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Applying Soft Systems Methodology for User-Centred Design

Diana Kassabova
Rachel Trounson

School of Information Technology and Electrotechnology
Otago Polytechnic
Dunedin, New Zealand
dianak@tekotago.ac.nz

ABSTRACT

The paper describes an implementation of the Soft Systems Methodology for modelling the users of a bionic baby. This is a computerised doll that can simulate a number of activities carried out by real babies. The doll can be used for teaching young people the amount of responsibility and care that comes with a baby. The doll is designed to be used by two different types of users: supervisors who can set up different modes for the doll through a specially designed computer application, and young people who are the target users of the electronic baby. The aim is to achieve good useability of the system as a whole.

Key words

Soft Systems Methodology, user modelling, conceptual model, child-care

1. INTRODUCTION

The idea of the Bionic Baby was developed through the Bachelor of Information Technology Degree at Otago Polytechnic (Brook *et al.*1999). The idea was to create a bionic baby of the actual size, shape and weight of a baby, that could be used as a training tool in schools and other child care organisations. The baby would be able to simulate the basic activities that a real baby can carry out. The baby will be used as a training tool in the education of young people in the care of a baby.

The teacher (or supervisor) will be able to set up different modes for the doll by connecting it to a computer that runs a specialised program. The modes can be translated in real baby's behaviour: specifying degrees of irritability, and the frequency of behaviour such as hunger, lonely, wet, or just needing attention (play). The student required to take care of the doll will need to work out why the baby is crying, and will be expected to take the appropriate action(s). The doll will record the care that it has received during the students' experience. The experience will range from about 1 up to 3 days depending on the supervisor's settings. The supervisors will be able to retrieve information about the way a student has cared about the Bionic baby.

It is important to view the doll, the computer program used to set up its modes, the supervisors and the students as one whole human-computer system, with its own interrelations, dynamics and characteristics. Furthermore, this system will work within certain social, educational and personal contexts. As the computerised doll is going to be used in a highly interactive mode, and not necessarily by experienced computer users, designing a user interface of a high standard is of critical importance.

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Evidently, the computerised doll will be used by a number of users that can be grouped in essentially two different groups: supervisors and students. While the students are expected to only use the interface presented by the doll itself, the teachers will have to be able to use the doll in conjunction with a computer and customise the baby's behaviour through the software application. The students though should also be able to understand there are different modes for the doll and how their own reactions would be recorded. All this means that two distinct groups of users must be considered when designing the user interface of both the doll and the program used to control it.

From the range of methods that could be used for user modelling, the Soft Systems Methodology (SSM) approach was taken to analyse and further develop the interface of the system. The alternative was to use either the Socio-Technical approach, which is too organisationally based, or the Participatory design which would be too costly for the resources we had available. The SSM showed more flexibility in describing the users and interpreting the context in which the computerised doll would be used.

2. AN OVERVIEW OF SOFT SYSTEMS METHODOLOGY (SSM)

Soft Systems Methodology was developed by P. Checkland in 1981 as a systematic approach to problem solving (Checkland, 1981). Although it may be used to analyse any problem or situation, it is most appropriate for the analysis of systems that contain interdependent human and technological components as it aims at understanding the context in which the system as a whole functions. It is often seen as "a heuristic and subjective approach for knowledge elicitation in complex and poorly defined areas." (Finegan, 1995, p.1).

The SSM approach places emphasis on understanding the context in which the system will function. Therefore the approach involves first of all finding out as much as possible about the problem situation, i.e. developing the so-called rich picture. This is followed by formulating a root definition of the system. The root definition is formulated by analysing a group of elements known by the mnemonic CATWOE, that defines a check-list for Customer, Actors, Transformation process, Weltanschauung (World View from German), Owner, and Environment (Checkland, 1981). Next a conceptual model is built in relation to the root definition. The conceptual model defines what the system will have to do in order to fulfil the root definition(s). Finegan (1994) argues that "the qualitative modelling process uses pictures and diagrams to define and communicate structure, logic, ideas and relationships. The Conceptual Model should be expressed by verbs." (p. 10).

