UNIVERSITY OF SOUTHERN QUEENSLAND

AN EXAMINATION OF FACTORS INFLUENCING BRUNEIAN SECONDARY TEACHERS' USE OF INFORMATION AND COMMUNICATION TECHNOLOGY IN TEACHING: A SURVEY EXPLORATION

A Dissertation submitted by

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ABSTRACT

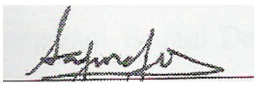
Examining teachers' attitudes/perceptions and their influence on behaviour can be an important step in understanding the psychosocial factors affecting teachers' use of Information and Communication Technology in teaching. This study attempted to provide such an understanding by elaborating Ajzen's theory of planned behaviour (TPB), a widely applied psychosocial theory in modeling behaviours. Basically, TPB explains a behaviour as a consequence of *attitude towards the behaviour, subjective norms*, and *perceived behavioural control.* These three direct factors of TPB are, in turn, influenced by salient beliefs or indirect factors: *behavioural, normative*, and *control beliefs,* respectively. In this study, the TPB was modified by (1) decomposing each of the three types of beliefs into two dimensions respectively, and (2) incorporating external variables – *age, sex, subject taught, teaching experience, teaching period, qualification, level of class, classroom access, and computer laboratory access.* Using these predictor variables, an Information and Communication Technology Use Model (ICTUM) was developed for assessment and comparison in performance with the TPB.

Using a survey questionnaire, data were collected from a total of 1,040 secondary school teachers in eighteen government schools in Negara Brunei Darussalam. Structural equation modeling, using AMOS 5.0 software, was employed as the major statistical analytic technique for a series of data analyses: measurement model assessment for validity and reliability tests; and assessments of the models, ICTUM and TPB.

The proposed model, ICTUM, was found to fit only marginally and the modification efforts through beliefs decomposition and external variables incorporation provided only a small increase in the amounts of variance explained by the predictor variables. However, the TPB model of direct factors was found to be a good-fitting model showing *attitude towards behaviour*, and *perceived behavioural control;* as predictors of *intention*; and *intention* as a stronger predictor of *use of ICT* than *perceived behavioural control*. By demonstrating the significance of those factors as predictors of *intention* and *use of ICT*, this study suggests that augmenting teachers' positive attitudes towards the use of ICT and supporting them technically and personally could encourage teachers to increase the use of ICT in their teaching. This study also suggested a need for future research on the direct influence of salient beliefs on *intention,* and behaviour (*use of ICT*) respectively. Although the TPB model is theoretically and statistically justifiable, further testing with different samples is required. Through its use of a theoretical and statistical modeling approach, the current study represents an initial step towards uncovering fundamental mechanisms that explain teacher use of ICT in teaching.

Certification of Dissertation

I certify that the ideas, experimental work, results, analyses, software and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.



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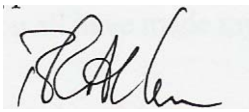
ENDORSEMENT



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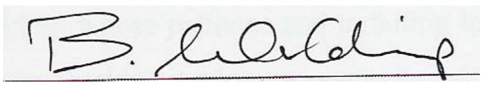

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I dedicate this dissertation to my mother whose unceasing prayer, motivation and inspiration encouraged me to complete this long journey, and to my beloved husband and children whose patience and unfailing love have accompanied me throughout this journey and making it a joyous one.

ABBREVIATIONS

ACOT	- Apple Classroom of Tomorrow
AMOS	- Analysis of Moment Structures
ASEAN	- Association of South East Asian Nations
BATT	- Beliefs About Teaching with Technology
BECTA	- British Educational Communication and Technology Agency
BIT	- Brunei Information Technology
CDD	- Curriculum Development Department
CD-ROM	- Compact Disk Read Only Memory
CFA	- Confirmatory Factor Analysis
EFA	- Exploratory Factor Analysis
FRSS	- Fast Response Survey System
ICT	- Information and Communication Technology
ICTE	- Information and Communication Technology in Education
ICTUM	- Information and Communication Technology Use Model
IT	- Information Technology
MOE	- Ministry of Education
NCES	- National Center for Education Statistics
SEM	- Structural Equation Modelling
SPSS	- Statistical Package for Social Science
TAM	- Technology Acceptance Model
TLC	- Teaching, Learning, and Computing
TPB	- Theory of Planned Behaviour
TRA	- Theory of Reasoned Action
UTAUT	- Unified Theory of Acceptance and Use of Technology

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Chapter 1 INTRODUCTION

This chapter describes the background and purpose of the study, the theoretical framework underpinning the study, the aims and research questions, and justification and significance of the research. The last section outlines the organization of the chapters.

1.1 Background Information

Brunei Darussalam is one of the ten-member nations of the Association of South East Asian Nations (ASEAN). It is located on the island of Borneo surrounded by the Malaysian states of Sarawak in the east and Sabah in the west, and the Indonesian territory of Kalimantan in the south. The north part of Brunei faces the South China Sea.

Brunei Darussalam has a land area of 5,765 sq. km. It is divided into four districts: Brunei-Muara, Tutong, Belait and Temburong. The capital of Brunei, Bandar Seri Begawan is located in the Brunei-Muara district.

Currently, there are twenty-six government secondary schools. Seventeen are located in Brunei-Muara district, four schools are in Tutong, four schools are in Belait, and one school is in Temburong. Of the seventeen secondary schools in Brunei-Muara district, three are at college level catering for students attending pre-university level.

By the year 2000, Brunei had an estimated population of 338,400 comprising 3.5% adults aged sixty-five years old and above, 32.2 % youth aged below fifteen years old, and 64.3% aged between fifteen and sixty-four years old. In the same year, the population of school goers comprised 57,643 at primary level and 33,372 at secondary level, while the population of teaching staff were 3,899 primary teachers, and 2,738 secondary teachers (Brunei Darussalam, 2000).

Information and communication technology (ICT) in education is relatively recent in Brunei Darussalam. Twelve schools were furnished with five computers each for teaching a new subject called computer studies in 1984 (Jahrah & Maawiah, 1989). Computer studies were officially incorporated into the secondary school curriculum as an elective subject in 1986, and were later offered as an examination subject in the Brunei Cambridge Ordinary Levels (taken towards the end of year 11) in 1994, and in the Lower Secondary Examination (taken towards the end of year 9) in 1997.

As part of a national ICT initiative, which launched the IT 2000 and Beyond master plan, an e-education master plan was also launched. Through the e-education master plan, an Education Information System was developed for all education institutions in Brunei in 1997 (Abdul Ghani, 2002) and the Department of Information Communication Technology was set up in the Ministry of Education (Department of Planning Development and Research, 2000). Among the roles of the Department of ICT were to promote the use of ICT in all aspects of education through ICT incorporation across the curriculum, and to oversee the development and progress of the ICT implementation project.

Through the Department of ICT, the Brunei government has embarked on several e-Education Projects (see Abdul Ghani, 2002). One of the projects is the Physical and Technological Infrastructure Development Project whereby each of the one hundred and twenty-three primary and twenty-six secondary schools has been equipped with a networked multimedia computer laboratory. The Internet for Schools Project that established Internet connectivity for every primary and secondary school was started in 2002 and is still in progress. As a component of the Integration of ICT into the Curriculum Project, teachers from secondary schools and colleges were selected to attend in-service training on the use of ICT in education (Ministry of Education, 2000).

1.2 Purpose of the study

The government secondary schools in the country are now ready in terms of infrastructure to incorporate ICT and teachers have been given in-service training for ICT incorporation and implementation. The Ministry of Education (MOE) has encouraged schools to move forward and incorporate ICT in education more thoroughly. However, are teachers ready to implement ICT in their teaching? After all, it is the teacher who plays an important role in making decisions about what to teach and how to teach it (Budin, 1991) and they are the ones who will use technology in classrooms.

Preliminary surveys on Bruneian science teachers' state of readiness in terms of attitude and competence in using information technology in teaching science showed that most teachers have positive attitudes towards ICT but did not have the skills to develop their own materials to use ICT in the classroom (Sallimah & Albion, 2002). Moreover, those teachers who were competent in developing their own ICT materials were not confident in using those ICT materials in their teaching (Sallimah & Leong, 2002). The latter study also revealed that teachers require training in the development of teaching materials using ICT as well as mentoring in their use in the classroom. Teachers argued that they were not using commercially prepared materials because of the lack of direct relevance to the topics they taught. The findings from these two preliminary surveys (Sallimah & Albion, 2002; Sallimah & Leong, 2002) appear to indicate that the Bruneian teachers' state of readiness for using ICT may impede the use of ICT in their teaching.

Moreover, it is crucial for the MOE to understand how ICT is perceived and used by teachers and how their perceptions are associated either positively or negatively with the actual use. Knowledge of such information is necessary in the early implementation of ICT in schools, since it helps encourage teachers to use ICT in teaching.

Most previous studies merely describe teacher characteristics and frequency of usage of ICT. As ICT significantly changes the teaching and learning environment, there is a need for studies that will not only provide such superficial information but also identify psychological mechanisms that explain the factors affecting the use of ICT. So far, few attempts have been made to discern psychological mechanisms that underpin teacher ICT use. Therefore, the purpose of the current study was to take a rigorous theoretical approach to identify the psychosocial factors influencing ICT use in the classroom.

1.3 Theoretical Framework, Aims and Research Questions

The purpose of this study was to develop and assess a theoretical model that could predict and explain teachers' use of ICT by focusing on psychosocial factors. To serve this purpose, a widely applied psychosocial theory, theory of planned behaviour (TPB) (Ajzen, 1985) was examined and elaborated. A brief review of TPB is provided below.

The TPB is considered an appropriate theoretical framework for the current study because of its unique approach to examining behaviour and its wide applicability in behavioural studies. In contrast to most theoretical models that use context-specific variables for explaining behaviour, the TPB approach uses a parsimonious set of three common factors that could explain most behaviours. The three common factors are (1) an individual's attitude toward a behaviour, (2) his/her perceptions of social pressure relevant to the behaviour, and (3) his/her perceived ability to control the behaviour. These attitudes and perceptions are respectively influenced by three distinctive beliefs determinants namely, behavioural, normative, and control beliefs.

The current study assumes that the three distinctive beliefs that serve as the motivating factors for teacher use of information and communication technology in teaching are: (1) teaching and learning benefits teachers would expect from using the technology (that is, *behavioural belief*); (2) teachers' significant others' expectation of their use of ICT (that is, *normative belief*); and (3) both perceived factors that would enable them to use ICT effectively in teaching **and** the perceived availability of those factors at their control (that is, *control belief*). These three fundamental beliefs were adopted to develop a theoretical model (based on the TPB) that explains teacher use of ICT in teaching.

The general competency of the TPB in modeling human behaviour has been demonstrated by studies that adopted the theory (Ajzen, 1991; Armitage & Conner, 1999, 2001; Conner & Armitage, 1998; Sutton, 1998; Taylor & Todd, 1995). However, some researchers contended that those three fundamental belief determinants of behaviour are necessary yet not sufficient, and suggested for a need for refinement of the theory (Ajzen, 1991; Conner & Armitage, 1998; Sutton, 1998; Taylor & Todd, 1995). The following discussion briefly illustrates two methods of modification, which were incorporated into the proposed model for the current study.

The first modification was to incorporate external variables into the TPB. Previous studies identified some external variables that have influence on teachers' use of ICT but how those variables may be related to other influencing factors that also have influence on teachers' behaviour has not been investigated. Based on previous research, the external variables incorporated into the model are: age (Braak, 2001;

Meredyth, Russell, Blackwood, Thomas, & Wise, 1999), (2) sex (Braak, 2001; Mathews, 2000; Meredyth et al., 1999; Yuen & Ma, 2002), (3) subject taught (Braak, 2001), (4) teaching experience (Mathews, 2000), (5) teaching periods per week, (6) highest qualification (Granger, Morbey, Lotherington, Owston, & Wideman, 2002; Mathews, 2000), (7) class level taught, and (8) computer access (Matthews, 2000; National Centre for Education Statistics, 2000).

