INVESTIGATION OF QUALITY OF COST DATA FOR LIFE CYCLE COST ANALYSIS IN UNIVERSITY BUILDING MAINTENANCE

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ABSTRACT
Life Cycle Cost (LCC) method has been stated in profession where it can be commonly applied to predict the maintenance and operation cost of the buildings. However, it was observed from the literature study that there is a limitation to access on the cost data input for LCC of building maintenance practice. This paper presents a study on the investigation of quality of data for LCC as input in unversity building maintenance practice.The study being reported in this paper is derived from 6 months programme of research carried by the first author to determine the readiness of the implementation of Life Cycle Costing approach in the university building maintenance practice in IIUM. The methodology designed for the study is a qualitative research strategy that comprises of two approaches, which are literature review and semi structured interview. The key finding of the study have been established that IIUM is not ready to implement life cycle costing practice in university building maintenance due to the problem of getting quality, current and reliable data as input for producing reliable LCC output.

Keywords: *Life Cycle Cost (LCC), cost data, quality, university building maintenance*

INTRODUCTION
Life Cycle Cost (LCC) is an assessment technique that estimates all costs related to the ownership of the building which include initial capital costs, financial costs, operation costs, maintenance and replacement costs and salvage cost throughout anticipated life (BS ISO 15686-5, 2008, Davis Langdon, 2010, Davis Langdon Management Consulting, 2006). LCC analysis used to compare amongst exclusive alternatives that provide significant cost savings (Boussabaine & Kirkham, 2006). The availability, accessibility, currency and reliability of cost data used as inputs in LCC analysis is of paramount importance that should be emphasized in the estimation to produce reliable LCC outputs (Mohd Fairullazi & Khairuddin, 2011, Mohd Fairullazi & Khairuddin, 2013, Mohd Fairullazi, 2014). Nevertheless, there is a limitation to implement LCC practice in the Malaysian construction industry. The majority of practitioners have given focused only on the formula to estimate LCC but very little emphasize given to the cost data inputs of LCC (Mohd Fairullazi & Khairuddin Abdul, 2011). Several scholars and researchers pointed out that the problems related to lack of reliable, accurate, and current cost data inputs in LCC analysis have been

reported elsewhere (Masoud, 2009; Masoud et al., 2010; Siti Hamisah et al., 2007a). Plus, there is no standard framework and guideline used to collect and compile all cost data input for LCC analysis (Wan Nur Hamizah, Norhanim & Muhammad Azzam, 2014). Hence, there is a crucial need of developing appropriate strategies to overcome the problems of getting quality of data as inputs for LCC in the Malaysian construction industry (Mohd Fairullazi & Khairuddin, 2013).

LITERATURE REVIEW

The maintenance management plays as a vital role to maintain the buildings and facilities in order to ensure the buildings are working in good performance condition. The role of maintenance management is not only to ensure the building is working productively but also to achieve optimum total cost throughout its service life.

In order to achieve optimum operation and maintenance cost, many scholars pointed out the decision making process should be embedded together with LCC. The output of LCC analysis assists the clients and building owners to measure their financial capability and to compare the most cost effective of mutually alternatives on making investment (Ashworth, 2010, ASTM International, 2010, BS ISO 15686-5, 2008, BSI, 2008, NATO Research and Technology Organisation, 2009, Kelly & Hunter, 2009, Kirk & Dell'Isola, 1995, as cited by Mohd Fairullazi, 2014). The literature study has identified the cost components of LCC analysis of a building including initial capital costs, financial costs, operation costs, maintenance and replacement costs and salvage cost (BS ISO 15686-5, 2008, Davis Langdon, 2010, Davis Langdon Management Consulting, 2006). Table 1 provides in summary the types of cost components of life cycle costing estimation.

