and multi objective approaches for space allocation and Beyrouthy et al. (2007)– issues on space allocation splitting problems. These researchers tried to find out the best solution and requirements to fill in the gap in space allocation planning of higher educational institutions. Indeed, the user’s requirement is very important in the facility management in higher educational institutions (Burke & Varley, 1998). Improvement in the

operational flexibility necessitates that facilities have to meet the needs of the clients (Douglas et al., 2008). Therefore, the challenge is how to manage the resources and meet with the user's requirements.

According to Burke & Varley (1999) there are three main constraint satisfactions on allocating the space such as resource specific requirements, ensuring grouping and close proximity of resources and ensuring distance between conflicting resources. The requirement has been explain in technical report by Varley (1997). However the requirements from the users view is still less inform in the articles and each university will have its own constraints and opinions as to what requirements should be satisfied to make a good allocation of space. Thus, the facility managers have to understand the business that property resource is supporting the academic faculties or department needs According to Housley (1997), there is conflict of understanding of the need of users in institution between estate directors and academic faculties. He suggested that it is important all parties to be involved in the facilities management. Hafizal B. Ishak (2009) found that space allocation has to consider the requirement of its users. From the research he found that there are several requirements from the user in T&L space allocation such as space location, class timetabling, class capacity and equipments which highly required by the lecturers and students and were not fully provided by the faculty administration. Therefore, the challenge is how to manage the resources and meet with the user requirements.

Today, higher education institutions are facing with the new millennium challenge in facilities management. The increasing number of students, departments, courses, staffs, facilities and assets are the factors of why a system must be revisited for better facilities management (National Assets and Facilities Convention, **NAFAM**). According to Esparcia-Alcázar et al. (2008), problem on allocation are the lack of suitable tools to perform the task which still using hand base method (manual approach). Amaratunga & Baldry (2000) cite the main problem in facilities management in higher education institution is the ongoing use of traditional management control and one of it affecting the misleading information on decision making Waheed & Fernie (2009)

explained that traditional perception in role of physical assets and related service is exploiting for the effectiveness of core competency. Thus, they purpose a new perception which is the role of physical assets and related service must have it core competence itself.

Albicini et al. (2006) discussed the problems in work prioritization processes. Generally there are ten problems highlighted, but it can be categorized into four main aspects which are maintenance, financial system, customer response and record keeping. These are the areas identified to be solved by the computerized processes. Research by Wan & Chan (2007) shows that facilities management (71%) is the most requested as compared to the campus helpdesk (25%), tenancy (3%) and remote operation centre (1%) by the campus users. In other findings, however, they showed that user also require services in terms of access to campus system, PC application, e-mail and files service. However, according to Michael (2004) until recently, higher education still paid little or no attention to data that can aid in their management for decision making. This is supported by Hamid B. Hj. Mar Iman (2007) said that the information storage in people is ineffective because they tend to forget easily. Therefore, the traditional method has proven to be a problem in many aspects of management and it has been debated for over than ten years.

As discussed above, the research focuses on two main issues which are the higher education environments issues and the traditional method of managing the facilities. In higher education environments, the research will lead into two aspects which are the strategy aspect that highlighting the need of determining the user requirements and the second aspect are the space management which focusing on the space allocation perspective. These two aspects (user requirements and space allocation) are much related to each other as for allocating the T&L space as required by the users. Base on the pilot study held in several faculties, user's (lecturers) usually change their timetable provided by the faculty because of the timetable is not suitable with their requirements such as room not suitable with user numbers, not suitable with subject teach, room location is not necessary, room installed with non suitable equipments and

furniture and the equipments is not available and lack of numbers. These problem shows that room allocated for the users are not suitable which is not according to the users need and may lead to inconvenient environments of study.

The statements are supported on the lecturer’s survey on their perceptions on the T&L space in the faculties and timetable suitability provided by the administration. Crosstabs is use as for the analysis method and the result shows that half of the respondent do not agreed with the time table provided with 17/30 respondents. The unsuitable timetable provide by the faculty lead to the needs of changing time slot with 23/30 respondents agreed. Therefore, the problems on allocating the space without taking consideration on the user requirements are exist within these faculties.

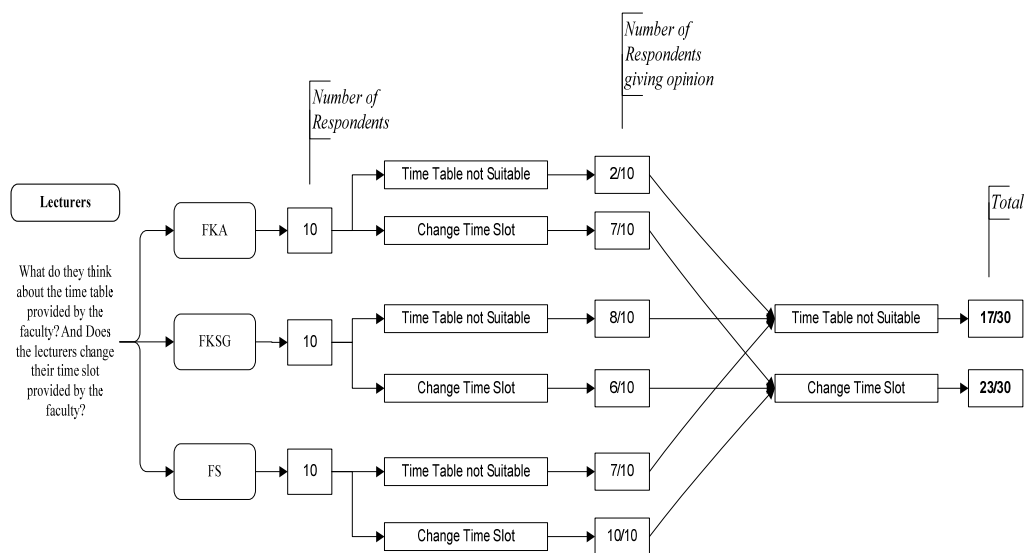


Figure 1.1: Lecturers Perception Analysis on Timetable Aspect in Selected Faculties

The second aspect of the research is focused on the traditional method of managing the facilities in the university. The administration is using manual method to pass on information and space allocation. Base on the survey from the staff in charge in managing the T&L space in the faculties, they still using manual method on allocating T&L space, hence they do get a lot of misleading information to the users. Thus, they require a more efficient system that can bring information to their users.

According to the SMG (2006) survey revealed that many space managers working centrally within HEIs may not know full details of room capacities and the number and type of workplaces, particularly in specialist areas or in non-centrally timetabled parts of the estate. They may not know real demand for space in terms of how many hours of what type of activity, or be involved at an early stage of developing strategic plans.

Based on 17 responses from HEIs through the telephone survey, access for managers to base data on contact hours and group sizes is mixed. Some do not have access. Some could have access but didn't use the data. One respondent could get the data if necessary, but would need to go to four different sources. Others have partial information, such as for lecture theatres, but not for how many hours the specialist space is needed and what group sizes will occupy it. They may not know the number of workplaces available in different types of space. There is often even less information about how nonteaching areas are used. Similarly in UTM, based on the survey from the staff that in charge on managing the T&L space in the faculty's shows that they still using the manual method on allocating their T&L space and received many lack of misleading information to the users. Thus, they required a system that can give information to their users as for T&L space purpose. **See Table 1.1.**

Table 1.1: Pilot Study among Selected Faculties on Staff Perception.

Num.	Faculty	Manual Method Used	Report on Lankness Information	Comments
1	Faculty of Science (FS)	√	√	The faculty needs to have a system that can bring information to the users especially the

				classroom.
2	Faculty of Civil Engineering (FKA)	√	√	Similarly with other faculties, they argue that a need of new system for allocating the space and meet the user requirements and time saving giving the room information to the users
3	Faculty of Geo information Science and Engineering (FKSG)	√	√	The faculties still base on manual method which lead to none standardize information to the users.

Therefore, the research are to identified what are the requirements from the user's for the allocating the teaching and learning space? What are the elements need to be considered on the requirements aspect? How to solve the lankness on giving the information? How it may help on delivering the information to the users? How a system can be developed? And what are the elements must be considered on the user requirements views for the system? The research issues and problems can be described in Figure 1.2.