The process continues with the comparison of the conceptual model with the real world system as expressed when developing the rich picture, thus identifying any discrepancies between the two and any changes that need to be made in the system.

3. APPLYING THE SSM TO MODELLING THE USERS OF THE COMPUTERISED DOLL

The SSM in its traditional seven stages form as described in Dix (1998) was applied for the modelling of the two groups of users of the system consisting of the Computerised doll, software application, teachers and students.

3.1. Recognition of the Problem and Initiation of Analysis.

The problem was first initiated by a home economics teacher at Kaikorai High School, Dunedin, Brenda Brook. She was concerned over the view of teenagers towards having a baby. A small team of students and lecturers in Otago Polytechnic (Brook *et al*, 1999) considered the creation and introduction of a Computerised Doll, or a Bionic Baby, as a means of teaching students the responsibility of caring for a baby, as an alternative to the usual egg or bag of flour used in schools and other organisations. The use of the egg or bag of flour teaches the student to take care of an object, but does not simulate all the demands that a real baby would have. By using the Bionic Baby the student would have to assess the baby's needs and respond appropriately. Detailed description of the problem situation: developing a rich picture.

3.2. Developing the Rich Picture

The two main groups of stakeholders are the supervisors and the students. Other stakeholders include parents who would be involved through their children, the government through their relationship with New Zealand education, and the community as a whole.

Preliminary research on the need for such a computerised doll was carried out among a variety of educators and in the community. This showed a very positive response, as "the key issue was that the purpose of the baby is to show responsibility, and to be as realistic as possible" (Brook et al 1999). Detailed discussions among the design team members as well as with some educators prompted that the Bionic baby should be a baby-sized model, which will cry for four main reasons: when it is wet, hungry, lonely, or wants to play. The software that accompanies the doll should enable the supervisor to alter various aspects of the baby as well as to retrieve information about the care received by the Bionic baby.

Later a more detailed research was conducted by asking each of the two main stakeholders, supervisors and students, to answer purposely created questionnaires. The questionnaire for the supervisors was mainly aimed at finding out what their attitude toward the computerised doll was, and finding out about their computer experience. The questions asked concerned the following areas:

- The age group best suited for using the Bionic baby and in what situations would they use the baby.
- The computing experience they have had and their preferred method of learning new software.

The majority of teachers believed that the age of students that would benefit the most of the Bionic Baby should be 15 years or older.

Eighty-six percent believed they would incorporate the Bionic Baby into an aspect of their teaching provided the cost was not too high. The majority of the supervisors were reasonably confident with computers and had worked with computers from 2 to five years. The preferred method of learning was to receive training with basic instruction, followed by an extensive help menu and a manual with the training course. No one was satisfied with only a manual at hand.

The next group of main stakeholders are the students. A questionnaire was developed and given to several groups of high school students aged 15 and older. The questionnaire consisted of a number of questions aimed at collecting information about students' knowledge of matters related to caring for babies and about their experience with computers. Although the students would not be directly involved in using the software for setting up the baby's modes, it would be important for them to understand the ability of the supervisor to specify different modes. The results showed the following background:

- 71% had received some form of childcare teaching about babies.
- 79% knew how to change a nappy.
- 64% had changed a baby's nappy.
- 82% had fed a baby.
- 79% had cared for a baby under 1 year of age.
- 50% had cared for a sibling unsupervised.

The students had a wide range of confidence levels on working with computers, with the majority showing an average level of confidence. The distribution of the students' confidence closely resembles the Gaussian normal distribution curve. This means that in general the students would not have any difficulties understanding the use of different modes for the baby and understanding how a computerised doll works.

The purpose of the system should be considered from the point of view of the various stakeholders. In first place, the purpose of the Computerised Doll would be to aid the understanding of the nature and amount of responsibility and commitment that caring for a baby entails. The doll could also contribute to the development of better parenting skills in young people. The supervisors (teachers) would be able to use the doll within their course as both a demonstration device and a means of enabling a student to care for a baby for a various length of time set by the supervisor. The length of time would also emphasise the effect a baby would have on the student's personal and social life. As the doll is to be used by various educational organisations, its cost should be kept within reasonable limits.