The second modification was to elaborate the TPB by further specifying the three respective types of beliefs into two dimensions by a method of decomposing each type of beliefs (Taylor & Todd, 1995). The original TPB operationalises the beliefs structures as expectancy-value dimensions and uses the method of multiplicative composites (the product of the expectancy-value measures) to assess the total effect of the beliefs determinants. However, arguments on the weakness in this statistical means (Ajzen, 1991 Hankins, French & Horne, 2000; Taylor & Todd, 1995) have prompted the current study to use the methodological means (decomposition of beliefs) to rectify the problem.

By incorporating the above two modifications (that is, inclusion of external variables and decomposition of beliefs), the current study proposed an information and communication technology use model (ICTUM), an adapted model of TPB (Figure 1.1). Therefore, the aims of this study were to test the proposed research model, ICTUM's ability in predicting and explaining teachers' use of ICT in teaching, and compare its performance with the original TPB.

The following specific research questions were formulated to achieve the aims of the current study:

1. How do the direct factors (teachers' attitudes, subjective norms, and perceived behavioural control) predict and explain teachers' intention, and behaviour for the use of ICT in their teaching?
2. How do the indirect factors (behavioural beliefs, normative beliefs, and control beliefs) relate to the respective direct factors (teachers' attitudes, subjective norms, and perceived behavioural control) of ICTUM and together explain teachers' intention and behaviour for the use of ICT in teaching?
3. How do the external factors (*age, sex, subject taught, teaching experience, teaching periods, qualification, teaching level, class access, and computer laboratory access*) predict and explain teachers' intention and behaviour for using ICT in their teaching?
4. How does the ICTUM perform in comparison to the TPB model in explaining teachers' intention and use of ICT in their teaching?

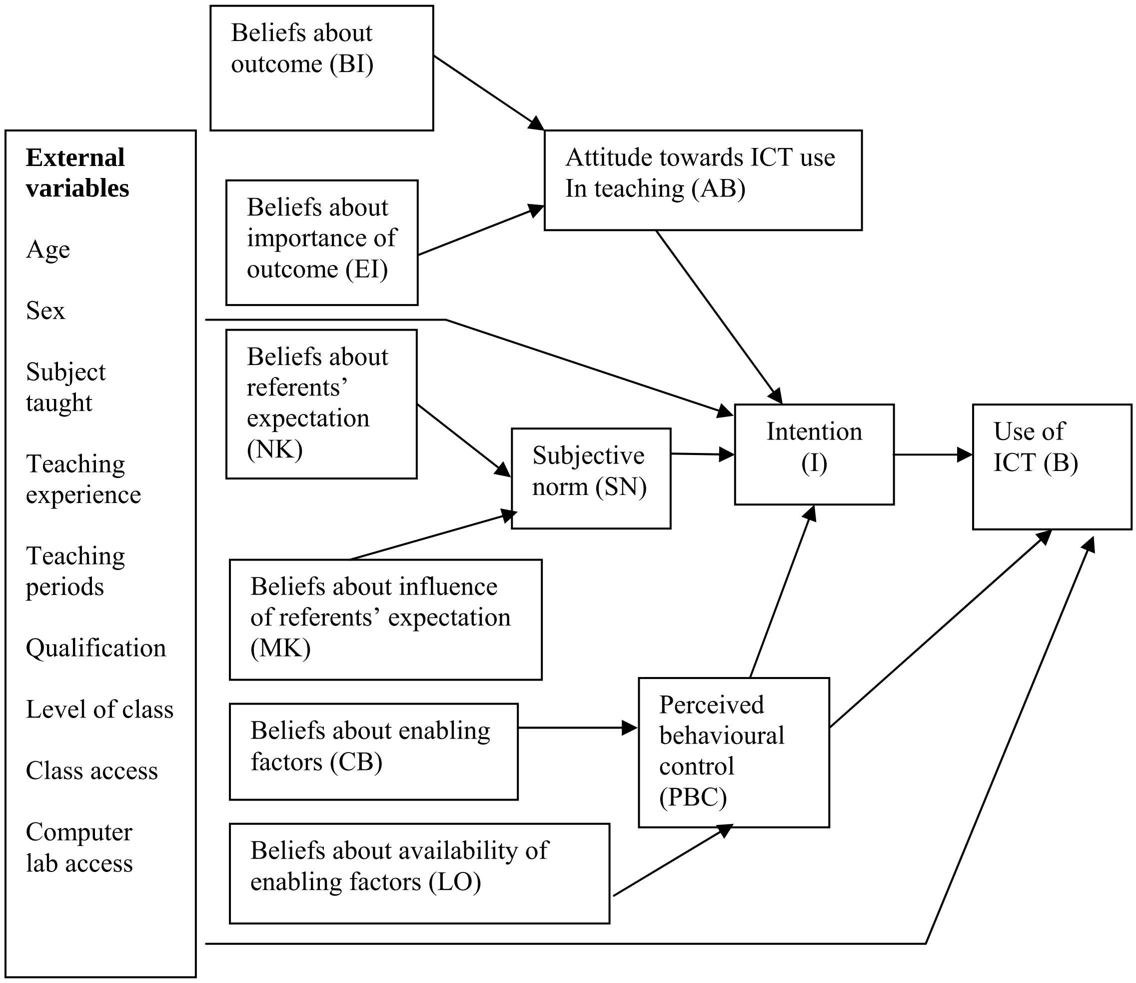

Figure 1.1. The Information and Communication Technology Use Model (ICTUM): The Proposed Research Model.

1.4 Justification for Research

Research into teachers' attitudes, beliefs, competence, and inhibitions in relation to their use of technology maight provide answers to a series of questions from administrators that relate to teachers' classroom implementation of ICT. For example, how can teachers be supported in becoming more confident, competent and effective in implementing ICT in their teaching? What do teachers find most effective in their use of technology in teaching? What persuades teachers to commit themselves to use ICT when their time is constrained by the curriculum demands and syllabus?

The rapid development of computer and communication technology will have an impact on teachers' use of ICT. For example, students can now access the Internet from their home computers, which have the potential to reduce the barriers of classroom instruction and provide teachers with many new opportunities for instruction. It is likely that these opportunities will require teachers to change their classroom practices. Furthermore, such pressures may affect teachers' attitudes towards technology and their perceptions of its usefulness in the classroom.

There are now requirements for Bruneian teachers to use ICT in their lessons (see Suriani, 2002) but evidence from previous research (e.g. Sallimah & Leong, 2002) has shown that many teachers are not yet ready. Therefore, it is important to examine what factors determine teachers' use of ICT in their teaching. Based on a widely applied theoretical model, the current study proposed a modified version of the model in an attempt to examine how psychosocial factors might influence teachers' ICT use.

1.5 Significance of Research

Empirical research relating to ICT in secondary education is lacking in Brunei. This study will form a basis for more local research and research in other contexts to be conducted. For instance, significant factors may be identified in this study that may be further investigated in future research.

Most existing findings about ICT integration in education are from Western nations. This study will provide empirical evidence from a non-Western country of different culture and values. The findings will contribute to the scholarly cross-cultural research and literature in the field of ICT integration in education by providing a basis for understanding the extent to which research conducted elsewhere may be applied in the Bruneian context.

This study will also provide a foundation for discussion among administrators whose pedagogical and curricular decisions have not been informed by local empirical evidence. For instance, the study will reveal factors that might be significant and most easily influenced for mounting an effective teacher development programme that might promote teacher use of ICT.

Subsequently, this study will have the potential to inform classroom practice among secondary teachers about factors that drive teachers' decisions about ICT use and consequently will inform relevant authorities such as school principals and the heads of the ICT departments about providing development and support to increase the driving forces and reduce the barriers.

The TPB is a useful model for providing a framework for predicting and explaining behaviours and a guideline for intervention purposes that would produce effective behavioural change (Fishbein, 1997). From the perspective of the theory of planned behaviour, this study expands the applicability of the theory to studies of ICT use in the classrooms. The elaborated TPB model, ICTUM would be used as a specific theoretical framework for the purpose of identifying factors that can be used for designing intervention or mounting professional development workshops for ICT implementation that will effectively induce change in teachers' behaviour. Furthermore, the study sought to test the adequacy of the elaborated TPB model, ICTUM, by adding the external variables and decomposing the belief structures. This research therefore breaks new ground.

1.6 Terminology

In this study, information and communication technology (ICT) is defined as an information technology that utilizes computer systems. Considering that ICT use mostly involved the use of information technology (IT), this study assumed that the variables important to IT use may be also important to ICT use as well.

The use of ICT in teaching referred in this study involves teachers' use of the computer, Internet and other related IT that allows the dissemination of information and knowledge through intra- and extra-connected computers, as well as educational software for the purposes of teaching and learning. Hence the terms computer technology, IT and ICT will be used synonymously and interchangeable.

1.7 Overview of Chapters

The subsequent dissertation chapters are organized as follows: **Chapter two** describes the status quo of ICT in education in Brunei Darussalam, the current practices of computer technology use, particularly focusing on the factors influencing teachers' uptake of ICT and the reasons for its use or under-use in the classrooms, and teacher personal factors affecting its use. **Chapter three** includes a discussion of the theoretical framework on TPB and a few other theoretical efforts in two other research areas: information technology use and educational technology use. **Chapter four** conceptualizes the research constructs and develops the theoretical model to be investigated in the study. The theoretical propositions and research hypotheses are in presented in the same chapter. **Chapter five** delineates the research methodology, including the study setting, population, data collection instrument and procedure, research design, operationalization of the research variables, and the planned statistical analyses. **Chapter six** discusses the procedure for preparing the data for analyses and the assessment of the measurement model. **Chapter seven** presents the findings of the current study, which includes the assessment of the research propositions by testing the research hypotheses. **Chapter eight** presents the discussions and conclusions drawn from the research findings, implications, limitations and strengths of the current study, and suggestions for future research.

Chapter 2 AN OVERVIEW OF COMPUTER USE AND FACTORS INFLUENCING USE OF ICT

This chapter reviews the related literature on the use of computers and information and communication technology (ICT) in the classroom in order to describe the research context of the current study. The chapter consists of four sections: the first section describes the status quo of ICT in education in Brunei; the second section reviews the literature that describes the current practices of computer technology and ICT use in the classrooms; the third section reviews the literature that provides explanations for use or under-use of computers and ICT and the fourth section examines the literature that empirically investigates the personal factors influencing teachers' use of ICT.

2.1 The Status Quo of Information and Communication Technology in education in Brunei Darussalam

In Brunei, ICT in education or e-education has been established only recently as one of the focal points of the e-education master plan drawn up by the Brunei Darussalam National Information Technology (BIT) council (Abdul Ghani, 2002). The goal of the e-education master plan is to produce an ICT literate workforce who will acquire thinking, learning and communications skills to meet the challenges of economic globalisation and trade liberalisation. The other goal is to develop ICT competency among the young generation so that they can contribute to the economic well being of the country.

In order to meet the second goal of the e-education master plan, three stages of ICT implementation projects have been launched. The first stage was the development of physical and technological infrastructure. This stage comprised two phases of ICT integration into the curriculum projects for primary and secondary schools respectively where all schools were provided with multimedia personal computers, and a single phase of Internet for schools project where Internet connectivity for all primary and secondary schools was established. Under the three phases of the ICT integration projects, all primary and secondary schools were equipped with networked multimedia computer systems in computer laboratories.