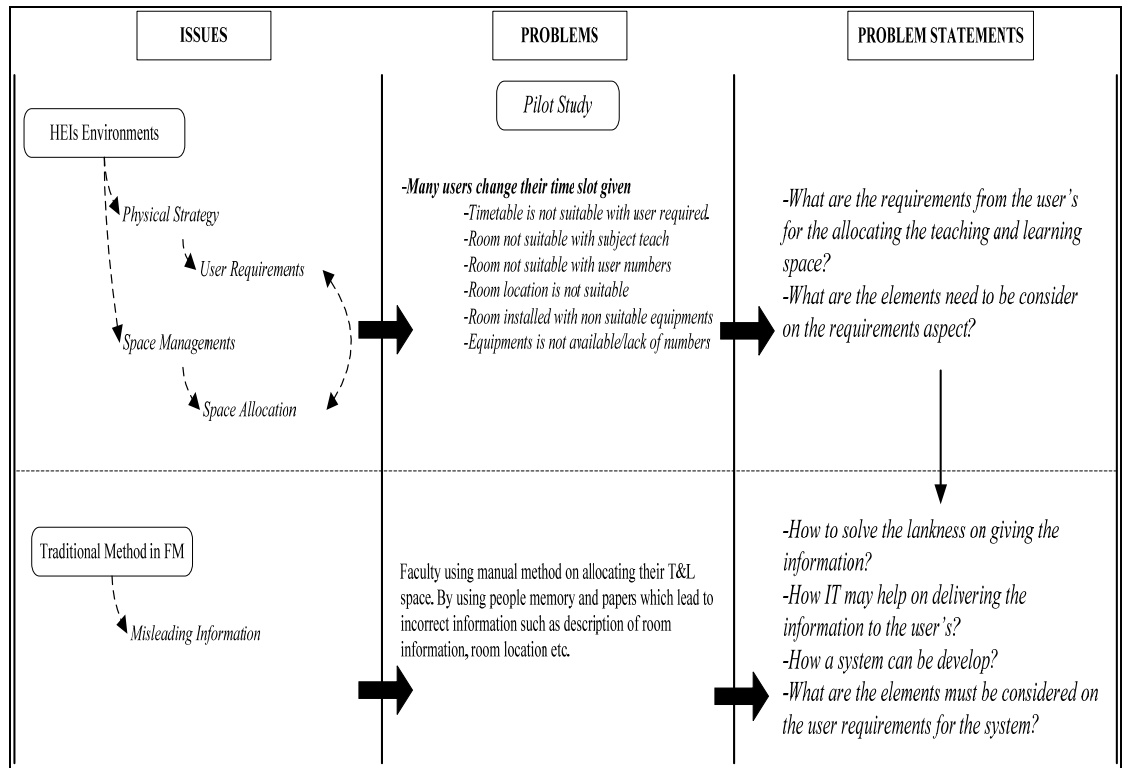


Figure 1.2: Research Issues and Problems Flow and Relation

Base on the previous research by Hafizal (2009), there are four main elements which are required the most by the users on allocating the teaching and learning space, such as space allocation, class timetabling, class capacity and equipments. Therefore, these elements are used again as basis of this research on allocating the teaching and learning space within higher education environment with additional scope of study. Previous research only highlighting the user requirements in Faculty of Geoinformation and Science Engineering which the basis is social science, however for this research, the scope are goes wider. The requirements for two other basis of study also been tackled, which are the pure science basis and pure engineering basis which lead for data collecting within additional two other faculties. Faculties selected are the Faculty of Science and Faculty of Civil Engineering which representing the two basis of study. Therefore, more requirements within different base of study are draw down for the user's requirements conceptual framework.

Since there are times constrain and budgeting for this research, the system only developed within Faculty of Geoinformation and Science Engineering. Similarly with late research by Hafizal (2009), with additional improvement of the system. Previous research is using the ArcView software as basis on developing the system. As for this research, the ArcGIS which is improved software by ESRI is used with combination with other software such as Microsoft Access and the HTML presentation. Therefore, the developed system is more users's friendly and advance capability compared to the previous system.

1.2 RESEARCH OBJECTIVE

The objectives of this research are:

- i. To develop a conceptual framework for teaching and learning space allocation according to the user's requirements.
- ii. To develop a prototype system for T&L space allocation information based on the user's requirements.
- iii. To test run the system based on the user's requirements analysis.

1.3 RESEARCH SCOPE

The scopes for this research are:

- i. The elements that are studied for this research are the four main elements on teaching and learning space allocation in higher education such as the space allocation, class timetabling, class capacity and equipments.
- ii. The research focuses on three faculties which are the Faculty of Science, Faculty of Civil Engineering and Faculty Geo-information Science & Engineering in

Universiti Teknologi Malaysia, Skudai, Johor only to determine the user's requirements.

- iii. In determining the user's requirements for space allocation, data collection involves only undergraduate students, lecturers and staffs in time table planning in those faculties as respondent for this research.
- iv. Only Faculty of Geo-information Science & Engineering in Universiti Teknologi Malaysia, Skudai, Johor is chosen as a case study for the prototype system development.
- v. Data such as site maps, building floor plan, and equipments data (i.e. numbers, condition, types etc) provided by the faculty are used for system database attribute.

1.4 RESEARCH LIMITATION

Limitations of the research are:

- i. This research is only taking into account T&L space allocation problem. Other problems in traditional facilities management in higher educational institutions are not being studied here.
- ii. Time table development is not being studied.
- iii. Time table for postgraduate classes will not be studied too.
- iv. Only one faculty is chosen to be studied (FKSG, UTM) for the prototype Teaching and Learning Space Information System development, while other faculties can be reviewed in future research.

1.5 RESEARCH METODOLOGY

This research has four stages to complete:

1.5.1 Stage 1: Definition, Problem Statement, Concept and Objective of the Research

At this stage, the definition and concept of this research is identified. The research is the combination of facilities management on user's requirements and space allocation aspect incorporated with the information technology (IT) capability. The research will answer problems identified from the users for allocating the teaching and learning space. What are the elements needed to be considered on the requirements aspect? How to solve the lankness on giving the information? How it may help on delivering the information to the users? How a system can be developed? And what are the elements that must be considered from the user's requirements? Therefore, the question of the research leads to its objectives, such as to develop a conceptual framework for teaching and learning space allocation, to develop a prototype system for T&L space allocation information based on the user's requirements and to test run the system based on the user's requirements analysis. Thus, a clear view of the research will be generated and helps in organizing and managing the research to the end.

1.5.2 Stage 2: Data Collection on User Requirements (Achievement of First Objective)

At this stage, the user's requirements for teaching and learning space allocation have to be investigated and analyzed. The respondents are the users of the T&L space. The investigation is covering Faculty of Science, Faculty of Civil Engineering and Faculty Geo-information Science & Engineering in Universiti Teknologi Malaysia, Skudai, Johor only. According to Flavin (1981), user's requirements can be analyzed through user's interview and questionnaires. Therefore, as for the purpose in determining the user's requirements, interviews and questionnaires are used.

1.5.3 Stage 3: System Design and Development (Achievement of Second Objective)

After analyzing the user's requirements for the T&L space allocation at the faculties, the system can be developed. The design of the system has to be base on the conceptual framework. The system will be base on WEB and can be explored by using Internet Explorer. In addition, the system also is combined with a small portion of GIS capability; therefore one of the softwares used for running the spatial data system developments is the ARCGIS. With the system developed, the second objective of the research can be achieved.

- Spatial Data: Drawing of UTM maps and Faculties building floor plan (FKSG).
- Attribute Data: Facilities data (Room Information; Information of the inventories; T&L space location and its information).

Computer software involve for the prototype interface system development:

- *Arc GIS*: Converting the CAD drawing format to GIS application format.
- *Auto CAD*: Drawing the maps and building floor plan for the system.
- *Microsoft Visual Studios*: Scrip creation for Web base interface.