Table 1: The components of life cycle costing estimation

Component	Description
Capital cost	All investments towards completion including decommissioning by the end use of the facilities (Langdon, 2010). This cost also includes land acquisition cost, construction work and other related cost and client defineable cost (BSI, 2008, BSI ISO 15686-5, 2008, Boussabaine & Kirkham, 2006, Kelly & Hunter, 2009, Stanford University Land and Buildings, 2005, Fuller, 2009, as cited by Mohd Fairullazi, 2013).
Financial cost	The cost of the money financing the business assets (Alberto Torres & Carlos Bustamante, n.d).
Operating cost	The total cost expected to maintain in daily, weekly and monthly that are repetitive within one year period for building and technical installation system to satisfy given functional demands and requirements (Langdon, 2010).
Maintenance and replacement cost	Maintenance cost includes all activities and efforts put forward in a period of more than one year by including planned maintenance, replacement and emergency repairs in order to ensure the buildings and technical systems are in the original quality and function **(**Langdon, 2010) Costs of replacement and repairs are costs of activities that are undertaken to take into account the changes to particular elements, materials and structures (Kristic &Marenjak, 2012).

Salvage cost	Salvage cost refers to projected resale value of an asset at the close of its useful life. The salvage value would be deducted from the cost of a fixed asset to decide the quantity of the asset price that will depreciate. Salvage cost is solitary used as a component of depreciation value (International Financial Reporting Tool, 2015).

(Alberto Torres & Carlos Bustamante, n.d, Langdon, 2010, Kristic &Marenjak, 2012, Department of Housing, 2006, Fuller, 2005, International Financial Reporting Tool, 2015, Matrixlab-Examples.com, 2015)

The LCC analysis process can be categorized into three main phases, i.e. data inputs, conversion and output (BS ISO 15686-5, 2008, Rist, 2011, Kelly & Hunter, 2009, NATO Research and Technology Organisation, 2009, as cited by Mohd Fairullazi, 2014). Cost data inputs are the important inputs for LCC conversion process. Net Present Value (NPV) is the most popular mathematical cost model to estimate total cost of building (Muhammad Zuhry, 2010, Davis Langdon, 2010, ASTM International, 2010). The basic requirements of NPV estimation are study life(n), discount rate (i) and yearly cost forecast estimates (Boussabaine & Kirkham, 2006). The NPV refer as an amount of investment required today to meet future financial requirement over a specified period. NPV method can be used to calculate the asset's net contribution by estimating the difference between the discounted present value and actual cost in today's value (Davis Langdon, 2010, BS ISO 15686-5, 2008, Schade, 2007). Study life is analysis period that costs of an asset is calculated until the client or the organization stop interest on the use and ownership of the structure (Stanford University Land and Buildings, 2005, Brandon 1995, BS ISO 15686-5, 2008, as cited Mohd Fairullazi, 2014). In order to make comparison total cost of alternatives in university building maintenance practice, there is a need to use a similar study life in the LCC estimation. In LCC analysis, discount rate is the parameter used to represent the time value of money. The time value of money depends on the inflation cost of capital, investment opportunities and personal consumption preferences (Davis Langdon Management Consulting, 2006).

The literature review has identified several types of mathematical NPV cost models that can be used for LCC in construction industry. One of the formulas of NPV mathematical cost model of LCC analysis is as follow:

$$NPV=C+R-S+A+M+E$$

Where:

C =investment cost

R= replacement cost

S= the resale value at end of study period

A= annually recurring operating, maintenance and repair cost (except energy, cost)

M= non-annually recurring operating, maintenance and repair cost (except energy, cost)

E= energy cost

The mathematical model was introduced by the American Society for Testing and Materials (ASTM 1983) to estimate LCC of building and system of building (Fuller, 2005, Nor Azizah & Zainal Abidin, 2010, Schade, 2010).

However, this research focuses only on cost data inputs of LCC in university building maintenance practice. The cost data inputs of LCC analysis in university building maintenance practice consist of operation cost and maintenance cost.

Operation cost of university building is the total cost expected to maintain in daily, weekly and monthly that are repetitive within one year period for building and technical installation system to satisfy given functional demands and requirements (Langdon, 2010). There are six cost components of operation cost in university building which are utilities cost, cleaning cost, administration cost, security cost, overhead cost, local and statutory charges in connection with building.