The second stage involved the development of skills in ICT for key personnel at basic, intermediate and advanced levels in both primary and secondary schools. These key personnel then provided in-service training in the use of ICT in education for all teachers as part of in-house training.

The third stage involved the development of a support infrastructure. This stage is an on-going process with some of the projects still at the preparatory stage while others are still in-progress. For instance, collaborative efforts among the local university, the Curriculum Development Department (CDD) and private institutions to introduce curriculum innovation for the enhancement of learning through the use of ICT to pre-service and in-service teachers are still at the preparatory stage. Examples of on-going projects are the setting up of a national framework to support the development of multimedia tools and products tailored to the curriculum in Brunei Darussalam, and the establishment of a national network for advice and support for schools to develop their own technology implementation plan.

Through the e-education master-plan for ICT implementation projects, schools are now equipped with computers and are connected to the Internet to fully utilise ICT in education (Ministry of Education Permanent Secretary's speech reported in Brudirect.com News, 2003). The Ministry of Education has established the Department of ICT to oversee the incorporation of ICT into the regular curriculum, and to oversee the development and progress of the implementation initiatives (Department of Planning Development and Research, 2000). Similarly, the CDD has also reviewed the existing curriculum and formulated a new curriculum that incorporates ICT across the curriculum (Curriculum Development Department, 2000).

The platform for ICT implementation in education in Brunei is now set, as the government has equipped schools with the required infrastructure for ICT implementation, and empowered schools to fully utilise the facilities, but how do the school authorities prepare teachers for the use of ICT in their teaching? Understanding how teachers would use ICT in the classroom could help school authorities to make the required preparation and management strategies for a successful ICT implementation program. In order to make comparisons, and considering that other countries believed to be at the leading edge of ICT- integrated education began ICT implementation years ahead of Brunei, the literature that deals with how ICT has been used in those countries is reviewed in the following section.

2.2 Trends of Information and Communication Technology Use in the Classrooms

This literature review reports on the trends in two aspects of computer technology and information and communication technology (ICT) use: the frequency of teacher use, and how the technology is being used in the classroom.

Towards the end of the previous decade, research studies showed that the trend of computer and technology use by teachers in the United States progressed from non-use, to occasional use (at least once a month), and to serious use (at least one or more times a week) (Cuban, 1986; Office Of Technology Assessment, 1995). For example, a 40-item questionnaire study of teacher technology use in the classroom conducted in 55 rural schools in southeastern Idaho, USA indicated that 30 percent to 50 percent of the 3,500 teacher respondents never used computer technology for any instructional purpose, over 70 percent of teachers never used the Internet in the classroom, while more than 50 percent of the teachers perceived themselves as novices in the use of technology (Matthews, 1998). This prevailing trend is still apparent in reports on computer technology and ICT use in this millennium (Cuban, 2001; Cuban, Kirkpatrick, & Peck, 2001).

In terms of the ways computer technology is used in the classroom, the trend that emerges from the literature survey is from supportive use, to instructive use and to a combination of both supportive and instructive use. In this review, supportive use of the computer technology is exemplified by teachers who use computer technology to support their current practices such as lesson preparation, drills and practice, management and communication. Teachers who use technology for instruction are characterized by their use of the technology for classroom instruction such as using computer software and ICT for activities that involves higher order thinking such as interpreting data; reasoning; writing; solving concrete, complex, real-world problems; and conducting scientific investigations. Instructive use of computer technology is favourable as it reflects actual implementation initiatives by teachers in using ICT in teaching.

However, reviews of contemporary studies showed that the trend of teachers' use of computer technology is mostly for supportive rather than instructive purposes. One study showed that teachers generally used computer technology to support their existing practices (such as practice drills, demonstration), and for communicative purposes (such as a medium for communicating information) rather than instructive use such as using computer technology for activities that involve higher order thinking (Becker, 2001).

Evidence from the literature reporting the frequency and supportive use of computer technology is provided by the National survey on Teaching, Learning, and Computing (TLC) survey, referred to by Becker (2001) that involved more than 4,000 grade 4-12 teachers in over 1,100 schools across the United States of America. Among the major findings of the survey were teachers' infrequent use of computers in the classroom; occasional assignment to lower-ability classes with computer games, and drills related to the subject area; and providing other students with sophisticated computer software as resources and tools for doing productive and constructive academic work. These findings reflected the supportive use of computer technology rather than using it as an instructional tool for teaching.

Even at a place claimed to be the epicenter of technological innovations (the Silicon Valley in the USA), supportive use of computer technology in the classroom was more prevalent than instructive use. This observation was made by Cuban (2001), who used a combination of case studies, classroom observations, on-site surveys and statistical data to investigate how computers were used in the Silicon Valley K-12 schools. Using empirical data, he demonstrated that teachers mostly used computers to prepare for classes rather than for direct instruction (Cuban, 2001, p. 85), adapted the computer to sustain current practices (Cuban, 2001, p. 97), and used the technology only for managing and communicative purposes (Cuban, 2001, p. 179).

Nevertheless, there is evidence in the literature for the instructional use of computer technology, which is illustrated by a national survey conducted in the USA in 1999, the Fast Response Survey System (FRSS) administered by the National Center for Education Statistics (NCES) to public school teachers. Among the NCES findings was that approximately half of the teachers who had computers or Internet access in the school used them for instruction (U. S. Department of Education National Centre for Education Statistics, 2000). Some of the instructional tasks were assigning students with work with word processing or spreadsheets, Internet research, solving problems, and analysing data. NCES also reported supportive use of computer technology where teachers also used computers or the Internet for lesson preparation, administrative and communicative purposes.

A more favourable trend beginning to emerge in literature is teachers' use of computer and information technology in the classroom that includes both supportive and instructive uses. This trend is illustrated by a more recent survey involving about two thousand teachers by Barron, Kemker, Harmes, and Kalaydjian (2003) in one of the largest school districts in USA. The study indicated that approximately 50 percent of the teachers who responded to the survey revealed that they were using technology as a classroom communication tool while smaller percentages reported that technology was used as a productivity, research, or problem-solving tool.

Whilst the trend of computer and technology use in the United States progressed from non-use and low use to that of use of different types (supportive or instructive), there are some indicators that the trend may be similar elsewhere in the world. For example, in Scotland, Conlon, and Simpson (2003) used data from a major Scottish study, the Impact of ICT Initiatives in Scottish Schools (IIISS) and compared the findings from that study to those of Cuban's (2001) investigations of the infusion of computers into the Silicon Valley (discussed earlier in this chapter). The IIISS study used questionnaire surveys involving 110 primary schools and 110 secondary schools, which was conducted in two phases within the period of two years. From their assessment of the findings from both studies, Conlon, and Simpson (2003) concluded a "large measure of agreement" between the two studies. They concurred with Cuban that teachers mostly have access to computers in their classrooms and computer laboratories but rarely use them for instructive activities. They reported that most teachers use ICT for supportive purposes such as for writing reports, preparing for teaching and other administrative tasks.

Another survey study of teachers from 300 primary and 100 secondary Scottish schools also reported that there was a relatively low use of ICT by both primary and secondary teachers, and that despite the availability of Internet in most secondary schools there was also a relatively low use of the Internet. The study also identified a clear pattern of low and high use of ICT among the secondary teachers where mathematics teachers were low users and teachers in business and management subjects were high users of ICT (Williams, Coles, Wilson, Richardson, & Tuson, 2000).

In Australia, a survey of a representative sample of primary and secondary schools across the country involving about 1,300 teachers, demonstrated irregular and supportive use of computer and technology. The common activities involving the use of computers were getting information from CD-ROM, using an educational program or game to help students learn, getting information from the Internet, or using computerized library catalogue and creative writing (Meredyth et al., 1999). Meredyth et al. (1999, p.340) commented that computers are used only irregularly in the computer laboratory without being integrated into the learning environment but schools that use technology effectively in teaching, engage students in communicating techniques such as e-mail, discussion groups and video conferencing. Further evidence illustrating the supportive rather than instructive use of ICT is obtained from a most recent international study that examines 174 case studies of technology classroom use from 28 countries (Kozma, 2003). In reporting the trends of classroom practice of ICT use in these countries, the study indicated that, teachers used ICT to plan or organize instruction (reported in 26 percent of the cases), and to monitor or assess student work (reported in 22 percent of the cases). Only a small percentage of the cases reported that teachers used ICT to support student collaboration (reported in 17 percent of the cases), or used simulations or modeling software packages for research or experimentation (reported in 13 percent of the cases).

This literature review so far has described the trend of computer technology use in terms of frequency of use and ways of use in the classroom. However, while it is important to identify how computers and other ICTs are used in the classroom and how often, it is more important to find out reasons for teachers' use or under-use, so that remedial or reinforcement initiatives could be put in place. The following section describes the literature that attempts to offer reasons that explain teachers' use or under-use of computers and ICT.

2.3 Reasons for Teacher's Under-use or Use of ICT: Obstacles and Facilitators

Of the published empirical research on teachers' use of ICT in the classrooms, only a few studies attempted to explain the under-use of ICT. An understanding of the source of teachers' resistance to the uptake of ICT is crucial in order to account for the huge investment in funds and time for the implementation of ICT innovation in schools.

An enormous amount of money has been invested to support ICT integration ventures that require massive computer purchases, refurbishment of school infrastructure and Internet connectivity. Extensive amounts of time and effort have also been invested in the endeavour to integrate ICT into the classroom. In fact, Carroll (2000) compared the scale of the school ICT-integration investment to that of the space program.

Computer technology and ICT have also been the focus of curriculum renewal projects and school funding debates and have mobilised many schools into the 21st century. In spite of such focus for ICT initiatives in schools, the computing technologies have had no more than a minimal impact on teaching and learning (Cuban, 1999, 2001) and the computer continues to play a minor role in the classroom unless due attention is given to the school conditions and the required expertise for its use (Cuban, 2001).

Some critics of school technology use the “low teaching and learning impact” situation to support their assertion that technology is not appropriate for use in the classroom while others put the failure on the shoulders of classroom teachers. Different sets of explanations have been offered in the literature to account for the low use of ICT by teachers. Some of the suggested reasons are concerned with conditions of the school, difficulty in adopting the innovation, and teachers’ personal opinions about the technology. Other reasons are related to challenges and obstacles for the uptake of ICT confronting the schools (Cuban, 2001; Granger et al., 2002; Scrimshaw, 2004). However, there are also explanations for successful use of ICT in the classrooms. The following paragraphs describe some possible explanations offered for computer technology under-use and the obstacles to the use, and some reasons for successful implementation of ICT and facilitators to the implementation.

Reasons for under-use of computer technology

Two views on the reasons for computer technology under-use described below are based on contextual perspectives, and teacher personal perspectives.

On the contextual perspectives, three explanations for the under-use of computers and technology were offered by Cuban (2001);

- Slow revolution – technological innovations take time to get people involved and trained;
- Historical, social, organizational, and political context of teaching – the structures and historical legacies of schools make change difficult,
- Contextually constrained choices – teachers still have autonomy in their classroom and make their choices independently.

Acknowledging the constrained choices facing teachers, and their classroom experiences and expertise, Cuban commented that the slow-revolution and history-and-contexts explanations are credible.

On teachers' personal perspectives, Scrimshaw (2004) offered four possible explanations for teachers not using ICT that are related to teachers' personal beliefs and obstacles hindering the uptake of ICT:

- Existence of teachers' views about ICT as being incompatible with their wider educational beliefs.
- Existence of obstacles associated with personal characteristics of teachers, such as lack of computer skills.
- Existence of social obstacles to increase level of ICT uptake, such as lack of support from colleagues.
- Existence of obstacles in school to expand ICT use, such as lack of technical support.