1.5.4 Stage 4: System Test Run (Achievement of Third Objective)

At this stage, after the prototype system has been developed, the system has to be tested. The test run concept is to determine whether the system is capable of delivering the information to the users. Elements to be considered on the system test run stage are the main four elements used for allocating the T&L space. Therefore, with the system developed, combined with the analysis of the user's requirements, the system can be test run base on those requirements.

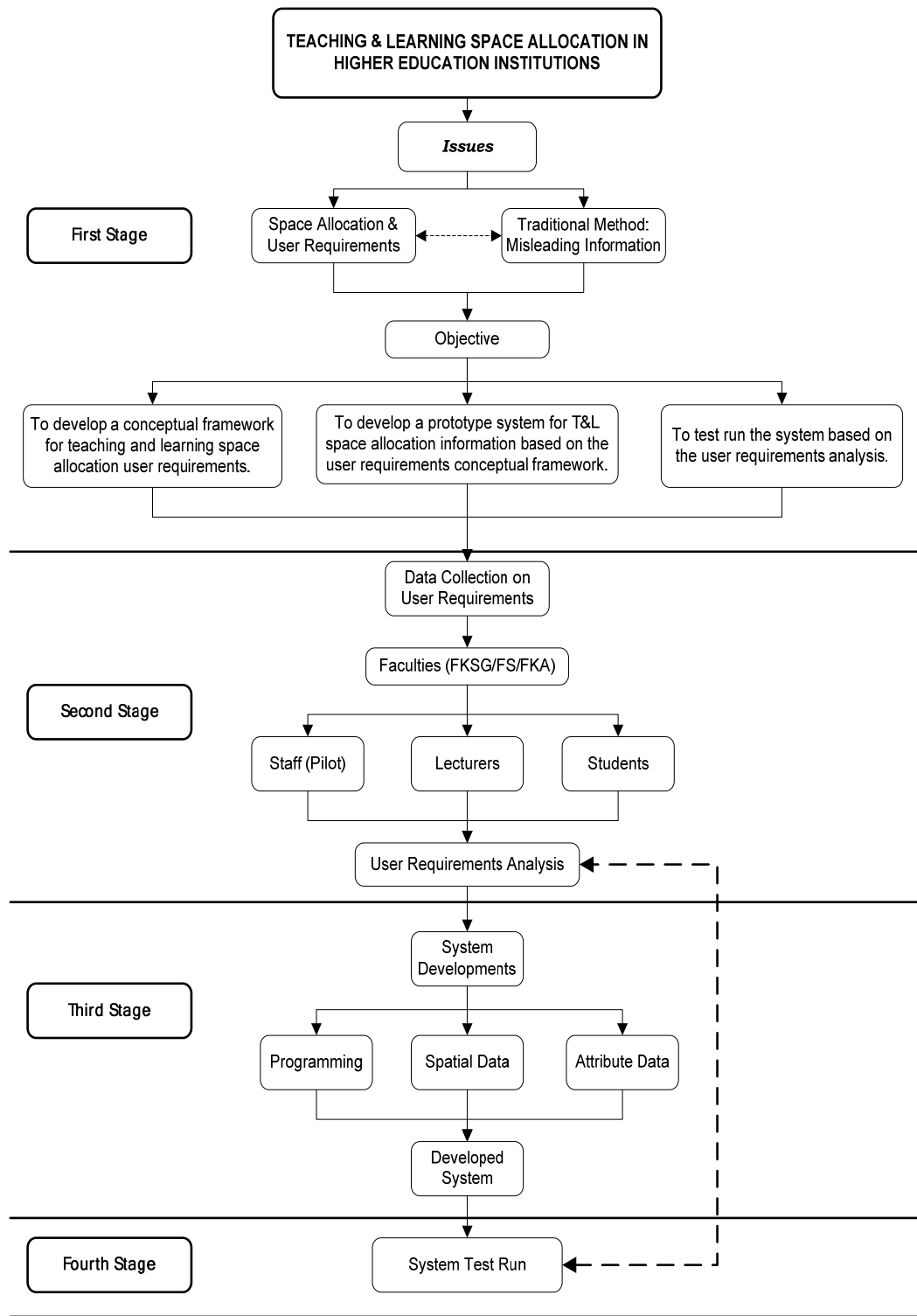


Figure 1.3: Research Methodology Flow Chart

1.6 STRUCTURE OF THE THESIS

Chapter 1: [INTRODUCTION].

This chapter gives an introduction of the topic of the research in the thesis. It presents the problem statement, research objective, overview of the research methodology, scope and limitation.

Chapter 2: [LITERATURE REVIEW].

This chapter presents the state-of-the-art literature review on topics related to FM. It also presents the role of facility manager in higher educational institutions, space allocation and user's requirements in higher education.

Chapter 3: [LITERATURE REVIEW].

This chapter presents the GIS application including the definition, elements, its benefits, integration with FM industries and its application to the higher education sector.

Chapter 4: [RESEARCH METHODOLOGY].

This chapter describes the method that is going to be used in this research. It shows how this research is conducted including discussion in questionnaire survey, interface system development and user's simulation method. Also discussed in this chapter is the background of the case study (UTM).

Chapter 5: [DATA COLLECTION AND ANALYSIS].

This chapter describes the data collected from the site. The data collection for user's requirements is discussed in this chapter and development of the conceptual framework for teaching and learning space allocation.

Chapter 6: [SYSTEM DEVELOPMENT]

In this chapter, the discussion will go through step by step in developing the prototype system for teaching and learning space allocation.

Chapter 7: [System Test Run].

This chapter discusses the test run of the system developed in Chapter 6. The test run will demonstrate on how to generate the information required in the system base on the conceptual framework.

Chapter 8: [CONCLUSIONS AND RECOMMENDATIONS].

This chapter will draw the main conclusions and summarizes them against the objectives set for the study.

REFERENCE

- Abdul Moied, M., (2004). Assessment of automating facilities management current practices: potential framework models for Saudi Arabian Universities. <http://eprints.kfupm.edu.sa/9642/>. Available at: <http://eprints.kfupm.edu.sa/9642/> [Accessed July 14, 2009].
- Abdullah. (2002). *Pengenalan Kepada Analisis Dan Reka Bentuk Sistem*, Selangor: Prentice Hall.
- Albicini, V., Marmaras, F. & Hanrahan, M., (2006). Strategic Asset Management — Getting the People and System Issues Right. In *Engineering Asset Management*. pp. 855-865. Available at: http://dx.doi.org/10.1007/978-1-84628-814-2_90 [Accessed July 10, 2009].
- Aldridge, S. & Rowley, J., (1998). Measuring customer satisfaction in higher education. *Quality Assurance in Education*, 6(4), 197 - 204.
- Alexander, K., (1992). Facilities Management Practice. *Facilities*, 10(5), 11 - 18.
- Alexander, K., (2003). A strategy for facilities management. *Facilities*, 21(11/12), 269 - 274.
- Alexander, K., (2007). 'Future trends in implementing an effective Facilities Management initiative – the European experience'. Available at: <http://www.nafam.com.my/2007/download.htm>.
- Alibrandi, M., (2002). Geography Is Everywhere: Connecting Schools and Communities with GIS; This Technology Enables Students to Perform Research and Draw Conclusion That Can Provide Authentic Benefits to the Community While Helping Students Meet Standards. *Learning & Leading with Technology*, 29(7), 32–38.
- Amaratunga, D. & Baldry, D., (2000). Assessment of facilities management performance in higher education properties. *Facilities*, 18(7/8), 293 - 301.
- Amaratunga, D. & Baldry, D., (2002). Moving from performance measurement to performance management. *Facilities*, 20(5/6), 217 - 223.
- Amaratunga, D., (2000). Assessment of facilities management performance. *Property Management*, 18(4), 258 - 266.
- Amaratunga, D., Sarshar, M. & Baldry, D., (2002). Process improvement in facilities management: the SPICE approach. *Business Process Management Journal*, 8(4), 18 - 337.