There have been several studies in the literature reporting that several kinds of freely published cost data in the Malaysia construction industry are appropriate to be used to estimate operation cost (Mohd Fairullazi, 2014, Mohd Fairullazi & Khairuddin, 2011). Table 2 provides the list of identified published cost data currently available in the Malaysian construction industry, and alternative data sources that can be used as inputs to estimate operation cost of the university building.

Table 2: Published cost data for operation cost of building

Cost component	Identified sources	Alternative data sources
Utilities cost *eg. water, electricity, gas.*	i. Tenaga Nasional Berhad, http://www.tnb.com.my/business/for commercial/pricing-tariff.html ii. Indah Water Konsortium, http://www.iwk.com.my/v/customer /commercial iii. Syarikat Bekalan Air Selangor Sdn. Bhd (SYABAS), http://www.syabas.com.my/consumer/water -bill-water-tariff iv. Gas Malaysia and Suruhanjaya Tenaga http://www.st.gov.my/index.php/consumer /gas/tariff.html	-
Cleaning cost *eg.cleaning classroom, offices and other academic facilities*	No published cost data	- Historical data
Administration cost *eg. salaries of supervisory staff, professional staff, administrative staff, and the use of the equipment and computer for supporting the administration of the maintenance*	No published cost data	- Historical data
Security cost *eg. high security arrangements that required personnel, digital entry points, alarm system and closed circuit television*	No published cost data	- Data from the manufacturers, suppliers, contractors and testing specialists
Overhead cost *eg. Insurance for the building paid by owner*	No published cost data	- Historical data
Local and statutory charges in connection with building operation *eg. charges in connection with the requirement of official approval,licenses or permit and*	No published cost data	- Historical data

pre-application advice particularly on the planning law and planning policy		

Sources: (Langdon, 2010, Fairullazi & Khairuddin, 2011, Khairani, 2009, BSI, 2008, Assem, 1991, Department for Communities & Local Government, 2014, Business Dictionary.com, 2015 and Ashworth, 2004, SYABAS, 2011, Gas Malaysia and Suruhanjaya Tenaga, 2013, Indah Water Konsortium, 2015, Tenaga Nasional Berhad, 2015)

The table above shows that only utilities cost is freely available in official websites such as Tenaga Nasional Berhad, SYABAS, Indah Water Konsortium and Gas Malaysia and Suruhanjaya Tenaga. While, there is no pulished cost data for other category of cost component for operation cost of university building i.e cleaning cost, administration cost, security cost, overhead cost, local and statutory charges. There are three categories of alternative data sources for LCC that can be used to mitigate non existance of published data such as data from manufacturers, suppliers, contractors and testing specialists, historical data and data from modelling techniques (Langdon, 2010). Data from manufacturers, suppliers, contractors and testing specialists is based on extensive knowledge of the performance and characteristics of their material and components.Historical data can be refered from organisation's internal data, feedback from operational assets and published benchmark sources (Langdon, 2010). While, mathematical models developed for analysing costs and statistical techniques can be incorporated to address the uncertainties (Langdon, 2010). From the data in Table 2, it is apparent that historical data is more appropriate that can be used to mitigate non existence of published data for operation cost by refering on the similar characteristics of the past projects. However, one of the disadvantages of historical data is the data can provide misleading information to the LCC analysis and the LCC outputs tend to become unreliable and show differences from the actual costs, where the data are collected from the past arranged periods of study and less current (Mohd Fairullazi & Khairuddin, 2011, Masoud, 2009, Masoud et al, 2010, Siti Hamisah et al, 2007, as cited by Mohd Fairullazi, 2014).

Maintenance and replacement cost have linked with operational activities. There is no published cost data for each category of cost components of university building maintenance and replacement cost. The literature review has proposed several types of alternative data sources for maintenance and replacement cost of university building as shown in Table 3.