Both explanations are suitable for understanding computer technology under-use at dual levels. The contextually-based reasons explain the trend of under-use at the macro level that is defined by a long term time frame, school-wide use, and involving all stakeholders, whilst the reasons based on teacher personal perspective explain the under-use trend at micro level that is defined by a short or an immediate time frame, classroom use and involving teachers only. However, it is apparent that the reasons suggested at the micro level are similar to those suggested at the macro level. For instance, Scrimshaw's third point about existence of social obstacles on teachers' personal level is related to the Cuban's second point about the historical, social, organizational, and political context of the school. Similarly, Scrimshaw's fourth point about existence of obstacles in schools is related to Cuban's third point about the contextually constrained choices. The similarity is not surprising as factors affecting teacher use of ICT in teaching partly originated from school factors.

Obstacles to ICT implementation

As a means to address the problems of under-use of computer technology, it would be useful to identify the common obstacles confronting ICT implementation initiatives. A useful report on empirical studies on educational practitioners' perceptions of the main obstacles for the integration of ICT in lower secondary education was presented by Pelgrum (2001). Representing an international perspective, the report described a survey among a representative sample of schools in 26 participating countries (comprising of 16 European countries, 5 Asian countries, Canada, Israel, Iceland, New Zealand and South Africa) that was conducted to obtain practitioners' views on the obstacles relating to ICT implementation, ICT-integrated curriculum, staff development for ICT implementation, and ICT management and organization.

In the report, Pelgrum (2001) wrote that the major obstacles for ICT implementation as perceived by educational practitioners were delineated into four material obstacles and six non-material obstacles. Among the material obstacles were insufficient numbers of computers, insufficient peripherals, not enough copies of software, and insufficient numbers of Internet-ready computers. The non-material obstacles were teachers' lack of knowledge and skills regarding ICT, difficulties in integrating ICT in instruction, difficulties in scheduling enough time for students to use computers, insufficient time for teachers, lack of supervisory staff, and lack of technical staff.

Pelgrum (2001) compared the data from the 26 countries and demonstrated that there were correlations between the contextual factors and the educational practitioners' perceptions of the most significant obstacles. For example, there was strong positive association between educational practitioners' perceptions about computer insufficiency as a major obstacle, and actual availability of computers in a country. For instance, countries with low student-computer ratio still had high percentage of the practitioners perceiving a lack of computers as a major obstacle for ICT integration. Practically, this observation implies that there will never be enough computers to support the increasing needs for computer use. Another observation made was the correlation between the lower level of complaints by educational practitioners about the teachers' lack of ICT knowledge and skills as an obstacle, and the availability of ICT support staff in the school for staff development.

In the United Kingdom, Jones (2004) wrote a report on the results of the British Educational Communications and Technology Agency (BECTA) on-line survey of 170 educational practitioners regarding their perceived barriers to the use of ICT. The report outlined a number of barriers to the uptake of ICT that were grouped into teacher level barriers and school level barriers. The teacher level barriers were related to teachers' (1) personal deficiencies such as lack of confidence, and lack of competence (due to lack of time for training, lack of pedagogical training, lack of skill training, and lack of ICT focus in initial teacher training); (2) resistance to change and negative attitudes, (3) anxiety, (4) inequalities such as age and sex differences, and (5) lack of perceptions of benefits of ICT use.

The school level barriers were identified as (1) lack of time scheduled by schools for teachers to use ICT, (2) lack of access to resources (due to lack of hardware, poor organization of resources, poor quality of hardware, inappropriate hardware, lack of personal access for teachers), (3) technical problems (fear of things going wrong, lack of technical support), and (4) impact of public examinations.

The BECTA study indicated that there were interrelationships between each of the identified barriers to ICT use; for example, teachers' confidence is directly affected by other barriers such as personal access to ICT, availability of technical support, and the amount of training.

In general, although the two reports used different terms such as material/non-material obstacles; and teacher/school level barriers, the trends of obstacles or barriers to technology use appear to be common across the countries, and that the obstacles are inter-related.

Facilitators to ICT implementation

Coupled with knowledge on obstacles to ICT implementation, knowledge of enabling factors is also necessary in order to better promote the use of ICT in teaching. The worthiness of acquiring such information was proven in BECTA study that indicated simultaneous knowledge about obstacles and barriers to ICT implementation at whole school and individual teacher levels would reveal the patterns of matches and mismatches between a school and an individual teacher's requirement. Such knowledge provides a framework that could be used to better understand teacher needs and the chance of the school providing them.

The BECTA study produced two simultaneous reports on teachers' implementation of ICT. In conjunction with the BECTA report (Jones, 2004) on barriers to teachers' use of ICT, Scrimshaw (2004) wrote a report on another BECTA study on enabling factors that were most effective in encouraging teachers to use ICT. The study used evidence from literature sources that recommended the effective ways to overcome the barriers (Jones, 2004) and from an on-line survey of practitioners' views of factors that facilitated or enabled them to integrate ICT in their teaching.

Factors encouraging teachers to integrate use of ICT in the classrooms were categorized as (1) individual level enablers (such as access to own personal laptop, availability of high quality resources, unlimited access to software and hardware, high level of technical support, access to an interactive whiteboard, and availability of good quality training) and, (2) whole school level enablers (such as on-site technical support, programme of staff ICT training, support from senior management, whole school policies on ICT use across curriculum, provision of interactive whiteboards in all classrooms, and effective timetabling of rooms and equipment and access to resources). Three other categories of enablers were also identified as follows:

- ensuring awareness, capability and confidence in teaching to use ICT,
- ensuring the required access to reliable systems,
- emphasising the educational benefits of using ICT.

Identification of factors promoting the use of computer technology and ICT and the reasons for their success are important for reinforcement and further development in ICT integration.

Reasons for successful implementation of ICT

Perhaps the most appropriate example to illustrate a successful implementation of technology in the classroom is the decade-long Apple Classrooms of Tomorrow (ACOT) project. The ACOT project was able to provide solid evidence that successful implementation of technology requires the following four key conditions (Sandholtz, Ringstaff, & Dwyer, 1997):

- Teachers need to confront their beliefs about learning and the efficacy of different instructional activities.
- Technology should be viewed as one of the many tools for instruction, and have little influence unless it is integrated successfully into a meaningful curricular and instructional framework.
- Teachers need to work in contexts that support risk taking and experimentation, and that provide collegial sharing and ongoing professional development.
- The process of technology integration should be viewed as a catalyst for change, and the process is long-term and challenging.

In Canada, Granger et al. (2002) interviewed teachers and principals in four schools. They identified three emerging conditions that supported successful use of ICT in teaching and learning, based on social perspectives. The conditions were:

- informal ICT education or "just-in-time" learning where teachers gain more knowledge about ICT during informal discussions or Internet surfing than formal workshops on ICT,
- supportive and collaborative relationships among teachers,

- commitment by the school community to pedagogically sound implementation of new technologies, and administrative encouragement especially by the principal.

From the above review, the enabling factors for ICT implementation and the reasons and conditions for the success of implementation appear to rest upon the teacher and school at large. It becomes clear that the teacher plays a particularly important role for accomplishing and achieving the tasks and goals of ICT implementation programs. In the following section, empirical studies that focus on investigating personal factors influencing teachers' uptake of ICT are reviewed and discussed.

2.4 Personal Factors Affecting Teacher's Use of ICT

Mumtaz (2000) reviewed the literature from the past twenty years (1980 to 2000) on factors that affect teachers' use of ICT and distinguished five major topics examined in the literature: (1) factors that discourage teachers from using ICT, (2) schools as organizations, (3) factors that encourage teachers to use technology, (4) the role of teacher in the ICT environment and its effect on pedagogy, and (5) teachers learning to integrate technology into their teaching. From her extensive review of those topics, Mumtaz concluded that three interlocking factors affect teachers' uptake of ICT: the institution, the resources and the teacher.

First, the school as an institution did not allocate ample time for teachers to manage time for ICT implementation, and did not provide a supportive network for teachers to use ICT. Second, the limited resources (such as lack of computers and software in the classroom) impeded the take-up of ICT to a desirable level. Finally, the teacher personal factors that influence the use of ICT in the classroom were numerous and grouped as follows:

- The personal factors including teachers' beliefs and attitudes, commitment to professional learning, and background in formal computer training.
- The social factors including influences from the principal, colleagues, support and collegiality of school, school and national policies,
- The external factors including the availability of resources, access to resources, quality of software and hardware, and ease of use.

Other studies that provide further evidence for the influence of the each of the above three factors on using ICT are described below.

Personal factors: Beliefs and Attitudes

The importance of considering teachers' beliefs about implementation of any educational initiative has been emphasized because teachers' beliefs are 'a critical ingredient in the factors that determine what happens in the classrooms' (Tobin, Tippins, & Gallard, 1994, p. 64). In fact, Mumtaz (2000) concluded that teachers' use of ICT in teaching was mainly influenced by their personal beliefs and theories about teaching and teachers needed to be given evidence that supported the usefulness of ICT in order for them to implement ICT in teaching.

Several studies investigating the influence of teacher beliefs on implementation initiatives corroborated the above conclusion. For example, findings from Haney, Czerniak, and Lumpe's (1996) research study on the influence of teachers' salient beliefs as one of the factors that influence teachers' implementation of a Competency Based Science Model into their classroom instruction, provided support for the notion that teachers' beliefs were important for determining their behaviour. Other evidence showed that teachers' beliefs about curriculum and instruction were important in the implementation of educational reforms such as using educational technology in the science classroom (Czerniak, Lumpe, Haney, & Beck, 1999), and using thematic units in science instruction (Czerniak, Lumpe, & Haney, 1999).

Research has also shown that teachers' beliefs are one of the important factors affecting teacher computer or ICT use. For example, Norton, McRobbie, and Cooper's (2000) case studies of five mathematics teachers showed that the use of computers in mathematics teaching was almost nonexistent despite the availability of computers for the mathematics staff. The study identified that the low levels of computer use were related to (1) teachers' personal factors such as beliefs about time effectiveness (that is, using a computer was time consuming and not time effective), (3) teachers' focus on completion of the syllabus, and (3) the drive for students passing examinations being more important to meet their educational goal than using computers.

In terms of the influence of teachers' attitudes on the use of ICT, Williams et al. (2000) found significant correlation between levels of use of ICT and teachers' attitudes. They also found that when attitude and use were analysed together, mathematics and science teachers tend to show more negative attitudes and lower use of ICT, followed by language teachers, while business and management teachers tend to have a more positive attitude and use more ICT.

More empirical studies based on a theoretical framework are needed to investigate further the influence of teachers' beliefs and attitudes on their ICT uptake and use.

Social factors

Studies cited the impact of social factors on classroom computer use. Teachers tend to comply with the social expectation of significant others' (such as principal, colleagues, students and professional body) opinion, termed subjective norm, with regard to computer use in teaching (Marcinkiewicz & Regstad, 1996). This means that teachers will not be motivated to use computers if they perceive that the significant others think it is not necessary or desirable to use computers. For example, Czerniak et al. (1999) indicated that teachers' enhanced uses of educational technology in the science classroom were influenced by their colleagues, parents, and community members.

Other studies showed that teachers would sustain their use of ICT in the individual subject if there was support from colleagues (Preston, 1999), senior staff (Norton et al., 2000) and principal (Mulkeen, 2003). Similarly, Kim (2000) found that teachers' sense of obligation resulting from the social environment was an important factor that lead to teachers' use of ICT.

Similar findings on the importance of social influence on use of technology was provided by Karahanna, Straub, and Chervany (1999) who showed that social environment (such as peer group and management pressure) was the only significant factor influencing potential users to use technology, besides being influenced by their voluntariness (the degree to which they perceived their use of ICT to be voluntary) and their attitude towards the technology itself.

Although evidence for the influence of social factors on teacher use of ICT is supported in literature, further examinations of the influence on a theoretical basis is required since increased understanding would help in building better social support for teacher use of ICT.