- Arayici, Y. & Aouad, G., (2005). Computer integrated construction: an approach to requirements engineering. *Engineering, Construction and Architectural Management*, 12(2), 194 - 215.
- Arayici, Y., Aouad, G. & Ahmed, V., (2005). Requirements engineering for innovative integrated ICT systems for the construction industry. *Construction Innovation*, 5(3), 179–200.
- Aschner, G.S., (1999). Meeting customers' requirements and what can be expected. *The TQM Magazine*, 11(6), 450 - 455.
- Astin, A.W., (1999). Student involvement: A developmental theory for higher education. *Journal of College Student Development*, 40, 518–529.
- Atkinson, J., Cornforth, D. & Spennemann, D.H.R., (2005). Redirecting under-utilised computer laboratories into cluster computing facilities. *Campus-Wide Information Systems*, 22(4), 201–09.
- Baker, J. & Cameron, M., (1996). The effects of the service environment on affect and consumer perception of waiting time: An integrative review and research propositions. *Journal of the Academy of Marketing Science*, 24(4), 338-349.
- Balch, W., (1994). An Integrated Approach to Property and Facilities Management. *Facilities*, 12(1), 17 - 22.
- Bar-Ilan, J. & Groisman, N., (2003). Modern Hebrew literature on the Web: a content analysis. *Online Information Review*, 27(2), 77 - 86.
- Beard, D.F., (2009). Successful applications of the balanced scorecard in higher education. *Education for Business*, 10(4), 275-282.
- Becker, G.S., (1965). A Theory of the Allocation of Time. *The Economic Journal*, 75(299), 493-517.
- Bell, J., (2003). Facilities – 20th anniversary issue. *Facilities*, 21(11/12), 249 - 250.
- Benjamin, C.O., Ehie, I.C. & Omurtag, Y., (1992). Planning Facilities at the University of Missouri-Rolla. *Interfaces*, 22(4), 95-105.
- Bennett, C., (1977). *Spaces for People: Human Factors in Design*, New Jersey: Prentice-Hall.
- Beynon, J., (1997). *Physical facilities for education: what planners need to know*, United Nations Educational, Scientific and Cultural Organization.

- Beyrouthy, C. et al., (2007). The teaching space allocation problem with splitting. *Lecture Notes in Computer Science*, 3867, 228.
- Billa, L., Mansor, S. & Mahmud, A.R., (2004). Spatial information technology in flood early warning systems: an overview of theory, application and latest developments in Malaysia. *Disaster Prevention and Management*, 13(5), 356 - 363.
- Bitner, M.J., (1992). Servicescapes: the impact of physical surroundings on customers and employees. *The Journal of Marketing*, 56(2), 57–71.
- Bon, R., McMahan, J.F. & Carder, P., (1994). Property Performance Measurement: From Theory to Management Practice. *Facilities*, 12(12), 18 - 24.
- Boyd, B. & Rainbolt, E., (2004). GIS for University Campus Planning and Facilities Management. Retrieved September, 20.
- Brackertz, N. & Kenley, R., (2002). Evaluating community facilities in local government: Managing for service enablement. *Journal of Facilities Management*, 1(3), 283 - 299.
- Brady, M.K. & Cronin, J.J., (2001). Some New Thoughts on Conceptualizing Perceived Service Quality: A Hierarchical Approach. *Journal of Marketing*, 65(3), 34-49.
- Brat, J.H., (1996). Developments in the management of facilities at large corporations. *Facilities*, 14(5/6), 39 - 47.
- Brochner, J., Adolfsson, P. & Johansson, M., (2002). Outsourcing facilities management in the process industry: A comparison of Swedish and UK patterns. *Journal of Facilities Management*, 1(3), 265 - 271.
- Brynjolfsson, E. & Hitt, L., (1995). Information technology as a factor of production: The role of differences among firms. *Economics of Innovation and New Technology*, 3(3), 183-200.
- Burke, E. et al., (1997). Automated university timetabling: The state of the art. *The Computer Journal*, 40(9), 565–571.
- Burke, E.K. & Varley, D.B., (1998). Space Allocation: An analysis of higher education requirements. *Lecture notes in computer science*, 20–36.
- Burke, E.K. & Varley, D.B., (1999). Automating Space Allocation in Higher Education. *Lecture notes in computer science*, 66–73.
- Burke, E.K. et al., (2001). Three methods to automate the space allocation process in UK universities. *Lecture Notes in Computer Science*, 254–276.

- Burke, E.K., Cowling, P. & Landa Silva, J.D., (2001). Hybrid population-based metaheuristic approaches for the space allocation problem. In *Proceedings of the 2001 Congress on Evolutionary Computation CEC 2001*. pp. 232–239.
- Burke, E.K., Cowling, P., Landa Silva, J.D. & Petrovic, S., (2001). Combining hybrid metaheuristics and populations for the multiobjective optimisation of space allocation problems. In *Proceedings of the GECCO*. pp. 7–11.
- Burke, E.K., Elliman, D.G. & Weare, R.F., (1995). The automation of the timetabling process in higher education. *Journal of Educational Technology Systems*, 23(4), 257-266.
- Cairns, G., (2003). Seeking a facilities management philosophy for the changing workplace. *Facilities*, 21(5/6), 95 - 105.
- Carr, J.J., (2000). Requirements engineering and management: the key to designing quality complex systems. *The TQM Magazine*, 12(6), 400 - 407.
- Castaldi, B., (1994). *Educational facilities: Planning, modernization, and management*, Allyn & Bacon (A Division of Simon & Schuster, Inc.), 160 Gould St., Needham Heights, MA 02194.
- Cervone, H.F., (2007). The system development life cycle and digital library development. *OCLC Systems & Services*, 23(4), 348 - 352.
- Chandrashekar, A. & Gopalakrishnan, B., (2008). Maintenance risk reduction for effective facilities management. *Journal of Facilities Management*, 6(1), 52 - 68.
- Changiz, T., Moeeny, A. & Jowshan, R., (2004). OFIS: online faculty information system. *Campus-Wide Information Systems*, 21(2), 95 - 100.
- Chase, R.B., (1981). The Customer Contact Approach to Services: Theoretical Bases and Practical Extensions. *Operations Research*, 29(4), 698-706.
- Chen, S., Wang, H. & Yang, K., (2009). Establishment and application of performance measure indicators for universities. *The TQM Journal*, 21(3), 220 - 235.
- Chotipanich, S., (2004). Positioning facility management. *Facilities*, 22(13/14), 364 - 372.
- Choy, C., (2007). Best Practices & Success Stories in Asset and Facility Maintenance - Call Centre Technologies. Available at:
<http://www.nafam.com.my/2007/download.htm>
- Clipson, C.W., (1974). *Planning for Cardiac Care: A Guide to the Planning and Design*

of Cardiac, Ann Arbor, Michigan: Health Administration Press, University of Michigan.

- Cobarsi, J., Bernardo, M. & Coenders, G., (2008). Campus information systems for students: classification in Spain. *Campus-Wide Information Systems*, 25(1), 50 - 64.
- Coleman, D.J., McLaughlin, J.D. & Nichols, S.E., (1997). Building a Spatial Data Infrastructure. In *Proceedings of the 64th Permanent Congress Meeting of FIG, Singapore, As seen at Http://www. digitearth. net. cn/GISConference/BuildingASpatialDataInfrastructure. pdf, Web site accessed April. p. 2004.*
- Coyle-Camp, E.M., (1994). IT Facilities Management: Why Companies Are Losing Their Competitive Edge. *Facilities*, 12(6), 8 - 12.
- Cullen, J. et al., (2003). Quality in higher education: from monitoring to management. *Quality Assurance in Education*, 11(1), 5 - 14.
- Diaz, J.S., Lopez, O.P. & Fons, J.J., (2001). From user requirements to user interfaces: a methodological approach. *Lecture notes in computer science*, 60-75.
- Dagleish, A. & Hall, R., (2000). Uses and perceptions of the World Wide Web in an information-seeking environment. *Journal of Librarianship and Information Science*, 32(3), 104-116.
- Dauer, J.P. & Krueger, R.J., (1977). An Iterative Approach to Goal Programming. *Operational Research Quarterly (1970-1977)*, 28(3), 671-681.
- De Jager, K., (2007). Towards Establishing an Integrated System of Quality Assurance in South African Higher Education Libraries. *IFLA Journal*, 33(2), 109-116.
- Dewan, S. & Mendelson, H., (1990). User Delay Costs and Internal Pricing for a Service Facility. *Management Science*, 36(12), 1502-1517.
- Douglas, B., (2008). *Achieving Business Success with GIS* First Edition., Hoboken: John Wiley and Sons.
- Douglas, J., (1996). Building performance and its relevance to facilities management. *Facilities*, 14(3/4), 23 - 32.
- Douglas, U.M., Mohd Ali, H. & Hamid B. Hj. Mar Iman, A., (2008). Delivering Facilities Performance. *Department of property management, Faculty of Geo-Inf. Science & Engineering Universiti teknologi malaysia Skudai, Johor.*, 1-15.