The parents would view the baby as a valuable educational tool to teach their child the responsibility of parenting. The government and the community view could incorporate the benefits that teenage education would create. These benefits could include the reduction in the number of teenage pregnancy and the increased age of first time parents as well as a young generation with better parenting skills.

3.3. Formulating the Root Definition for the System

The main issue that instigates the development of the Bionic baby is the community's concern with the high rate of teenage pregnancies in New Zealand. Therefore when defining a root definition for the system all its components should be considered in the context of the community. "The root definition should identify the various people involved in the system who will benefit or suffer from the system (the clients), who is involved in the system (the actors) and who has commissioned the system (the owners)" (Preece *et al*, 1994, p. 374).

In the case of the Bionic Baby, the clients include students, supervisors, parents, government, community, and Otago Polytechnic's students and lecturers who develop the Bionic Baby. Immediately involved, by performing activities within the system, are the students and supervisors. They are the Actors.

The system as a whole should be able to transform the teachers' knowledge (of the educational curriculum, child care and health, students' learning abilities and limitations) into an understanding by the students of the issues related to caring about a baby both in practical and cognitive terms. Another component of the root definition, the world view (or Weltanschauung) gives an indication of 'how the system is perceived in a particular root definition' (Dix *et al*, 1998, p. 228). The Bionic baby is perceived as a means to teach students through example and experience that caring for another human being is a demanding undertaking that requires a large amount of responsibility and commitment. It is a known fact that "knowledge can be divided into knowing-how, which is a set of dispositions (tendency, capacity, skill, propensity, etc.), and knowing-that, which is the information about a domain as a result of the exercise of knowing-how" (Checkland and Tsouvalis, 1996, p. 4) The system therefore should facilitate the acquisition of the higher level, 'know-that' knowledge through gaining experience in the domain of the lower level, 'know-how' knowledge. The aim of the Bionic Baby is not to discourage the students from ever wanting a child, but to encourage them to wait until they can emotionally and physically care for another live being. Currently the Owner of the computerised doll is the team of people (lecturers and students) who have been working on the project and are able to introduce changes in the system.

The environment in which the system is developed and functions comprises a number of various constranits:

- The educational curriculum
- Understanding of the students' socio-economic background.
- The responses of the Bionic Baby should be consistent with the potential behaviour of a baby.
- The Bionic Baby hardware needs to be able to fit inside the baby manikin, and have the ability to connect to a computer.
- The software for the Bionic Baby should be easy to use, enabling the supervisor to read information from the baby and should also allow modifications of the behaviour of the baby.
- The cost of the final product needs to be affordable for the schools and other childcare organisations.
- The hardware and program development of the Bionic Baby is constrained by the developers' knowledge, developers being mainly current and former students.

3.4. Building the Conceptual Model

The computerised part of the system actually consists of two distinct components, the computerised doll and the software application. Each of them have their own respective group of users. When the supervisor inputs some data using the software, it is transformed into a particular settings of the doll and then output by the doll. This output is perceived by the student as some part of the baby's behaviour. On the other hand, any student's input to the baby, which is essentially the student's reaction to the baby's behaviour, is to be transformed into different states that are recorded by the hardware built in the doll and later output to the supervisor by the computer software.

In order to better understand the specifics of the sytem, the process of building its conceptual model has been carried out step by step, in an incremental manner. First the main components of the system were determined as well as the minimum set of necessary activities performed by the system as shown in Figure 1.

Figure 1. First step in building a conceptual model of the system.