Table 3: Solutions to overcome non available data of maintenance and replacement cost

Cost Component	Description	Alternative data sources
Cost of regular custodial care	A custodial service provides cleaning, moving, and general services such as pest control, recycling collection, reporting of maintenance needs, funiture moves and others.	- Data from the manufacturers, suppliers, contractors and testing specialists
Repair and replacement cost	Repair and re-establishment of building component to original function.	- Data from manufacturers, suppliers, contractors and testing specialists
Annual maintenance contracts	Fixed fee services provided by contractor for maintenance of building.	- Historical data
Maintenance management	Maintenance management software such as Computerized Maintenance Management System.	- Data from manufacturers, suppliers, contractors and

		testing specialists
Refurbishment cost of the building	Renovation, cleaning up, restoration to its better looking condition.	- Data from manufacturers, suppliers, contractors and testing specialists, - Data from modelling techniques
Redecoration cost of the building	Beautify or furnish something with ornamental eg redecorate wall with murals.	- Data from manufacturers, suppliers, contractors and testing specialists
Salaries of facility staff performing maintenance task	Salary to facilities maintenance technicians that perform building maintenance task such as cleaning, maintaining, and repairing.	- Historical data

(BS ISO 15686-5,2008,BSI, 2008, Davis Langdon,2010, Fuller,2009, Kelly and Hunter, 2009, University of Wisconsin, n.d, Mohd Fairullazi & Khairuddin,2011, Business Dictionary.com, 2015, Dictionary.com,2015, The Free Dictionary,2015, Gateway Technical College,2015)

As shown in Table 3, data from manufacturers, suppliers, contractors and testing specialists can be seen as the best way to mitigate non existence of published data because extensive knowledge and experience of specialist manufacturers and suppliers are valuable sources that can be referred for life cycle information (Flanagan & Jewell, 2005).

OBJECTIVE OF THE PAPER

The objective of this paper is to review the quality of cost data used as input for university building maintenance and the identification of appropriate strategies to improve the quality of data for LCC analysis in IIUM building maintenance practices. The scope of this paper is the cost data that available and accessible for public reviewing in the Malaysian construction industry. The study being reported in this paper is derived from 6 months programme of research to improve the quality of data for LCC analysis in IIUM university building maintenance (Nor Khalisah, 2015). This paper focuses only on cost data inputs in LCC of university building maintenance practice.

METHODOLOGY DESIGNED FOR THE STUDY

The research strategy chosen for the study is a qualitative research rather than quantitative research and mixed method researches because the nature of research in LCC data input is subjective and the data is often rich. Hence, this study requires the researcher to study the data inputs based on the facts, views, opinions from the practitioners that have knowledge in LCC analysis with specific reference to university building maintenance practice (Mohd Fairullazi & Khairuddin, 2011, Mohd Fairullazi, 2014).

By refering to the research methodology outline in Figure 1, qualitative research strategy comprises of literature review and semi structured interview approach. Literature review was carried out at the initial stage of the study to gain the clear picture and understanding of the research topic on the maintenance management in university buildings and cost data inputs of LCC by refering primary sources and secondary sources.

FIELDWORK APPROACH

Semi structured interview was chosen as fieldwork approach to answer the second and third objectives of the study i.e to identify availability, accessibility and currency with specific reference to cost data input of LCC in university building maintenance and to identify solutions in order to improve LCC approach specific cost data input in university building maintenance practices. Semi structured interview approach can be described as an interview based on six to twelve well chosen and well-phrased questions that consist of closed ended and open ended questions (Rowley, 2012). Semi structured interview was chosen to obtain more understanding and explanation regarding cost data input that have been used to estimate operation and maintenance cost rate in university. Plus, the respondents can share their experience and difficulty that they face during estimating university building maintenance cost rate and provide suggestion to overcome these problems. In addition, there are some previous researchers that have been used interview approach to study the concepts, practice and data input for LCC building maintenance, for example, Nor Azizah Mohammed Rum & Zainal Abidin Akash (2011), Olanrewaju, Mohd Faris & Arazi (2010).