- Downe-Wamboldt, B., Content analysis: method, applications, and issues., (1992). *Health care for women international*, 13(3), 313.
- Downie, M.L., (2005). Efficiency outcomes from space charging in UK higher education estates. *Property Management*, 23(1), 33 - 42.
- Dyer, J.S. & Mulvey, J.M., (1976). An Integrated Optimization/Information System for Academic Departmental Planning. *Management Science*, 22(12), 1332-1341.
- Earthman, G.I., (2002). School facility conditions and student academic achievement. *UC Los Angeles: UCLA's Institute for Democracy, Education, and Access*. Retrieved from: <http://www.escholarship.org/uc/item/5sw56439>.
- Easterby-Smith, M., Thorpe, P.R. & Lowe, D.A., (2001). *Management Research: An Introduction* Second Edition., Sage Publications Ltd.
- Eekelen, I.M., Boshuizen, H.P. & Vermunt, J.D., (2005). Self-regulation in higher education teacher learning. *Higher Education*, 50(3), 447–471.
- Erdener, E. & Gruenwald, H., (2001). CAD standards and the institutions of higher education. *Facilities*, 19(7/8), 287 - 295.
- Esparcia-Alcázar, A.I. et al., (2008). A Multiobjective Evolutionary Algorithm for the Linear Shelf Space Allocation Problem. In *Proceedings of the 10th international conference on Parallel Problem Solving from Nature: PPSN X*. pp. 1001–1010.
- Evenden, E.S., Strayer, G.D. & Engelhardt, N.L., (1938). *Standards for College Buildings*, New York City: Teachers College, Columbia University.
- Fauzi A. Wahab, A., (2005). Pengurusan Sumber Fizikal IPT: Pengurusan Ruang. *Universiti Teknologi Malaysia*, 43(E), 15-28.
- Featherstone, P. & Baldry, D., (2000). The value of the facilities management function in the UK NHS community health-care sector. *Facilities*, 18(7/8), 302–11.
- Finch, E., (2000). Third-wave Internet in facilities management. *Facilities*, 18(5/6), 204 - 212.
- Fisher, R., Oyelere, P. & Laswad, F., (2004). Corporate reporting on the Internet: Audit issues and content analysis of practices. *Managerial Auditing Journal*, 19(3), 412 - 439.
- Flavin, M., (1981). *Fundamental Concepts of Information Modeling*, Englewood, Cliffs, N.J: Yourdon Press.
- Fournier, V., (1996). Cognitive Maps in the Analysis of Personal Change During Work

- Role Transition¹. *British Journal of Management*, 7(1), 87-105.
- Francis, R.L., (1974). *Facility Layout and Location: An Analytical Approach*, Englewood Cliffs, New Jersey: Prentice-Hall.
- Gabriel, G.C. & Ceccherelli, L., (2004). User-centric facilities management: a decentralized approach. *Facilities*, 22(11/12), 296 - 302.
- Geisinger, R.W., (1968). Systems Analysis and Education Research Literature Review. Available at: <http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?acno=ED047354> [Accessed November 19, 2009].
- Getting a Better Performing Building: Commissioning and Real Time Data Analysis., (1969). Available at: <http://txspace.tamu.edu/handle/1969.1/5185> [Accessed November 6, 2009].
- Ghalayini, A.M. & Noble, J.S., (1996). The changing basis of performance measurement. *International Journal of Operations & Production Management*, 16(8), 63 - 80.
- Giannikos, I., El-Darzi, E. & Lees, P., (1995). An Integer Goal Programming Model to Allocate Offices to Staff in an Academic Institution. *The Journal of the Operational Research Society*, 46(6), 713-720.
- Gondeck-Becker, D. & AIA, A., (1999). Implementing an Enterprise-Wide Space Management System-a Case Study at the University of Minnesota. In *ESRI User Conference, San Diego, Calif.*
- Gotel, O. & Finkelstein, A., (1994). An analysis of the requirements traceability problem. In *Proceedings of the First International Conference on Requirements Engineering*. pp. 94–101.
- Goyal, S. & Pitt, M., (2007). Determining the role of innovation management in facilities management. *Facilities*, 25(1/2), 48 - 60.
- Goyal, S., Pitt, M. & Sapri, M., (2005). Innovation As A Facilities Management Tool. In 1225-36. University of London: Association of Researchers in Construction Management.
- Graneheim, U.H. & Lundman, B., (2004). Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse education today*, 24(2), 105–112.
- Grimshaw, B., (1999). Facilities management: the wider implications of managing

change. *Facilities*, 17(1/2), 24 - 30.

Grupe, F. & Burch, J., (1993). Geographic Information System: A primer for the facilities manager. *Facilities Manager, Spring*, 26-31.

Gulko, W.W. & Hussain, K.M., (1971). A Resource Requirements Prediction Model (RRPM-1): An Introduction to the Model. Available at:
<http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?acno=ED062949> [Accessed November 19, 2009].

Gulko, W.W., (1971). The Resource Requirements Prediction Model 1 (RRPM-1): An Overview. Available at:
<http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?acno=ED047648> [Accessed November 19, 2009].

Hackos, J.T. & Redish, J.C., (1999). User and task analysis for interface design. *SIGCHI Bulletin*, 31(3), 19.

Hafizal B. Ishak, M., (2009). *Apliaksi GIS Untuk Alokasi Ruang Pengajaran dan Pembelajaran Di Institusi Pengajian Tinggi. Kajian Kes: Fakulti Kejuruteraan Sains Geoinformasi, Universiti Teknologi Malaysia, Skudai, Johor*. Thesis: PSM. Universiti Teknologi Malaysia, Skudai, Johor.

Hakim Mohammed, A., Sapri, M. & Baba, M., (2006). Konsep Pengurusan Fasiliti. In *Pengurusan Fasiliti*. Universiti Teknologi Malaysia, p. 5.

Halici, A. & Kucukaslan, A., (2005). Turkish companies' ethical statements: content analysis with comparisons. *Management Research News*, 28(1), 45 - 61.

Hamid B. Hj. Mar Iman, A., (2006). *Pelaksanaan sistem teknologi maklumat dalam pengurusan harta wakaf.*, Pusat Kajian Harta Tanah (CRES), FKSG: Universiti Teknologi Malaysia, Skudai, Johor.

Hamid B. Hj. Mar Iman, A., (2007). Geographic information system application for site selection: A case of waqf land development. *Malaysian Journal of Real Estate, CRES, FKSG, UTM, Skudai, Johor*, 2(1), 19-41.

Hammami, M., Chahir, Y. & Chen, L., (2005). Using visual content. *International Journal of Web Information Systems*, 1(4), 241 - 254.

Han, S.S. & Yu, S.M., (2001). EMAPS – a GIS application in town council management in Singapore. *Facilities*, 19(11/12), 428 - 435.

Harindranath, G. et al., (2002). *New perspectives on information systems development*, University of London, London, UK.: Springer.