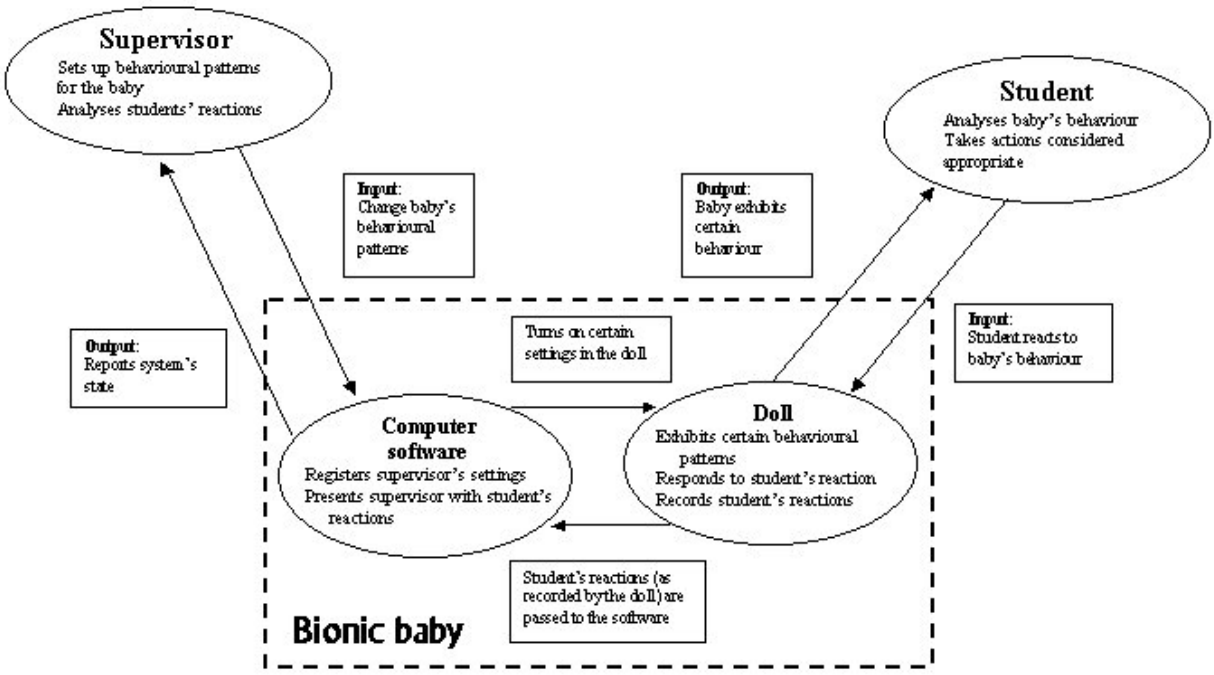
In the second step an abstraction is introduced, i.e. the two computerised elements of the system, the computer software and the electronic doll, are replaced by a new entity, the Bionic Baby. This is done as we are only interested in the way users would interact with the baby and therefore there is no need to analyse the actual technical details concerning the relation between the software and the doll.

By applying the same incremental approach, the activities performed at the two ends of the system, Supervisor-Bionic Baby and Bionic Baby-Student, are further broken down and the conceptual model built as a result is shown in Figure 2.

3.5. Comparison

According to Chiew *et al.* (1999) there are four different methods that can be used at this stage. The most commonly used method is Comparison by question generation.

"In this method questions are generated about the activities in the conceptual model.



For each activity, the following type of questions are asked:

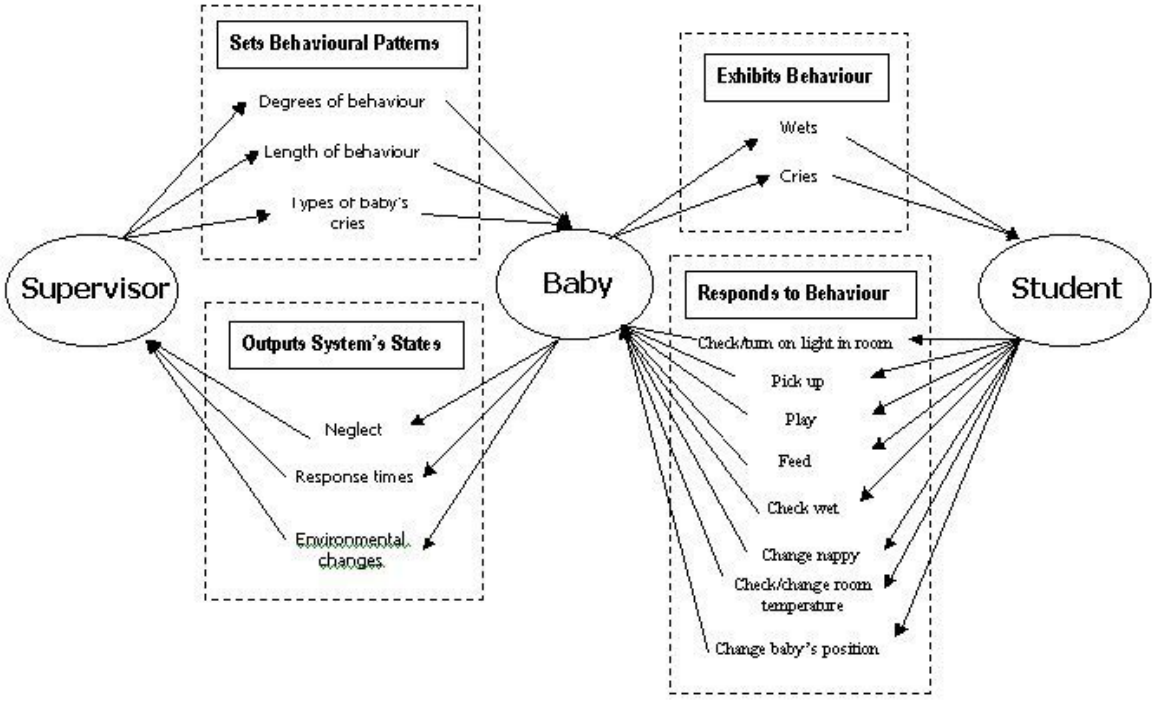


Figure 2. Second step in building the conceptual model.

- Is the activity carried out in the real world?
- How is it done?
- How is the performance measured?
- Is the activity carried out effectively?" (Chiew *et al*, 1999, p.11)

The main aim of the comparison stage is to find out how and to what extent the activities defined in the conceptual model compare to the real life situation. In the case of the Bionic baby it translates into comparing the conceptual model to what activities have to be performed when caring about a real baby as well as what feedback the supervisors would need in order to asses a student's performance. This in turn would determine the interface of the doll as well as the interface of the software application used by the supervisor.

As a result of the comparison process, an interface for the doll can look as shown in Figure 3. The interface should allow the interaction between a student and the Bionic Baby to closely simulate real life situations.

Some important points are:

1. A 3-way mercury switch registers the baby's position (when it is picked up or just rolled over)
2. A light sensor simulates the baby's vision and inputs information about the light in the room.
3. Key P simulates feeding the baby. It has to be pressed continuously until the baby is played with enough (i.e. as set by the supervisor)
4. Key F simulates feeding the baby. It has to be pressed continuously until the baby is fed enough (i.e. as set by the supervisor)
5. A light emitting diode (LED) simulates that the baby is wet.
6. A light sensor (covered by the baby's clothes) detects if the nappy is being changed.
7. A temperature sensor inputs information about the room temperature
8. A battery indicator helps monitor the battery charge.
9. A speaker for crying
10. The interface of the software application should allow the supervisor to easily determine the Bionic Baby's behaviour in terms of:

- Degrees of behaviour: irritability (the ease to which the baby will start crying), frequency (indicates if the baby will cry more or less often) and predictability (whether next type of cry is related to the previous one).
- Duration of behaviour: feeding, sleep, play and wake.
- Types of cry: wet, play, hungry, lonely, and the percentage of each type of cry.

Degrees and duration of behaviour would be best expressed in fuzzy terms, i.e. least - most, and short - long. This would allow for customising the system by assigning to them different ranges of values.

When the supervisor needs it, the information stored in the doll would be displayed by the software application in the form of a report. The Neglect feedback from the Bionic Baby would be represented by a Black Mark, indicating that the baby was not cared for correctly, e.g. not fed enough.

The report would also contain information about student's response times, i.e. the time between a baby's cry and the student's action.

Information about any environmental changes (room temperature and light) made by the student while caring for the Bionic Baby would be also reported.

The software interface would also offer the user a menu containing commands for opening a new session of settings, saving the session, updating the session, undo settings, uploading the session to the Bionic baby. It would also offer help menu, as well as a simple tutorial. The degrees and lengths of behaviour would be set by scroll bars as they best suit the fuzzy terms for determining different aspects of behaviour. The help menu would contain a step-by-step tutorial as well as a task-specific help facility. Training sessions with the potential clients would be also conducted.