External factors

There are few studies that specifically examine the influence of external variables such as demographic characteristics on teacher computer or ICT use in teaching. However, one research study involving 236 teachers from Belgium secondary schools, investigated the relationship between class computer use and external variables such as sex and gender; and teacher individual characteristics such as teachers' technology-related subject, general computer attitudes, attitudes toward computers in education, technological innovativeness, and general innovativeness (van Braak, 2001). With regard to sex and gender, the research findings were that sex differences were related to class use of computers and that male teachers made more use more of computers in class than female teachers, and age was not significantly related to the dependent class use of computer variable.

In another study, Yuen and Ma (2002) administered a questionnaire survey to 186 pre-service teachers in Hong Kong and found significant sex differences with regard to the influence of perceived usefulness and perceived ease of use of computers on pre-service teachers' intention to use computers as follows;

- Perceived usefulness influenced intention to use computers more strongly for females than males.
- Perceived ease of use influenced intention to use computers more strongly for females than males.
- Perceived ease of use influenced perceived usefulness more strongly form males than females.

Other external factors reported to have influence on use of ICT were reported by Williams et al. (2000) who used questionnaire surveys involving 300 primary schools and 100 secondary schools in Scotland. They found that some of the factors inhibiting secondary teachers' use of ICT are their lack of skills and lack of familiarity with Internet and lack of availability for Internet access.

Czerniak et al.'s (1999) survey involving 250 private and public school teachers in Ohio, U.S.A. found that external factors such as availability of resources, support for use of technology, and opportunities for staff development would enhance their use of educational technology.

Most of the above studies survey demographic characteristics of teachers and describe their personal factors that influence their use of ICT. However, those studies fail to demonstrate, using a psychosocial theoretical approach, how the demographic characteristics and personal factors influence and explain teachers' uptake of ICT from the teachers' perspectives.

An accurate understanding of how the demographic characteristics of teachers may influence their thoughts about ICT use and how these thoughts influence their decisions to use ICT may be useful to motivate teachers. However, knowledge of the demographic characteristics alone may not be enough because such characteristics change with the rapid development of ICT in education. Moreover, there may also be other factors associated with the demographic characteristics that may influence use. Therefore, a comprehensive approach where psychological variables are simultaneously considered is required.

To provide an adequate explanation, there is a need for a study that investigates teachers' psychological attributes associated with computer use. In such a study, what beliefs and attitudes are involved in determining teacher ICT use, how teachers perceive use, how those perceptions and attitudes are associated with actual use, and how demographic characteristics are related to their use, should be examined.

2.5 Summary

This chapter reviewed previous literature on teachers' use of computers and technology, or ICT, in order to understand the current status of their use. Research showed low use of computers and technology. They were mostly used as a tool for supporting teachers' existing practices and only occasionally were used in classroom instruction. Research also showed that due to multiple factors, teachers had been minimally successful in implementing ICT in their teaching. Some studies offered some explanations for the under-use of computer and technology while others suggested some factors that influence teachers' uptake of computers and technology. However, the literature failed to offer a comprehensive theoretical basis for explaining how those factors affect teachers' uptake of ICT. As a way to provide better support for teachers' use of ICT, systematic knowledge about teachers' perceptions and their current use should be provided. Thus, relevant theoretical frameworks that help to understand teachers' perspectives about the use of ICT will be reviewed in the following chapter.

Chapter 3 THEORETICAL FRAMEWORK

This chapter reviews the theoretical framework that would help to investigate Information and Communication Technology (ICT) use from the teachers' perspectives. The theory of planned behaviour (TPB) (Ajzen, 1985, 1988, 1991) has been selected as the baseline model on which a research model of teachers' use of ICT in teaching, the Information and Communication Technology Use Model (ICTUM) was developed for this study. This review includes literatures on both theoretical and empirical investigations of the behaviours of teachers' classroom use of ICT, information technology and educational technology, which are used synonymously in this review. The literature that deals with the characteristics of the TPB, and that adapted the TPB as the theoretical approach to explain those behaviours is reviewed in the first section. In order to develop the theoretical model, ICTUM for the current study, it is necessary to identify specific behavioural characteristics of teachers for their classrooms use of ICT. Therefore, different approaches to modification of the TPB by various studies are reviewed in the second section. The last section reviews educational research studies that use TPB as the theoretical framework for explaining teachers' intentions and behaviours.

3.1 Ajzen's Theory of Planned Behaviour

A research model adapted from a widely applied theory of social psychology, the theory of planned behaviour (Ajzen, 1985, Ajzen, 1991) is particularly chosen as a useful theoretical framework as a basis for this study as it is a research model that employs psychosocial factors to predict and explain behaviour in specific contexts (Ajzen, 1991, p. 181), is capable of identifying the beliefs linked to implementation behaviour (Haney et al., 1996) and the operationalization of the research constructs is easy and simple (Sutton, 1998).

3.1.1 Direct, indirect and external factors of Theory of Planned Behaviour

Ajzen's theory of planned behaviour (TPB) consists of a set of parsimonious variables that attempt to explain social behaviours. The TPB is an expansion of the theory of reasoned action (TRA) (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). TRA prescribes that execution of volitional behaviours can be predicted by attitudes toward the behaviour, and the influence of significant others, mediated by intentions to perform (or not perform) the behaviour. TPB expands the TRA by extending an additional predictor, perceptions of control over performance of the behaviour (Ajzen, 1988; 1991). Hence, the TPB prescribes two layers of antecedents that explain social behaviour or behavioural intention: the direct factors and indirect factors.

TPB Direct Factors

According to the TPB (see Figure 3.1), three direct factors are required to predict behaviour (B) and behavioural intention (I). The first factor is *attitude towards the behaviour* (AB), which is a personal factor that refers to the degree to which a person has a favourable or unfavourable evaluation or appraisal of the particular behaviour. The second factor is *subjective norm* (SN), which is a social factor that refers to the perceived social pressure to perform or not to perform the behaviour. The third factor is the degree of *perceived behavioural control* (PBC), which refers to the perceived ease or difficulty of performing the behaviour.

The theory postulates that these three direct factors (AB, SN, and PBC) influence the individual's *intention* to perform a given behaviour (I), and *intention* together with *perceived behavioural control*, in turn; influence the individual's actual *behaviour*

(B) (Ajzen, 1988; Ajzen, ; Ajzen & Fishbein, 1980).These relationships are represented in the following equations:

$$B \approx I \text{ and } PBC$$

$$I \approx AB + SN + PBC$$

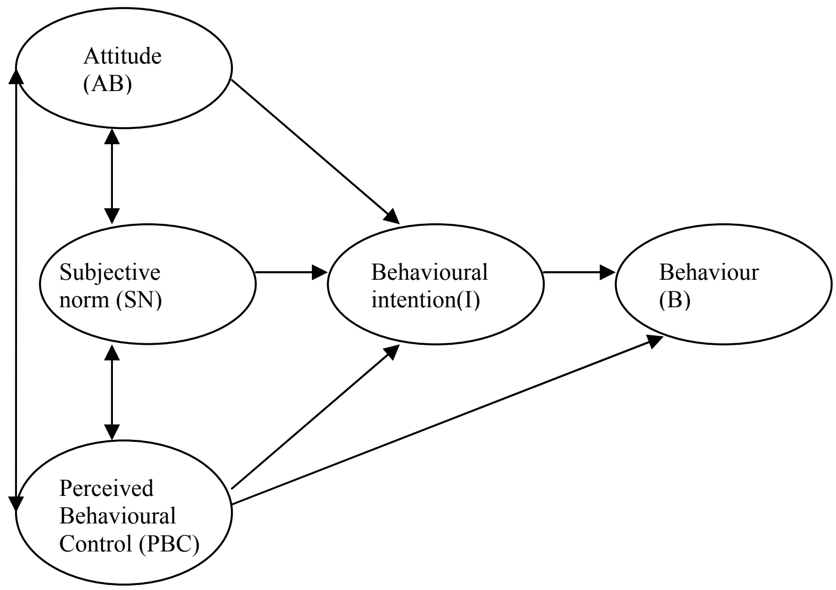

Figure 3.1. Theory of Planned Behaviour (Ajzen, 1985).

According to Ajzen (1991), the TPB constructs (AB, SN, and PBC) are directly linked to behaviour and that relationship is causal and unidirectional as represented in the following equation (adapted from Haney et al., 1996, p. 974):

$$B \sim I \sim (AB + SN + PBC) = W_1 AB + W_2\, SN + W_3 PBC.$$

W_1, W_2, and W_3 reflect the relative weights, or contributions, that each of the constructs makes to the prediction of *intention*, and ultimately *behaviour*.

The theory further postulates that these direct factors (AB, SN, and PBC), in turn, are functions of the sum of their respective salient beliefs or indirect factors. Salient beliefs refer to the primary or immediate determinants of an individual's attitude and perceptions.

TPB Indirect Factors

The AB indirect factor includes the salient beliefs about that behaviour, termed *behavioural beliefs* (ABi). The behavioural beliefs reflect the extent to which the individual believes that engaging in the behaviour will lead to favourable outcomes. The behavioural beliefs (ABi) construct encompasses two subsidiary parts: perceived consequences of performing the behaviour (BI) and the evaluation of those consequences (EI). For example, if a teacher believes that her/his use of ICT in the classroom will improve the teaching process, and s/he thinks that improved condition due to ICT is desirable, s/he is likely to have a positive attitude toward using ICT in her/his teaching.

The SN indirect factor includes the salient beliefs about specific individuals' or groups' approval or disapproval of performing that behaviour, termed *normative beliefs* (SNi). The normative beliefs reflect the extent to which the individual believes that significant others think the behaviour should be performed. Normative beliefs (SNi) also involve two subsidiary parts: the perceived expectation of others (NK) and individual's motivation to comply with those expectations (MK). For example, if a teacher believes that her/his principal thinks that s/he should use ICT in teaching and if her/his motivation to comply with the principal is strong, that teacher is likely to feel that her/his principal encourages her/him to use ICT in teaching.

Finally, the PBC indirect factor includes the salient beliefs regarding the presence or absence of resources and obstacles that may promote or hinder an individual's engagement in the behaviour, termed *control beliefs* (PBCi). Control beliefs comprise two subsidiary parts: perceived control concerning the performance of the behaviour (CB) and evaluation about the likelihood that the occurrence of object of the control belief facilitates or inhibits performance of the behaviour (LO). For example, if a teacher believes that s/he needs Internet access during classroom teaching and if access is an important factor for successful teaching, s/he is likely to feel less control over use if Internet access is not available.

In addition to the constructs described above, TPB designates room for additional variables external to the model. In the case of teacher behaviour related to using ICT in teaching, external variables, particularly teacher characteristics are important because they may present some influences on teacher use of ICT. Being placed prior to beliefs, external variables are thought to affect behaviour indirectly and to be mediated by one or more of the TPB variables (Ajzen, 1985; Ajzen & Fishbein, 1980).

External Factors

According to Ajzen & Fishbein (1980), demographic variables such as age and sex; considered to be *external variables,* may cause considerable variations, but only to the extent that an individual attributes personal attitude, subjective norm, and perceived behavioural control to them. These external variables mediate behaviour and give rise to variations in salient beliefs, belief strengths (BI), outcome evaluations (EI), normative beliefs (NK), motivation to comply (MK), control beliefs (CB), and likelihood of occurrence (LO). Figure 3.2 represents the relationship of the direct, indirect and external variables on intention and behaviour.

Ajzen & Fishbein (1980) also considered the potential effects of two other external variables, personality traits, and attitudes toward targets (people, policies and institutions) of behaviour. However, they have shown that measures of personality and attitudes towards targets correspond to behavioural categories, rather than a single behaviour. Therefore, these two variables will not be considered in this study as this study focuses on a single behaviour, that is, teachers' implementation of ICT.