- Hassanain, M.A. & Mudhei, A.A., (2006). Post-occupancy evaluation of academic and research library facilities. *Structural Survey*, 24(3), 230–239.
- HEFCE, (2000). *Estate strategies: a guide to good practice*, England: HEFCE. Available at: http://www.hefce.ac.uk/Pubs/hefce/2000/00_04.htm [Accessed September 3, 2009].
- Hermann, F. & Heidmann, F., (2002). User requirement analysis and interface conception for a mobile, location-based fair guide. *Lecture Notes in Computer Science*, 2411, 388–392.
- Hertel, K. & Sprague, N., (2007). GIS and census data: tools for library planning. *Library Hi Tech*, 25(2), 246 - 259.
- Hill, F.M., (1995). Managing service quality in higher education: the role of the student as primary consumer. *Quality Assurance in Education*, 3(3), 10 - 21.
- Hinks, J. & McNay, P., (1999). The creation of a management-by-variance tool for facilities management performance assessment. *Facilities*, 17(1), 31–53.
- Hinks, J., (1998). A conceptual model for the interrelationship between information technology and facilities management process capability. *Facilities*, 16(9/10), 233 - 245.
- Hinks, J., (2002). The transition to virtual: The impact of changes in business operations on facilities management. *Journal of Facilities Management*, 1(3), 272 - 282.
- Ho, W. et al., (2009). Measuring performance of virtual learning environment system in higher education. *Quality Assurance in Education*, 17(1), 6 - 29.
- Holsti, O.R., (1969). *Content analysis for the social sciences and humanities*, Addison-Wesley Reading, MA. Addison-Wesley Publishing Company, Inc. Philippines.
- Housley, J., (1997). Managing the estate in higher education establishments. *Facilities*, 15(3/4), 72 - 83.
- Hughes, A., (1997). Information strategy threat or opportunity? *Librarian Career Development*, 5(2), 60 - 66.
- Ibrahim, R. & Minoi, J.L., (2005). Usage of Information Technologies in Malaysian Businesses. *Journal of Information Technology Impact*, 5(1), 5–14.
- IFIP WG 8.1 Working Conference on Feature Analysis of Information Systems Design, (1983). *Information Systems Design Methodologies: A Feature Analysis*, New York: Elsevier.

- Ignizio, J.P., (1978). A Review of Goal Programming: A Tool for Multiobjective Analysis. *The Journal of the Operational Research Society*, 29(11), 1109-1119.
- Ismail, M., (2007). Developing a Core Competency-Based Career and Development Framework for Facilities and Asset Managers. Available at: <http://www.nafam.com.my/2007/download.htm>.
- Ismail, Z. & Nor Said, M.,(2007). *GIS application for school information and management system.*, UTM: Universiti Teknologi Malaysia, Skudai, Johor. Available at: <http://eprints.utm.my/view/year/NULL.html>.
- Israel, G.D., (1992). Determining Sample Size1. *Agricultural Education and Communication Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida*.
- Jain, D., (2001). GIS for Facilities Management at the University of Virginia. In San Diego, CA: ESRI. Available at: <http://www.esri.com/>.
- Jamieson, P., Dane, J. & C. Lippman, P., (2005). Moving beyond the classroom: Accommodating the changing pedagogy of higher education. *Forum of the Australasian Association for Institutional Research*.
- Jamilus, J.M., (2007). Leveraging on the use of Technology for effective and efficient management of Government Assets and Facilities. Available at: <http://www.nafam.com.my/2007/download.htm>.
- Jewett, F.I. & And Others, (1970). The Feasibility of Analytic Models for Academic Planning: A Preliminary Analysis of Seven Quarters of Observations on the "Induced Course Load Matrix.". Available at: <http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?acno=ED046320> [Accessed November 19, 2009].
- Jewett, J.E., (1971). College Admissions Planning: Use of a Student Segmentation Model. Available at: <http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?acno=ED081400> [Accessed November 19, 2009].
- Jiao, J. & Tseng, M.M., (1999). A requirement management database system for product definition. *Integrated Manufacturing Systems*, 10(3), 146 - 154.
- Johnes, J., (1996). Performance assessment in higher education in Britain. *European Journal of Operational Research*, 89(1), 18–33.
- Johnston, D.A., Taylor, G.D. & Visweswaramurthy, G., (1999). Highly constrained multi. *Integrated Manufacturing Systems*, 10(4), 221 - 233.

- Johnston, S. & McCormack, C., (1996). Integrating information technology into university teaching: identifying the needs and providing the support. *International Journal of Educational Management*, 10(5), 36 - 42.
- Joris, M., van den Berg, C. & van Ryssen, S., (2003). Home, but not Alone: Information and Communication Technology and Internationalisation at Home. *Journal of Studies in International Education*, 7(1), 94-107.
- Kassarjian, H.H., (1977). Content analysis in consumer research. *Journal of Consumer Research*, 4(1), 8.
- Khamouch, M., (2005). Jewel of Chinese Muslim's Heritage. *Foundation for Science Technology and Civilisation (FTSE), United Kingdom*, 1-24.
- Kincaid, D., (1994). Integrated Facility Management. *Facilities*, 12(8), 20 - 23.
- King, J.L. et al., (1994). Institutional factors in information technology innovation. *Information Systems Research*, 5(2), 139–169.
- Kostagiolas, P.A. & Asonitis, S., (2009). Intangible assets for academic libraries: Definitions, categorization and an exploration of management issues. *Library Management*, 30(6/7), 419 - 429.
- Kujala, S., Kauppinen, M. & Rekola, S., (2001). Bridging the gap between user needs and user requirements. In *Advances in Human-Computer Interaction I (Proceedings of the Panhellenic Conference with International Participation in Human-Computer Interaction PC-HCI 2001)*, Typorama Publications. pp. 45–50.
- Kutucuoglu, K. et al., (2001). A framework for managing maintenance using performance measurement systems. *International Journal of Operations & Production Management*, 21(1/2), 173 - 195.
- Kyle, B., (2001). Toward effective decision making for building management. In *Innovations in Urban Infrastructure*. Philadelphia: Public Works and Government Services Canada, Hull, Quebec, pp. 51-65.
- L. Smith, D., (1999). Developing an Enterprise GIS for Facilities Management. In *Proceedings of the Nineteenth Annual ESRI User Conference*. San Diego, California: ESRI.
- Lackney, J.A., (1999). Assessing School Facilities for Learning/Assessing the Impact of the Physical Environment on the Educational Process: Integrating Theoretical

Issues with Practical Concerns.

- Lavy, S. & Bilbo, D.L., (2009). Facilities maintenance management practices in large public schools, Texas. *Facilities*, 27(1/2), 5 - 20.
- Lavy, S., (2008). Facility management practices in higher education buildings: A case study. *Journal of Facilities Management*, 6(4), 303 - 315.
- Lee, P., Hui, S. & Fong, A., (2003). A structural and content. *Internet Research*, 13(1), 27 - 37.
- Lee, S.M. & Clayton, E.R., (1972). A Goal Programming Model for Academic Resource Allocation. *Management Science*, 18(8), B395-B408.
- Longley & Clark, (1995). *GIS for Business and Service Planning*, New York, NY: John Wiley & Sons.
- Loosemore, M. & Hsin, Y., (2001). Customer-focused benchmarking for facilities management. *Facilities*, 19(13/14), 464 - 476.
- Lunn, S. & Stephenson, P., (2000). The impact of tactical and strategic FM automation. *Facilities*, 18(7/8), 312 - 323.
- Maciaszek, L., (2007). *Requirements analysis and system design* 3rd ed., United Kingdom, England.: Addison-Wesley.
- Maguire, M. & Bevan, N., (2002). User requirements analysis. In *Proceedings of IFIP 17th World Computer Congress*. pp. 133-148.
- Marmolejo, F., (2007). Higher Education Facilities: Issues and Trends. *PEB Exchange 2007/ 1 University of Arizona, United States*, 1-14.
- Mawson, A., (1994). Integration of Workplace Management Systems. Why Bother? *Facilities*, 12(4), 10 - 15.
- McClea, M. & Yen, D.C., (2005). A framework for the utilization of information technology in higher education admission department. *International Journal of Educational Management*, 19(2), 87 - 101.
- McCord, S.K. & Nofsinger, M.M., (2002). Continuous assessment at Washington State University Libraries: a case study. *Performance Measurement and Metrics*, 3(2), 68 - 73.
- McDougall, G. et al., (2002). A review of the leading performance measurement tools for assessing buildings. *Journal of Facilities Management*, 1(2), 142 - 153.