4. CONCLUSION

The project is currently at the stage of developing the electronic doll with its interface closely resembling the suggested one in Figure 3. It is yet to be decided what exactly the interface for the software application would look like. The constraints of the system's environment as described in 3.3 above would have to be taken into account when working on the interfaces.

The soft systems methodology approach was relatively easy to implement for the user centred design of the Bionic Baby's interface as it provides a useful framework for analysing the system and its components. It is envisaged though that more elements of participatory design will have to be introduced at a later stage of the interface design in order to fine-tune all aspects of the interfaces.

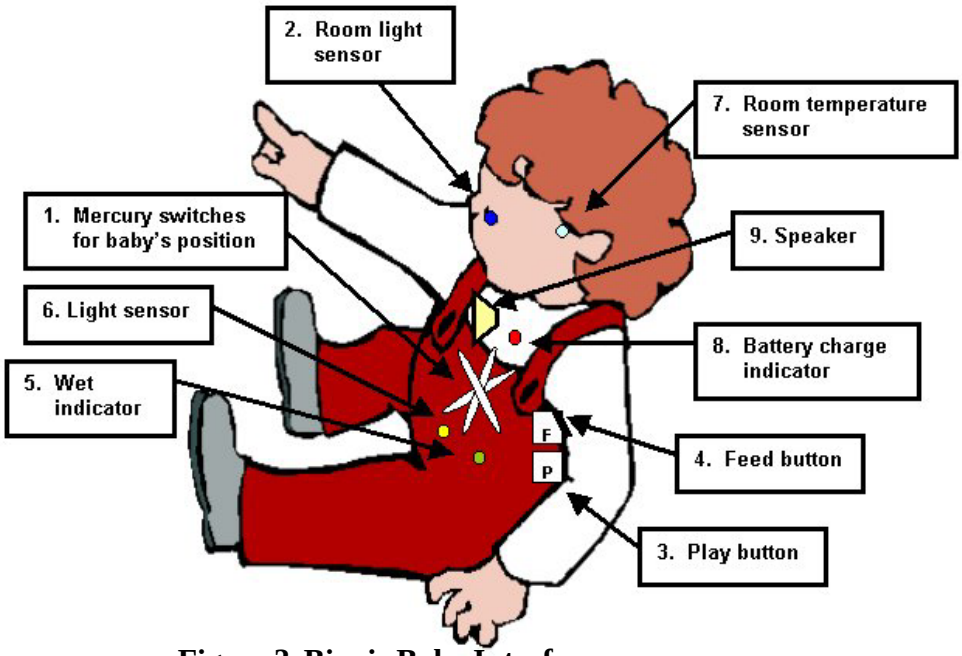


Figure 3. Bionic Baby Interface

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Database Design and the Reality of Normalisation

Dave Kennedy

Institute of Technology
Christchurch Polytechnic
Te Whare Runanga O Otautahi
kennedyd@chchpoly.ac.nz

ABSTRACT

What is normalisation all about? Why do we teach it? How do we teach it? How can we explain normalisation to our students so that they will understand it?

This paper presents a method of teaching normalisation that, experience has shown, students can understand.

The paper also considers the broader questions of:

- Why is normalisation important?
- Where does it fit in the process of database design?
- How important is it in the "real world"?

Database design can be done using an entity relationship diagram (ERD) - a top down approach or by normalisation of sets of data - a bottom up approach.

The question is, What do real database designers do?

- What methodologies do they use?
- How important is normalisation?
- What normalisation rules do they use i.e. how far do they take it?
- How important is denormalisation?

This paper presents a summary of findings, from interviews with database designers, that should help us in our teaching of Database design.

Keywords

Normalisation, database design, dependency diagram

1. INTRODUCTION

"I use a mostly ERD approach to database design but I don't do it unaware of normalisation"

Database designer

What is normalisation all about? Why do we teach it? How do we teach it? How can we explain normalisation to our students so that they will understand it?

This paper presents a method of teaching normalisation that, experience has shown, students can understand. The paper also considers the broader questions of:

- Why is normalisation important?
- Where does it fit in the process of database design?
- How important is it in the "real world"?