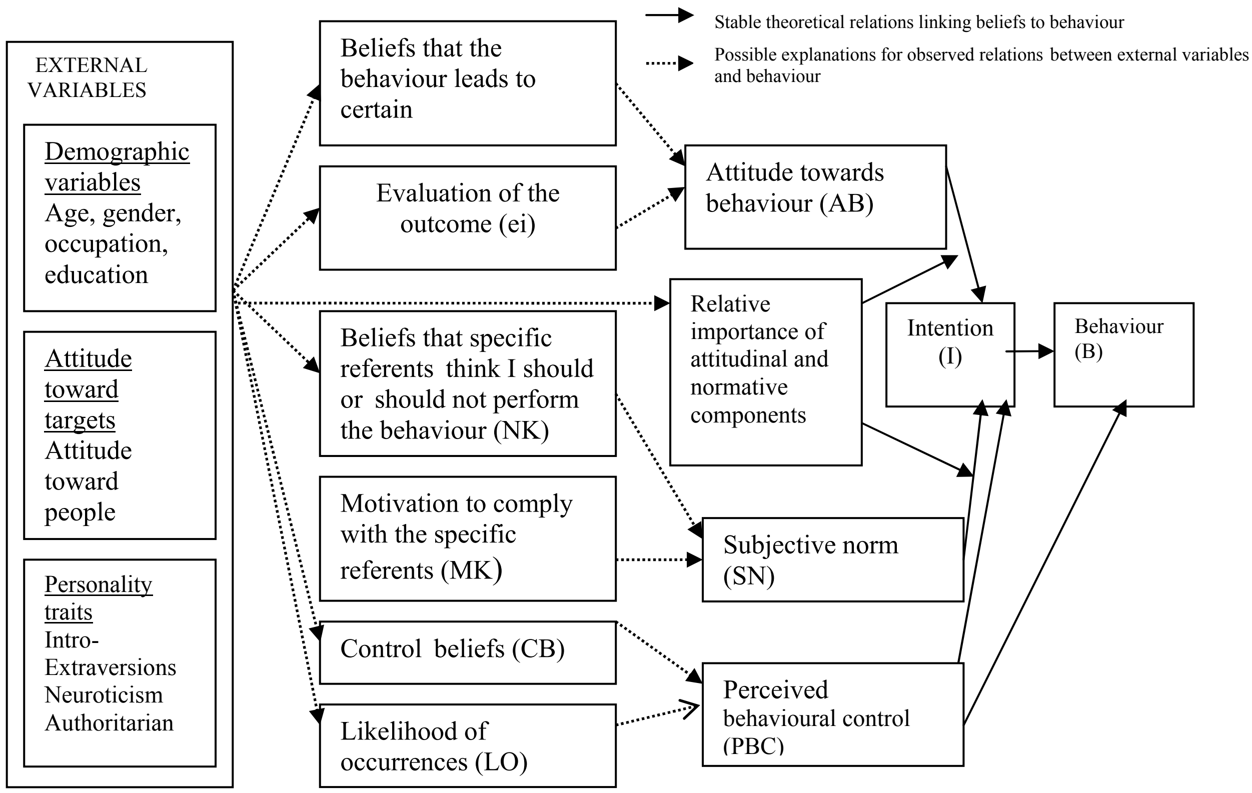

Figure 3.2. Relationships of direct, indirect and external variables on intention and behaviour (Adapted from Ajzen & Fishbein, 1980, p. 84).

3.1.2 Adaptability of the Theory of Planned Behaviour

Many studies have been conducted in the area of IT adoption, acceptance or use in order to identify the factors determining the uptake of a particular information technology. In theorizing an individual's IT use behaviour, researchers are confronted with the need to select a model from among a multitude of models. While some researchers borrowed a theoretical framework from other disciplines, others developed unique models to explain IT use behaviours. The following section describes studies that apply or adapt the theory of planned behaviour and other theories that were used to explain or predict behaviour.

There are studies that adapt the theory of planned behaviour (TPB) and developed a unique model for explaining information technology (IT) use. A considerable number of research studies has been conducted in order to identify the factors that determine people's adoption, acceptance or use of a particular IT (Davis, Bagozzi, & Warshaw, 1989; Taylor & Todd, 1995).

An example of a conceptual model that was developed from other models was the model proposed by Davis (1989). The Technology Acceptance Model (TAM, Figure 3.3) was specifically developed in order to explain individual use of IT. TAM was developed by adapting the theory of reasoned action (TRA), diffusion of innovation (Bandura, 1982; Rogers, 1995) and social-cognitive theory (Bandura, 1982). TAM is a conceptual model that predicts IT use with two constructs, *perceived usefulness* and *perceived ease of use*. *Perceived usefulness* represents the functional aspect of IT use while *perceived ease of use* represents the control aspect of use. These two constructs are almost equivalent to TPB's behavioural beliefs and control beliefs, respectively.

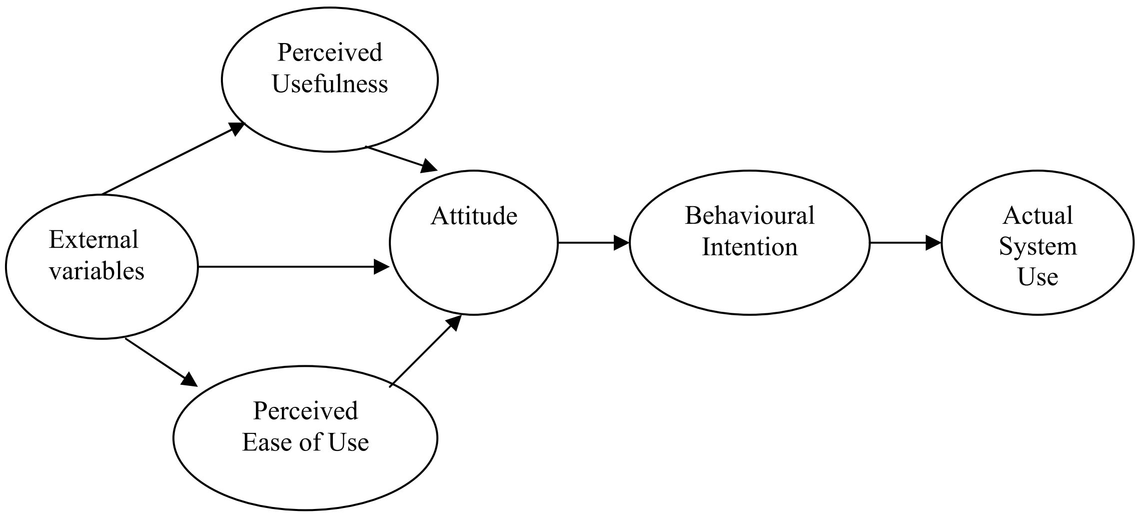

Figure 3.3. Technology Acceptance Model (Davis, 1989).

Generally, in terms of model fit and the ability to explain use, the performances of TAM and TRA were almost comparable (Davis et al., 1989; Mathieson, 1991; Taylor

& Todd, 1995). This conclusion suggests that both TAM and TRA are effective in explaining use by using the two parsimonious variables. This suggests that the functional and control sources, represented by the two parsimonious variables, are pivotal in explaining IT use.

In another elaborated study that investigated user acceptance of IT, Venkatesh, Morris, Davis, and Davis (2003) formulated and tested a unified model called the Unified Theory of Acceptance and Use of Technology (UTAUT, Figure 3.4) by integrating elements from across eight prominent models: the theory of reasoned action (TRA), technology acceptance model (TAM, Davis et al., 1989), motivational model (Davis, Bagozzi, & Warshaw, 1992), the theory of planned behaviour (TPB, Ajzen, 1991), a model combining the technology acceptance model and the theory of planned behaviour (Taylor & Todd, 1995; Thompson, Higgins, & Howell, 1991), the model of PC utilization (Thompson et al., 1991), the innovation diffusion theory (Rogers, 1995), and the social cognitive theory (Bandura, 1986).

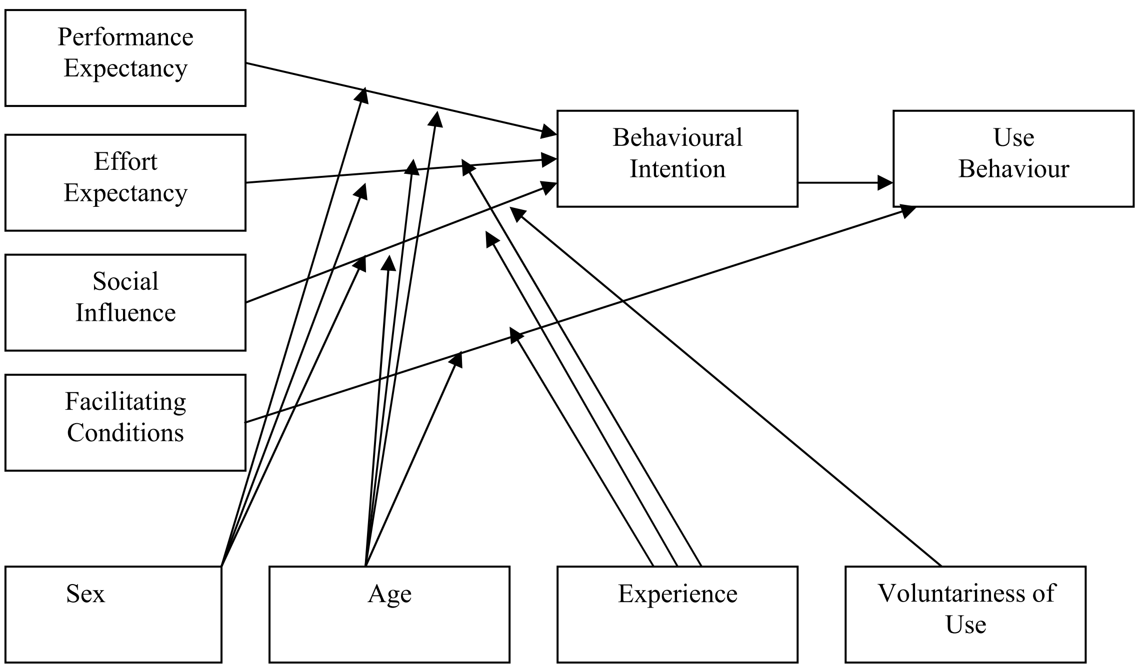

Figure 3.4. Unified Theory of Acceptance and Use of Technology (UTAUT, (Venkatesh et al., 2003).

The model identified four direct determinants of intention and usage: *performance expectancy, effort expectancy, social influence*, and *facilitating conditions*; and four key moderators: sex, age, experience, and voluntariness of use. UTAUT theorized that *attitude towards using technology, self-efficacy,* and *anxiety* are indirect determinants of intention.

When the performance of UTAUT was compared with the eight individual models, the unified model outperformed the others (Venkatesh et al., 2003). This conclusion suggests that UTAUT was an effective model for understanding the factors driving individual's acceptance of technology and inclination to adopt them. It also suggests that the direct factors and moderating external factors also play crucial roles in explaining IT use.

In the area of educational technology use, Lumpe and Chambers (2001) designed an instrument, Beliefs About Teaching with Technology (BATT) to assess teachers' context beliefs (beliefs about the ability of external factors or people to enable a person to reach a goal plus the belief that a factor is likely to occur, p. 95) about using educational technology in the classroom. They reported that teacher context beliefs (which they maintained to be similar to Ajzen's (1985) *perceived behavioural control* construct) and self-efficacy beliefs were significant predictors of teachers' reported use of technology in teaching. This conclusion suggests that context beliefs or perceived behavioural control are important factors for explaining educational technology use.