- McGregor, W., (2000). The future of workspace management. *Facilities*, 18(3/4), 138 - 143.
- McQueen, R.A. & Knussen, C., (2002). *Research methods for social science: a practical introduction*, Pearson Education.
- Michael, R.K., Sower, V.E. & Motwani, J., (1997). A comprehensive model for implementing total quality management in higher education. *Benchmarking: An International Journal*, 4(2), 104 - 120.
- Michael, S.O., (2004). In search of universal principles of higher education management and applicability to Moldavian higher education system. *International Journal of Educational Management*, 18(2), 118 - 137.
- Middleton, I.A. & Marcella, R., (1997). In need of support: the academic help desk. *Campus-Wide Information Systems*, 14(4), 120 - 127.
- Minter, J. & Lawrence, B., (1969). Management Information Systems: Their Development and Use in the Administration of Higher Education. Available at: <http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?acno=ED042427> [Accessed November 19, 2009].
- Modell, S., (2003). Goals versus institutions: the development of performance measurement in the Swedish university sector. *Management Accounting Research*, 14(4), 333–359.
- Moied, A. & others, (2004). Assessment of automating facilities management current practices: potential framework models for Saudi Arabian Universities. Available at: <http://www.eprints.kfupm.edu.sa/9642/1/9642.pdf>.
- Morrison, J.L., (2003). US higher education in transition. *On the Horizon*, 11(1), 6 - 10.
- Musyoka, S. et al., (2007). Market segmentation using geographic information systems (GIS): A case study of the soft drink industry in Kenya. *Marketing Intelligence & Planning*, 25(6), 632 - 642.
- Muthanna, G. & Amin, M., (2005). Irrigation planning using geographic information system: A case study of Sana'a Basin, Yemen. *Management of Environmental Quality: An International Journal*, 16(4), 347 - 361.
- Nagata, H. et al., (2004). The dimensions that construct the evaluation of service quality in academic libraries. *Performance measurement and metrics*, 5(2), 53–65.
- Najmi, M., Rigas, J. & Fan, I., (2005). A framework to review performance measurement systems. *Business Process Management Journal*, 11(2), 109 - 122.

- Na-Lamphun, R. & Lee, H., (2002). Focusing on Information and Knowledge Management: redesigning the graduate program of library and information science at Chiang Mai University. *Information Development*, 18(1), 47-60.
- Naoum, S.G., (2003). *Dissertation research and writing for construction students*, Butterworth-Heinemann, Oxford.
- Nasirin, S., Morar, S. & Ramayah, T., (2006). Managing User's Resistance to Technological Change: A Case of GIS Implementation and its Implications to Malaysian Retailers. *The Tenth Pacific Asia Conference on Information Systems (PACIS 2006)*.
- Ndubisi, N.O. & Jantan, M., (2003). Evaluating IS usage in Malaysian small and medium sized firms using the technology acceptance model. *Logistics Information Management*, 16(6), 440 - 450.
- Neely, A. & Adams, C., (2000). Perspectives on performance: the performance prism. *Handbook of Performance Measurement*, Gee Publishing, London.
- Neely, A., (1999). The performance measurement revolution: why now and what next? *International Journal of Operations & Production Management*, 19(2), 205 - 228.
- Nyamboga, C.M. & Kemparaju, T., (2002). Information Technology in University Libraries in Karnataka. *Information Development*, 18(4), 257-265.
- O'Mara, C.E., Hyland, P.W. & Chapman, R.L., (1998). Performance measurement and strategic change. *Managing Service Quality*, 8(3), 178 - 182.
- Oh, C.H., (2003). Information Communication Technology and the New University: A View on eLearning. *The ANNALS of the American Academy of Political and Social Science*, 585(1), 134-153.
- Olle et al, (1991). *Information Systems Methodologies: A Framework for Understanding* 2nd ed., Wokingham, Eng: Addison-Wesley.
- Olsen, M.D., (2008). *Strategic Management in the Hospitality Industry* 3rd ed., New Jersey, NJ: Prentice Hall.
- Orlikowski, W.J. & Baroudi, J.J., (1991). Studying information technology in organizations: Research approaches and assumptions. *Information Systems Research*, 2(1), 1-28.
- Owlia, M.S. & Aspinwall, E.M., (1996). A framework for the dimensions of quality in higher education. *Quality Assurance in Education*, 4(2), 12 - 20.

- Parker, C., (2000). Performance measurement. *Work Study*, 49(2), 63 - 66.
- Parmenter, D., (2007). *Key performance indicators: developing, implementing, and using winning KPIs*, Wiley.
- Pascual, C. et al., (2009). Socioeconomic environment, availability of sports facilities, and jogging, swimming and gym use. *Health and Place*, 15(2), 553–561.
- Pathirage, C. et al., (2008). Knowledge management practices in facilities organisations: a case study. *Journal of Facilities Management*, 6(1), 5 - 22.
- Pitt, M. & Hinks, J., (2001). Barriers to the operation of the facilities management: property management interface. *Facilities*, 19(7/8), 304 - 308.
- Poll, R., (2003). Measuring impact and outcome of libraries. *Performance Measurement and Metrics*, 4(1), 5 - 12.
- Pors, N.O., (2006). The public library and students' information needs. *New Library World*, 107(7/8), 275 - 285.
- Post, G.V., (2000). *Management Information Systems: Solving Business Problems with Information* 2nd ed., Boston: McGraw-Hill.
- Powers, M.J., (1984). *Computer Information Systems Development: Analysis and Design*, Cincinnati: South-Western Pub.
- Preiser, W.F. & Wang, X., (2006). Assessing library performance with GIS and building evaluation methods. *New Library World*, 107(5/6), 193 - 217.
- Price, I. et al., (2003). The impact of facilities on student choice of university. *Facilities*, 21(10), 212 - 222.
- Radloff, P., (1998). Do we treat time and space seriously enough in teaching and learning. In *Teaching and Learning in Changing Times. Proceedings of the 7th Annual Teaching Learning Forum. The University of Western Australia, February*.
- Rai, L.P. & Lal, K., (2000). Indicators of the information revolution. *Technology in Society*, 22(2), 221–235.
- Ramlal, B., (2005). Assets management in Trinidad and Tobago. *APETT Journal. University of the West Indies, St Augustine, Trinidad and Tobago*, (5), 1-15.
- Ramos, P., Salazar, A. & Gomes, J., (2000). Trends in Portuguese tourism: a content analysis of association and trade representative perspectives. *International Journal of Contemporary Hospitality Management*, 12(7), 409 - 417.

- Rashdan Salleh, K. & Ahmad, F., (2007). Best Practices & Success Stories in Asset and Facility Management –Sharing of Experiences. Available at: <http://www.nafam.com.my/2007/download.htm>.
- Read, P., Higgs, G. & Taylor, G., (2005). The potential and barriers to the use of geographical information systems for marketing applications in higher educational institutions. *Marketing Intelligence & Planning*, 23(1), 30 - 42.
- Revill, D., (2002). Digital developments in higher education: theory and practice – a review. *New Library World*, 103(3), 98 - 102.
- Ritzman, L., Bradford, J. & Jacobs, R., (1979). A Multiple Objective Approach to Space Planning for Academic Facilities. *Management Science*, 25(9), 895-906.
- Robson, I., (2004). From process measurement to performance improvement. *Business Process Management Journal*, 10(5), 510 - 521.
- Rolstadas, A., (1998). Enterprise performance measurement. *International Journal of Operations & Production Management*, 18(9/10), 989 - 999.
- Rouse, P. & Putterill, M., (2003). An integral framework for performance measurement. *Management Decision*, 41(8), 791 - 805.
- Rowley, J., (1995). Contextual issues for education in library and information studies in England for the year 2000. *Library Review*, 44(8), 49 - 55.
- Sabry, K. & AlShawi, S., (2009). Information systems for higher education: interactive design perspective. *Transforming Government: People, Process and Policy*, 3(2), 163 - 180.
- Sahney, S., Banwet, D. & Karunes, S., (2004). Conceptualizing total quality management in higher education. *The TQM Magazine*, 16(2), 145 - 159.
- Sapri, M. & Kaka, A., (2006). A Conceptual Framework of Measuring Facilities Performance in Service Environment. *CIB W70 Trondheim International Sysposium*.
- Sapri, M. & Pitt, M., (2005). Performance measurement in facilities management; state of knowledge. In University of London: Association of Researchers in Construction Management, pp. 431-40.
- Sapri, M., Kaka, A. & Finch, E., (2008). Using Repertory Grid Technique for the Appraisal of Library Servicescapes. *Conference in Facilities Management, Heriot Watt University, Edinburgh*.