The teaching method I use is based on Rob & Coronel (1997). The reality check was made by interviewing three industry people involved in relational database design.

2. NORMALISATION

2.1 What is Normalisation

Normalisation is a set of rules which can be used to modify the way data is stored in tables. (Rob & Coronel, Lecture #5, Date, Date & Fagin).

Normalisation The process of converting complex data structures into simple, stable data structures (McFadden & Hoffer).

There are rules for 1NF, 2NF, 3NF, BCNF, 4NF, 5NF and domain-Key NF. Most textbooks mention 5NF and DKNF only in passing and note that they are not particularly applicable to the design process (Rob & Coronel, pg303, Pratt & Adamski, pg 161, Howe p87). Normalisation is really about the "formalisation of simple ideas" (Date & Fagin). All too often the simplicity is lost in esoteric terminology and papers are "often excessively concerned with the formalism and provide very little practical insight" (Date & Fagin).

2.2 Why Normalisation

Normalisation is about designing a "good" database i.e. a set of related tables with a minimum of redundant data and no update, delete or insert anomalies.

Normalisation is a "bottom up" approach to database design. The designer interviews users and collects documents - reports etc. The data on a report can be listed and then normalised to produce the required tables and attributes.

Normalisation is also used to repair a "bad" database design, i.e. given a set of tables that exhibit update, delete & insert anomalies the normalisation process can be used to change this set of tables to a set that do not have problems.

Another approach to database design is to use Entity-Relationship Diagrams (ERD). This is a "top-down" approach. An Entity is a thing about which we wish to store data. An ERD models the entities, their attributes and the relationships between them. The ERD "rules" are:

1. Each entity has its own table
2. M-M relationships are resolved by creating a composite (bridge) entity which has, at least, the primary keys of its parent entities
3. The aim is to minimise data redundancy.

If we follow the ERD approach and then check the resultant tables against the normalisation rules we usually only need to go to 3NF. If we blindly normalise sets of data then often we will need to go to 4NF.

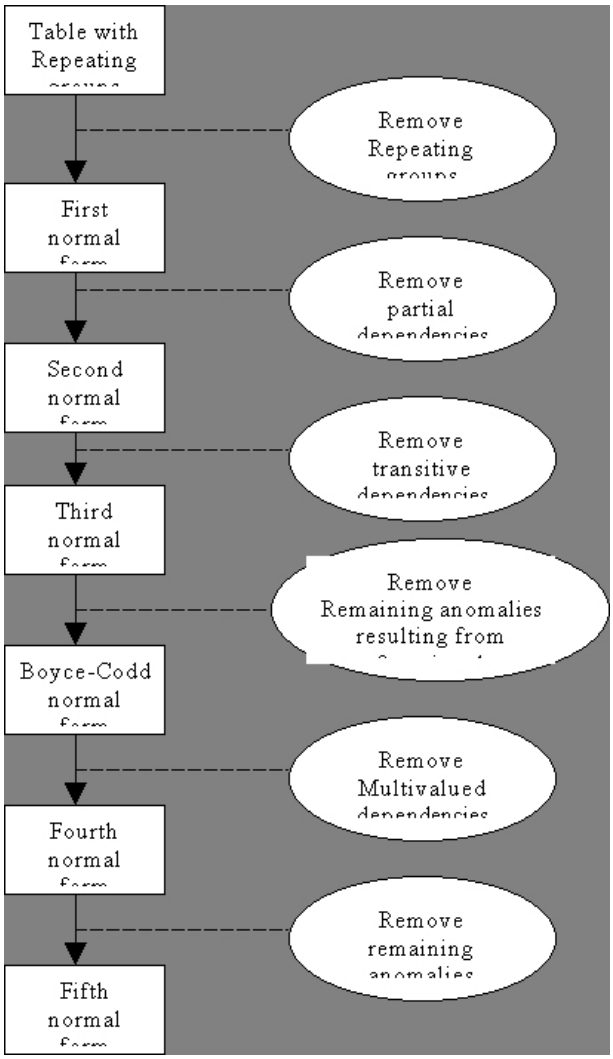

Figure 1. Steps in Normalisation