Figure 2 shows the schematic flow of development interview process that starting from research question until summarize responses. In the early phase, the researcher has to construct a questionnare with the assistance of research supervisor in order to answer research questions. The questions were developed in open ended format to obtain wide range of responses from the respondents. The questionnare has divided into two sections which are section A and section B. Section A consists of the profile information and professional qualification of the respondents to establish the expertise of respondent in cost management in Facility Management as purpose to identify the suitability of the respondents to fulfil the specific criteria as well as to obtain reliable data. While, section B is designed to obtain valuable opinion from the respondents regarding the state of data inputs availability, accessibility and currency in FM and to provide the strategies or solutions in order to improve LCC approach specific cost data input in facility management. In this study, the pilot questionnare was carried out through face to face discussion with the research supervisor and academician at the Kulliyah Architecture and Environmental Design, International Islamic University Malaysia. Based on the comment and suggestion from the research supervisor, the researcher revised the questionnare in order to improve the quality of the question and to ensure the question is answerable. In addition, the researcher identified the potential interviewee based on pilot study, recommendations from the institutions as well as from snowball method where the researcher obtained recommendation of other people who have expertise in cost management in university building maintenance which can be potentially invited as respondents to this research.

RESULTS AND DISCUSSION

The main results were generated from the semi structured questionnare. The questionnare has been divided into two sections which are section A and section B. Section A consists of profile information and establishing expertise of respondent in cost management in university building maintenance. For Section B the respondents were asked to determine the state of data availability, accessibility and currency as inputs for LCC analysis and to recommend appropriate solutions to improve the quality of data for producing reliable LCC output in university building maintenance practice.

The respondents also were required to state the sources of cost data that can be used as input for LCC analysis in university building maintenance practice. The details are shown in Table 5. The majority of the respondents have reached agreement that historical data is identified as the most preferred data to estimate operation, maintenance and replacement cost. The result is consistent with other scholars such as Flanagan and Jewell (2005), Langdon (2010) and Schade (2007) found that historical data is one of the alternative data sources to estimate LCC for university building maintenance. Mohd Fairullazi (2014) suggested another alternative to be used for LCC analysis which is from published website that have been updated by agencies such as Tenaga Nasional Berhad, Indah Water Konsortium, Syarikat Bekalan Air Selangor Sdn. Bhd (SYABAS) and others.

In the second section of the questionnare, the respondents were required to recommend the strategies on how to improve the quality of data for LCC analysis in university building maintenance practices. The results of semi structured interview show that there are several strategies are worthy to be considered. Table 6 shows the top three priorities for recommendations to be implemented. Based on the results, it was found that the majority of the respondents have same opinion that the problem of carrying out LCC analysis in IIUM building maintenance practice is to obtain and access to current and reliable cost data. The majority of them proposed that past data which have the same project works and characteristics suitable to be referred, refering Facility Management, the Government should make data accessible for the good use of practitioners and using comparative analysis by looking at increment for the first five years to extrapolate for future cost. However, these findings contradict the study by Mohd Fairullazi (2014), who considered there is a need to create protocol of LCC data input in order to enhance the quality data input requirements.Thus, there is a need future study to improve LCC approach by providing learning system relating to cost management in university building maintenance practice.

Table 6: Top three priorities for recommendation to overcome the problem of not availability, accessibilty and currency

Key quality of data inputs	Recommendations
Data availability	• *The estimators have to refer to the past data that have the same work or equal project and detailed billing(2 respondents)* • *Refering Facility Management.(1 respondent)*
Data accessibility	• *The Government should make data accessible for the good use of practitioners.(1respondent)*
Data currency	• *Comparative analysis is proposed and looking increment year by year (first 5 years) to extrapolate for future cost.(2 respondents)*

Table 5: The summarize of responses from semi structured interview

COST COMPONENTS	Services providers (TNB, SYABAS, etc)	Bills	Subcontractor quotation	Facility Managers	Public Work Depart-ment	Contract document	Supplier	Past data record of project	Insurance companies	Historical data	Not available, assessible and current	**Number of respondent Total**
Utilities cost	2	1								1		4/5
Cost of regular custodial care and cleaning cost			1							3		4/5
Administration cost				1	1					2		4/5
Security cost			1							1	3	5/5
Local and statutory charges						3				1		4/5
Repair and Replacement cost							1			3		4/5
Salaries of facility staff performing maintenance task					1			1		2		4/5
Maintenance management				3							1	4/5
Annual Maintenance Contracts						2				2		4/5
Redecoration cost										1	3	4/5
Refurbishment cost										2	2	4/5
Overhead cost									1	1	3	5/5
Total	2	1	2	4	2	5	1	2	1	19	12	