- Saudi, A., (2007). Practical Database Management Notes. Available at:
<http://www.azalisaudi.com/vkuliah/NotaDB.pdf>.
- Schaerf, A., (1999). A survey of automated timetabling. *Artificial Intelligence Review*, 13(2), 87–127.
- Schroeder, R.G., (1974). Resource Planning in University Management by Goal Programming. *Operations Research*, 22(4), 700-710.
- Scott Bollinger, J., Koffman, L. & E Austin, W., (2004). GIS Management of Facilities Deactivation and Decommissioning. In *Twenty-Fourth Annual ESRI User Conference, 2004*. San Diego, CA: ESRI.
- Sharma, R.D. & Kumar, S., (1985). Space Allocation to Academic Departments in a High Rise Building of an Australian Educational Institution. *Research in Higher Education*, 23(1), 86–95.
- Silva, J.D. & BEng, M.S., (2003). *Metaheuristic and multiobjective approaches for space allocation*, University of Nottingham.
- Skov, A. & Skærbak, H., (2003). Fighting an uphill battle: teaching information literacy in Danish institutions of higher education. *Library Review*, 52(7), 326 - 332.
- Smith, W., (2009). Theatre of Use: A Frame Analysis of Information Technology Demonstrations. *Social Studies of Science*, 39(3), 449-480.
- SMG. (2006). Space Utilisation: Practice, performance and guidelines. Available at:
<http://www.smg.ac.uk/resources.html>.
- Spaccapietra, S., Parent, C. & Vangenot, C., (2000). Gis databases: From multiscale to multirepresentation. *Lecture Notes in Computer Science*, 1864, 57-70.
- Steiner, J., (2005). The art of space management: Planning flexible workspaces for people. *Journal of Facilities Management*, 4(1), 6 - 22.
- Stephen, D.P. & Karen, K.K., (1991). *GIS Teaching Facilities: Six Case Studies on the Acquisition and Management of Laboratories*, Santa Barbara, California: University of California at Santa Barbara.
- Stilwell, C., (2007). Library and Information Services in South Africa: an overview. *IFLA Journal*, 33(2), 87-108.
- Stockard, J. & Mayberry, M., (1992). *Effective Educational Environments.*, Corwin Press, Inc., 2455 Teller Road, Newbury Park, CA 91320 (paperback: ISBN-0-

8039-6012-3; \$20; cloth: ISBN-0-8039-6011-5).

- Summers, T.A. & Vlosky, R.P., (2001). Technology in the classroom: the LSU College of Agriculture Faculty perspective. *Campus-Wide Information Systems*, 18(2), 79 - 84.
- Swift, J., 2000. IT: useful tool or nemesis for facilities management? *Facilities*, 18(10/11/12), 456 - 458.
- Symons, R.Y., (2008). *Student experience of Learning and Teaching Taxonomy for analysing qualitative data from the SCEQ/ CEQ*, University of Sydney, Australia: Office of the Deputy Vice Chancellor (Education).
- Tan, K.H., Platts, K. & Noble, J., (2004). Building performance through in process measurement: Toward an “indicative” scorecard for business excellence. *International Journal of Productivity and Performance Management*, 53(3), 233 - 244.
- Tarn, J.M. et al., (2003). Efulfillment: the strategy and operational requirements. *Logistics Information Management*, 16(5), 350 - 362.
- Teicholz, E., (1992). *Computer-Aided Facility Management*, New York: McGraw-Hill. Available at: http://www.ahuri.edu.au/publications/download/50366_pp.
- Teng, S. & Hawamdeh, S., (2002). Knowledge management in public libraries. *Aslib Proceedings*, 54(3), 188 - 197.
- Thomas, C., (2004). *Measuring up: The Business Case for GIS* 1st ed., Redlands, CA: ESRI Press. Available at: http://www.library.yale.edu/MapColl/gis_reference.html
- Timmermans, H., Arentze, T. & Joh, C., (2002). Analysing space-time behaviour: new approaches to old problems. *Progress in Human Geography*, 26(2), 175-190.
- Toro, A.D. et al., (1999). A Requirements Elicitation Approach Based in Templates and Patterns. In *Proc. Ibero-American Workshop on Requirements Engineering WER99*. pp. 9–10.
- Tucker, M. & Pitt, M., (2009). Customer performance measurement in facilities management: A strategic approach. *International Journal of Productivity and Performance Management*, 58(5), 407 - 422.
- Turney, C. et al., (2009). Using technology to direct learning in higher education: The way forward? *Active Learning in Higher Education*, 10(1), 71-83.
- Umbugala, M.D., Mohd Ali, H. & Mar Iman, A.H., (2008). Delivering facilities performance. Available at: <http://eprints.utm.my/5589/> [Accessed July 11, 2009].

- UPE, (2008). *Garis panduan dan peraturan perancangan bagi perancangan pembangunan 2008th ed.*, Unit Perancang Ekonomi Jabatan Perdana Menteri Putrajaya, Malaysia.: Unit Perancangan Ekonomi Malaysia. Available at: <http://www.epu.gov.my/standardsandsubcommitte>.
- Varley, D., (1997). *An Automated Space Allocation System – Technical Documentation*, UK: University of Nottingham. Available at: <http://www.asap.cs.nott.ac.uk/publications/pdf/spacetechnical.pdf>
- W. Creswell, J., (2003). *Research Design Qualitative, Quantitative, and Mixed Method Approaches*. 2nd ed., University of Nebraska, Lincoln: SAGE Publications. International Education and Professional Publisher.
- Waheed, Z. & Fernie, S., (2009). Knowledge based facilities management. *Facilities*, 27(7/8), 258 - 266.
- Walters, A., Mangold, J. & Haran, E.G.P., (1976). A Comprehensive Planning Model for Long-Range Academic Strategies. *Management Science*, 22(7), 727-738.
- Wan, S.H. & Chan, Y., (2007). Improving service management in outsourced IT operations. *Journal of Facilities Management*, 5(3), 188 - 204.
- Wilson, M., (1997). *The Information Edge: Successful Management Using Information Technology*, London: Pitman Publishing.
- Worboys, M. & Duckham, M., (2004). *GIS a computing perspective* Second Edition., Boca Raton, Florida, USA.: CRC Press.
- Worboys, M., (1995). *GIS: A Computing Perspective*, London: Taylor & Francis.
- Workshop on User Interface. Management Systems and Environments, (1990). *User Interface Management and Design: Proceedings*, Berlin: Springer-Verlag.
- Wyatt-Haines, R., (2007). *Align IT: Business Impact Through IT*, Hoboken, NJ: John Wiley.
- Xia, J., (2004). Library space management: a GIS proposal. *Library Hi Tech*, 22(4), 375 - 382.
- Xia, J., (2005). Visualizing occupancy of library study space with GIS maps. *New Library World*, 106(5/6), 219 - 233.
- Yaakup, A. & Said, M.N., (2003). GIS bagi perancangan dan pemantauan wilayah: Isu dan strategi pelaksanaan. In UTM, Skudai, Johor: Biro Inovasi dan Perundingan, Universiti Teknolgi Malaysia, pp. 1-21.

- Yang, H. & Tang, J., (2005). Key user roles on web-based information systems requirements. *Industrial Management & Data Systems*, 105(5), 577 - 595.
- Yin, C.M., (2007). *The application of Archibus/FM for space management in UTM*.
Fakulti Kejuruteraan Sains Geoinformasi, Universiti Teknologi Malaysia,
Skudai, Johor.
- Zahedi, F., (1997). Reliability metric for information systems based on customer requirements. *International Journal of Quality & Reliability Management*, 14(8), 791 - 813.
- Zheng, P. & Plenert, G., (1996). Facilities management systems and automated mapping systems. *Kybernetes*, 25(3), 45 - 50.