The above studies of IT and educational technology use provide evidence for the appropriateness of implementing unique models for explaining specific behaviours of use. In order to provide an accurate understanding of behavioural characteristics of teachers' use of ICT in the classroom, two strategies for TPB model modifications that are supported by the literatures were made for the current study. These are discussed in the following section.

3.2 Information and Communication Technology Use Model: Modifications of the Theory of Planned Behaviour

Over the last couple of decades, a vast number of studies have demonstrated the general applicability of the TPB. However, refinement and elaboration of the theory have been recommended. Several studies tested the theory in different contexts or with different operational definitions in order to identify the boundary for modifications of the theory (Conner & Armitage, 1998; Davis et al., 1989; Sutton, 1998; Taylor & Todd, 1995).

Some researchers have suggested that TPB should be improved in order to enhance its moderate explanatory power (Ajzen, 1991; Notani, 1998). Others argued for further inclusion of additional variables even though Ajzen and Fishbein (1980) contended that the TPB variables are sufficient since they mediate influences of all other variables that are not modeled in the theory (Ajzen, 1991; Conner & Armitage, 1998; Sutton, 1998)

In the context of this study, it may be useful to develop a unique TPB model, by focusing on specific beliefs (Taylor & Todd, 1995) related to teachers' ICT implementation behaviours such that the model would be relevant for predicting teacher ICT usage in teaching.

In order to develop a unique TPB model, two modifications of the TPB would be incorporated into the proposed research model for the current study: (1) inclusion of external variables, and (2) specifying or decomposing the belief dimensions.

1. Incorporation of external variables into TPB

Within the context of educational research, the TPB has been used as an instrumental research tool to examine the influence of attitudes, subjective norms and perceived behavioural control on teachers' intentions to (1) use technology in the science classroom (Czerniak, Lumpe, Haney, & Beck, 1999), (2) use cooperative learning in teaching science (Lumpe & Haney, 1998), and (3) implement a Competency Based Science Model in science teaching (Haney et al., 1996). It has also been used to predict teachers' computer use (Marcinkiewicz & Regstad, 1996). However, these studies have not included the effect of external factors such as the demographic variables, which are contended to have certain influence on intention and behaviour (Ajzen & Fishbein, 1980). Therefore, the first modification was to incorporate external variables into the model.

Several studies identified empirically the various external variables determining teachers' uptake of ICT but the effects of those variables on behaviour have not been explained on any theoretical basis. However, research findings that indicated the influencing effect of those external variables on teachers' use of ICT are useful. The external variables which are demonstrated to have certain influence on teachers' use of ICT included in the proposed model are: (1) age (Braak, 2001; Meredyth et al., 1999), (2) sex (Braak, 2001; Mathews, 2000; Meredyth et al., 1999; Yuen & Ma, 2002), (3) subject taught (Braak, 2001), (4) teaching experience (Mathews, 2000), (5) teaching periods per week, (6) highest qualification (Granger et al., 2002; Mathews, 2000), (7) class level taught, and (8) computer access (Matthews, 2000; National Centre for Education Statistics, 2000).

2. Specifications and decomposition of beliefs structures

While empirical evidence supported the applicability of TPB, there are some unresolved issues with various aspects of TPB that required particular attention. Ajzen (1991) pointed out his uncertainty about the exact nature of relations between each of the theory constructs (AB, SN, PBC) and their respective salient beliefs: behavioural beliefs (ABi), normative beliefs (SNi) and, control beliefs (PBCi). He also added that the formulations of expectancy-value measure (i.e. multiplicative composites) as a means of dealing with these relations are only partly successful. In order to overcome the issue of multiplicative composites, Ajzen (1991) suggested optimal rescaling of expectancy and value measures as a means of dealing with measurement limitations.

Hankins, French, and Horne (2000) urged that the operationalisation of expectancy-value variables as the product of expectancy and value measures (i.e. multiplicative composites), not to be used in statistical analysis such as multiple regression. They argued that although the expectancy-value measures may represent a relationship, the product of the two did not result in a useful measure of the interaction of the two measures. For instance, a teacher's rating on her/his expectation of students' learning being improved if s/he uses ICT in teaching, may be related to her/his rating on the evaluation of the usefulness of ICT. However, the product of those ratings does not indicate her/his behavioural beliefs about using ICT.

Instead, Hankins et al. (2000) recommended that, a methodological approach, not statistical means, must be implemented. One such method was the development of questionnaire items that directly elicit responses for the expectancy-value measures rather than rating and multiplying expectancy and value measures. They quoted Eagly and Chaken's (1993) method of separating measures of expectancy and value as providing evidence of the usefulness of using separate measures for the TPB modal salient beliefs. Therefore, in compliance to Hankins et al.'s suggestions (2000), the current study developed and used specific questionnaire items to elicit the belief measures.

Further, a method of decomposing the belief structures in the TPB employed by Taylor and Todd (1995) was also applied in this study as it was found to provide a fuller understanding of behavioural intention. In order to understand students' use of a college computer center, Taylor and Todd (1995) proposed a "decomposed TPB" model by specifying and decomposing the beliefs structures of the TPB. The beliefs about the sources of influence on attitudes were the expectations of three advantages of (1) perceived usefulness, (2) ease of use, and (3) compatibility. The beliefs about the sources of influence of subjective norms were decomposed into two referent groups, subordinators and super-ordinators. The beliefs on the sources of behavioural control were beliefs about (1) self-efficacy, (2) resource-facilitating conditions, and (3) technology-facilitating conditions. The findings of this study were that there were variations in the strengths of influence within each type of belief. For example among the three sources of beliefs on attitude, a significant path from perceived usefulness to attitude was found while the paths from ease of use and compatibility to attitude were not found. Both peer and superior influences were significant determinants of subjective norms. While both self-efficacy and resource-facilitating conditions were significant determinants of control beliefs, technology-facilitating conditions were not. These findings support the usefulness of belief decomposition in developing a theoretical framework that is modeled on significant determinants of behaviour.

Moreover, Notani's (1998) meta-analytic study of 36 empirical studies that tested TPB provided support for the usefulness of belief decomposition. He demonstrated that PBC was predicted significantly by two sources of control beliefs: internal source of control (e.g., self-control) and external source of control (e.g., availability of resources). The study further supports the usefulness of belief decomposition as a means to characterize the studied behaviour. Therefore, the second modification was to extend the original unidimensional TPB constructs into multiple dimensions by decomposing the TPB belief structures (Taylor & Todd, 1995).

In the current study, the beliefs dimensions are decomposed according to the original belief sources as proposed by the TPB. Therefore, the behavioural beliefs are decomposed into beliefs about outcome (BI), and beliefs about importance of outcome (EI). The normative beliefs are decomposed into beliefs about referents' expectations (NK), and beliefs about influence of referents' expectations (MK). Finally, control beliefs are decomposed into beliefs about enabling factors (CB), and beliefs about availability of enabling factors (LO).

By incorporating the above two modifications (i.e. incorporating external variables; and specification and decomposition of beliefs), the current study proposed an ICT use model (ICTUM), as a modified research model of TPB as shown in Figure 3.5.

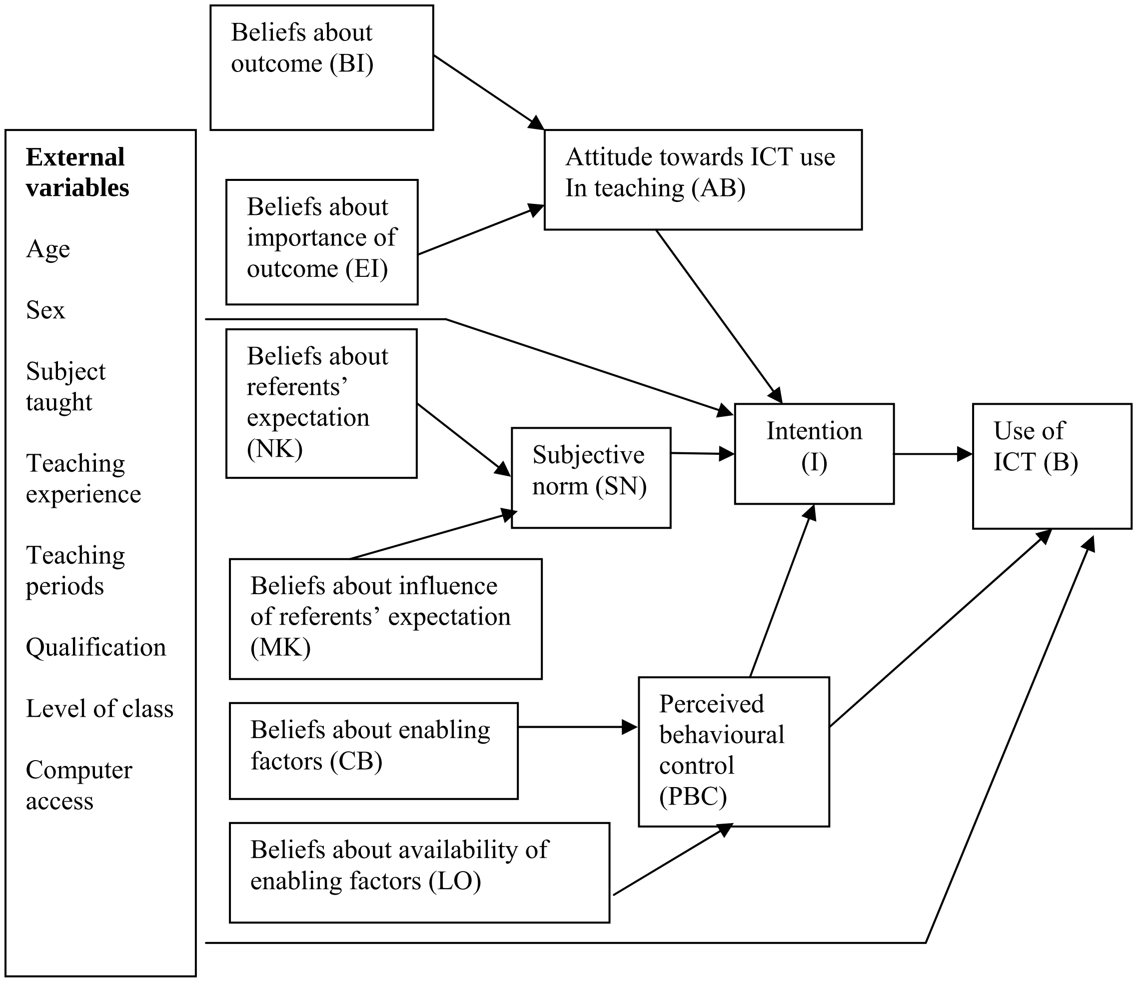

Figure 3.5. ICT Use Model (ICTUM, Modified from Ajzen and Fishbein,1980; p.84).

3.3 Application of the Theory of Planned Behaviour in Educational Research Studies

The TPB was found to be well supported by empirical evidence (see Armitage & Conner, 2001; Hagger, Chatzisarantis, & Biddle, 2002) in its general utility as a theory in modeling various human behaviours and in studies that have adopted the use of the theory.

Meta-analytic reviews support the predictive validity of the TPB. Intention explains between 19% and 38% of the variance in behaviour, while attitudes and subjective norms explain between 33% and 50% of the variance in intention (Armitage & Conner, 2001; Hagger et al., 2002; Notani, 1998; Sheeran, Trafimow, Finlay, & Norman, 2002; Sutton, 1998).

In terms of the performance of the individual constructs of TPB in predicting intention and behaviour, Ajzen (1991) demonstrated that intention to perform behaviours can be predicted with high accuracy from attitudes toward the behaviour, subjective norms and perceived behavioural control, and intention can explain the considerable discrepancies in actual behaviour.