CONCLUSION AND RECOMMENDATIONS

This paper presents the study of reviewing the quality of cost data used as input for university building maintenance and the identification of appropriate strategies to improve the quality of data for LCC analysis in IIUM building maintenance practices. The methodology designed for this study comprises of literature review and semi structured interview to collect primary and secondary data. This approach is adopted due to it is useful to collect detailed and contextual information as well as to obtain more understanding and explanation regarding cost data input for the practice of LCC analysis in university building maintenance practice. The majority of respondents have reached agreement that cost data of university building maintenance can be obtained from historical data. Thus, IIUM is not ready to implement LCC approach in university building maintenance practice. This is due to historical data is less current cost data and not quality enough that makes the LCC outputs tend to become unreliable and show differences than the actual cost. Most of respondents have made suggestions on how to improve the quality of data used as input in the practice of LCC analysis i.e by refering to the past data which have the same project works and characteristics suitable to be referred, refering Facility Management, the Government should make data accessible for the good use of practitioners and using comparative analysis by looking at increment for the first five years to extrapolate for future cost. In addition, the quality of cost data can be improved by having a protocol or standard guideline for LCC analysis that can help the estimator to collect, record and update the cost data of operation and maintenance efficiently. The study is limited by constrains in finding suitable respondents that have expertise in the field university building maintenance practices. The study also could not access to internal university building maintenance cost data as the data confined by the organization in the library and restricted for public viewing. Further research is encouraged as second part of this study to propose a guideline, which provides the most appropriate procedures to improve the quality of cost data for the practice of LCC analysis in IIUM university building maintenance practice.

ACKNOWLEDGEMENT

The author would like to express deepest gratitude to the principal investigator, Dr. Mohd Fairullazi Ayob for his invaluable guidance and assistance throughout the research.

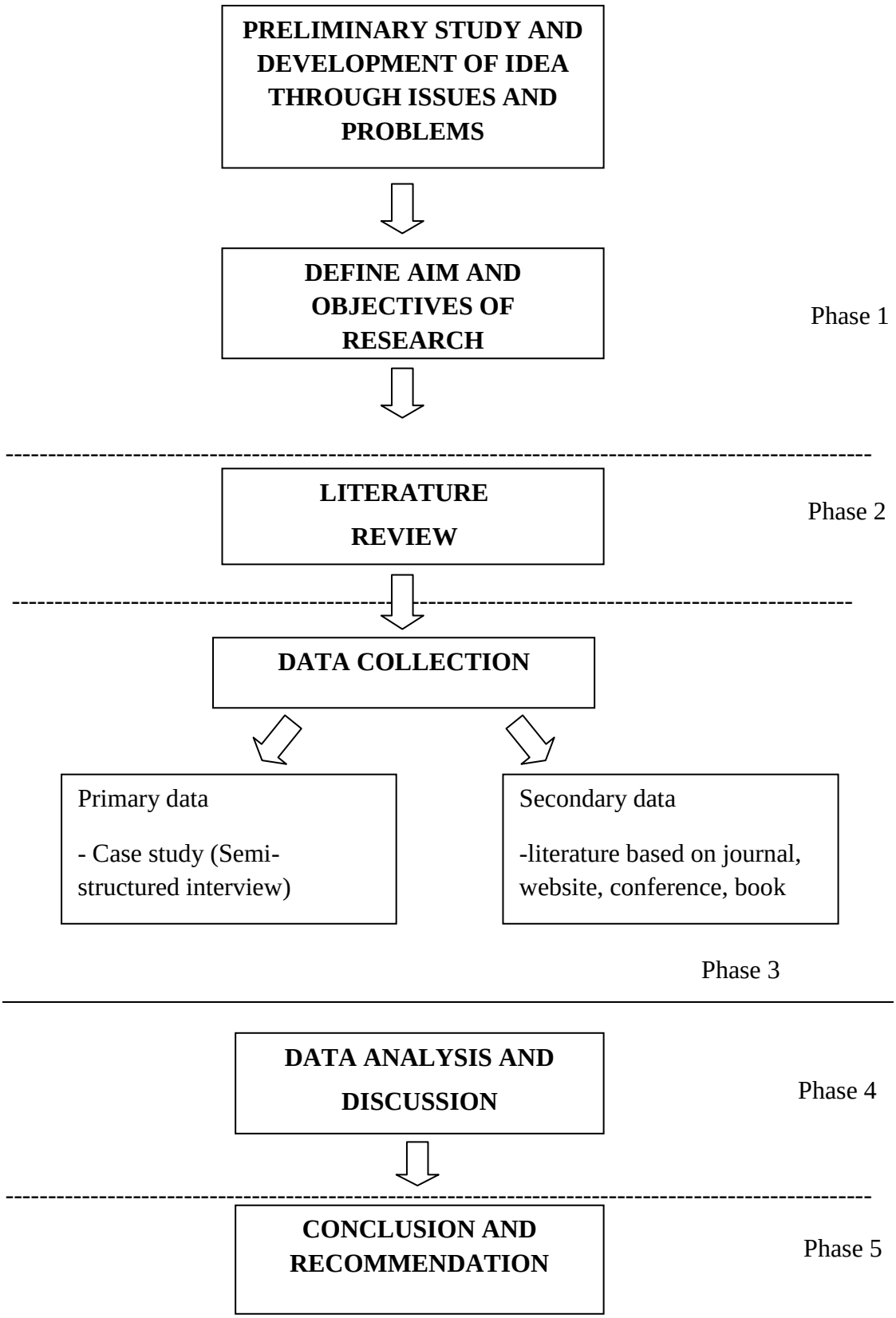

Figure 1: Research Methodology Outline

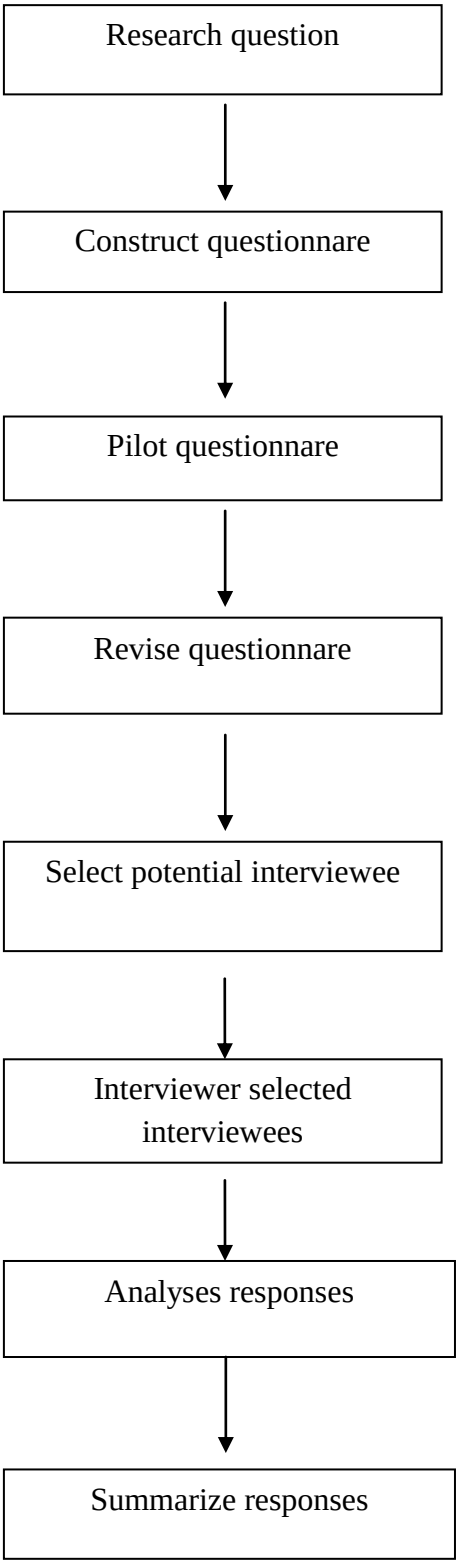

Figure 2: The schematic flow of development interview process

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