A review of the related literature for the last ten years shows that although there are extensive applications of the TPB in the social and psychological studies, only a few studies in the educational field addressing teachers' behaviour that apply the TPB were found. The context and major findings of some of these studies that provide empirical evidence for the applicability of the TPB in the educational field are described below.

With the purpose of testing the applicability of TPB, Burak (2002) used the constructs of TPB: *attitudes, subjective norms*, and *perceived behavioural control* as the framework for examining teachers' intention to teach health education. They found that the variables of the TPB explained more than about 52% of the variance in teachers' intention and that *perceived behavioural control* contributed substantially to the prediction. The results of this study provided empirical support for the TPB in predicting intention and explaining behaviours. However, the study did not investigate how the indirect factors, or beliefs antecedents, affect the respective constructs of the TPB model as investigated. The current study will investigate how the beliefs antecedents are related to the respective direct factors determining intention and behaviour.

Using a survey questionnaire involving about 1,300 teachers, Zint (2002) conducted an investigation on what personal factors would predict science teachers' intention to incorporate environmental risk education, and assessed the predicting ability of three theories; the theory of planned behaviour, theory of reasoned action, and theory of trying (Bagozzi & Warshaw, 1990). Zint (2002) concluded that teachers' *attitude toward the behaviour, perceived behavioural control*, and *subjective norm* were important factors for predicting and modifying behaviour. Zint (2002) also concluded that given the consistency of results, the theory of planned behaviour augmented with past experience provided the best prediction of science teachers' intentions to act.

In their study, Bagozzi and Warshaw (1990) extended the original TPB by incorporating another variable, past experience, which was found to contribute to the prediction. Since ICT in education is fairly recent in the Bruneian context, the current study does not include past experience as a research variable, as it is assumed that that teachers will not have much prior experience in using ICT in teaching.

The influence of external factors as well as teachers' beliefs and social factors was investigated by Czerniak et al. (1999) who used the TPB as the theoretical framework to investigate the influence of teachers' beliefs on their intention to use educational technology in the science classroom. They employed a questionnaire survey to 204 kindergarten to twelfth grade (K-12) teachers. They were able to confirm that teachers' beliefs about the usefulness of educational technology; social influence (such as from colleagues, parents, and community members); and external factors (such as availability of resources, support for use of technology, opportunities for staff development) would enhance their use of educational technology. They also found that *perceived behavioural control* (perceived ease of educational technology implementation) provided the strongest influence on *behavioural intention* followed by *subjective norm* (influence by others to use educational technology) while *attitude toward the behaviour* (attitude regarding the use of educational technology) did not have a significant influence on intention. However, the study did not measure the actual behaviour that would provide information on whether or not teachers' intention is reflected in actual classroom behaviour. In the current study, teacher actual behaviour is based on self-report despite the arguments about vulnerability to the self-presentational biases. Some researchers have argued that dishonesty in self-report would be minimal when examining socially desirable behaviours (such as classroom use of ICT) when compared to other less desirable social behaviours (such as tax evasion), and few effects of social desirability on relationships between TPB constructs were found (Armitage & Conner, 1999). Therefore, the current study assumes that the participating teachers would be honest and sincere when reporting their actual use of ICT in teaching.

The influence of demographic variables such as grade level, years of experience, and sex were also examined in a study that investigated the factors that influence K- 12 teachers' (N = 107) intention to use cooperative learning in science instruction. From this study, Lumpe and Haney (1998) found that *attitude* and *perceived support* directly influenced teachers' intention to implement cooperative learning and that *perceived behavioural* control was also found to have the greatest influence on intention. In terms of the relationships between demographic variables (grade level assignment, years of experience, and sex), and intention/beliefs, the study found that grade level assignment is negatively correlated with intention to implement cooperative learning; and that there were no significant beliefs differences associated with sex and grade level assignment. The influence of those demographic variables (class level, years of experience, and sex) on teachers' intention to use ICT in teaching will be investigated in the current study. The findings of the current study will either support or refute previous research findings.

In another study, Haney et al. (1996) used structured interviews (N = 13) and a questionnaire (N = 800) as data collection instruments to examine the factors that influence teachers' intention to implement the four strands (inquiry, knowledge, conditions, and applications) of the Competency Based Science Model. The structured interview was conducted to elicit teachers' *attitudes, subjective norms* and *perceived behavioural control* factors for all four strands of the science model. Four questionnaires, one for each strand of the science model, were developed based on the data obtained from the structured interview. The findings of the study showed that each of the constructs in TPB (*attitude toward the behaviour, subjective norm,s* and *perceived behavioural control*) made significant contributions toward behavioural intention for at least one of the strands of the science model. In this study, the researchers were able to control for self-report threat to validity by using both verbal and written statements to verify their report on behaviour. Verification of self-reports (by interviewing or observing participants' classroom practices) was not conducted in the current study due to time constraint. The current study involved more than a thousand participants that it was not feasible to interview or observe a statistically representative number of participants within the limited time frame of the study. However, I was able to identify "truthfulness" of teacher self-report about using ICT in teaching by placing two items: "Do you use the computers for teaching?", and "Indicate the frequency of your use of ICT in teaching" at different places in the questionnaire. It is assumed that if a teacher who does not use computers for teaching would indicate that s/he never uses ICT in teaching.

Marcinkiewicz (1996) developed a questionnaire to measure *subjective norms* using the procedures described by Ajzen and Fishbein (1980) and used it as one of the variables for predicting elementary school teachers' (N = 138) use of available computers for teaching. However, he did not measure the other constructs of the TPB. Nevertheless, he found that *subjective norms* are useful for predicting and promoting teachers' computer use for teaching. In the current study, influence of subjective norms (such as principal, colleagues, parents, students and the curriculum department) on teachers' intention to use ICT in teaching was investigated.

The above studies provide strong evidence for the utility of the TPB for understanding the factors that influence teachers' belief- intention- behaviour relationship in an educational context. The current study utilises the modified TPB as an underpinning theoretical framework for examining how teachers' beliefs may influence their intention and subsequent implementation of ICT in their teaching in Bruneian secondary schools.

The next chapter presents the conceptualisations of the research constructs, research propositions and hypotheses, which are formulated for the current study.

Chapter 4 CONCEPTUALISATIONS OF RESEARCH CONSTRUCTS, RESEARCH PROPOSITIONS AND HYPOTHESES

This chapter focuses on the discussions of the conceptualisation of research constructs and the research model. The chapter ends with the descriptions of the research propositions and hypotheses formulated for answering the four research questions.

4.1. Conceptualisations of Research Constructs

The research constructs conceptualised for the current study are based on previous related literature and the theory of planned behaviour. In this section, each of the research constructs is defined and is theorized to have a direct or indirect influence on the dependent variables in the proposed research model.

4.1.1. Direct factors of Theory of Planned Behaviour: Determinants of *Intention* to use (I) and *Use of ICT (B)*

1. Attitude towards behaviour (AB).

According to Ajzen (1991), attitude toward the behaviour (AB) refers to the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behaviour in question.

In their meta-analysis of 185 studies, Armitage and Conner (2001) found significant correlation between *attitude* and *intention* (r = .49). The attitude-intention relationship accounted for the largest variance (R^2 = .24) in behaviour.

This finding adds support to an earlier meta-analytic study by Notani (1998) which revealed that the path in the attitude-intention relation is positive and the strength of the path is the second strongest (B = .37), following the intention-behaviour relationship (B = .38).

Previous studies on teachers' attitudes towards technological innovations generally show that teachers have positive attitudes towards Information and Communication Technology (ICT) as they want to develop their ICT skills and knowledge. Teachers who recognised the benefits from the use of ICT for students and themselves, use ICT as a tool for providing additional information, aiding presentation and for motivational effect on students (Williams et al., 2000; Williams, Wilson, Richardson, Tuson, & Coles, 1998). Studies on Information Technology (IT) use also showed attitude as a strong predictor of intention (Davis, 1989; Taylor & Todd, 1995).

Based on these findings, the current study proposed that there might be a positive relationship between *intention* (I) to use ICT and *attitude towards use of ICT* (AB). The current study defines *attitude toward use of ICT* as the degree to which a teacher has a favourable or unfavourable evaluation of ICT use in their teaching.

2. Subjective norms (SN)

Subjective norms refers to the perceived social pressure to perform or not to perform a behaviour (Ajzen, 1991). Typically, subjective norm is measured by requesting participants' response to a choice of whether or not a "significant other" would approve of their performing a given behaviour.

There were different findings regarding the role of subjective norms as a determinant of intention in previous literature. Some studies found significant relationships between subjective norms and intention (Ajzen & Madden, 1986; Notani, 1998) while other studies did not (Davis, 1989; Mathieson, 1991). Armitage and Conner's (2001) meta-analytical study provided some support for the weak subjective norm-intention relationship. They showed that the subjective norm-intention correlation was significantly weak (r =.34). They attributed the poor performance of subjective norms to the type of measure used, and suggested the use of multiple-item scales as opposed to single-item measure typically used in a majority of TPB studies.

The success of multiple-item scales in improving the predictive power of subjective norms was evidenced in a study investigating teacher computer use that showed strong association between subjective norms and use. Using a multi-item scale for measuring subjective norms, Marcinkiewicz and Regstad (1996) found that subjective norms were important factors in predicting elementary teachers' use of computers (r=.30). This finding provided support for subjective norms as an important predictor variable for computer use (Corwin & Marcinkiewicz, 1998; Marcinkiewicz, 1996).

Other studies provide evidence that key enthusiasts (particularly head teachers) help to promote effective use of ICT (Williams et al., 2000; Williams et al., 1998). For example, it was shown that people who have important influence on teachers to integrate ICT were school principals (Mulkeen, 2003), ICT coordinators (Kwok-Wing Lai & Pratt, 2004; Lai & Pratt, 2004; Lai, Trewern, & Pratt, 2002; Mulkeen, 2003), and colleagues (Kim, 2000). Therefore, the current study proposed that subjective norms, that is, perceived influence from significant other people, would affect teachers' intention to use and use of ICT in teaching. This study defines *subjective norms* (SN) as the perceived social pressure to use or not to use ICT in teaching.

3. Perceived behavioural control (PBC)

Perceived behavioural control is defined as the perceived ease or difficulty of performing a behaviour (Ajzen, 1991). This perception encompasses the perceptions of the presence or absence of requisite resources or opportunities necessary to perform the behaviour. Previous studies have shown that the strength of the perceived behavioural control-behaviour relationship appears to depend on other factors such as type of person (Sheeran, Trafimow, & Armitage, 2003; Sheeran et al., 2002) and accuracy of PBC (Sheeran et al., 2002). The literature also shows that the predictive power of perceived behavioural control on behaviour is contingent upon certain knowledge, skills, and resources (Ajzen, 1985; Fishbein, Hennessy, Yzer, & Douglas, 2003). Therefore, perceived behavioural control is regarded as a strong predictor of information technology use since the behaviour requires certain knowledge (such as computer jargon), abilities (such as computer skills) and resources (such as possession of computer, etc). Hence, the current study also made the same prediction since ICT use also involves computer and Internet skills and other resources (such as educational CD- ROMs). Thus, this study defines *perceived behavioural con*trol (PBC) as the perceived ease or difficulty of using ICT in teaching.

Unlike attitude and subjective norms that influence behaviour through the mediation of intention, TPB designates a direct path from perceived behavioural control to behaviour, in addition to an indirect path to behaviour mediated via intention. Meta analysis shows that the PBC-intention correlation is strong (r=.43), independently accounts for 6% of variance (controlling for attitude and subjective norms), and PBC adds an average of 2% to prediction of behaviour (Armitage & Conner, 2001).

Empirical studies show that teachers would use ICT in teaching if they (1) have access to the Internet; (2) are familiar with computer hardware and software; (3) have acquired the skills and knowledge for using ICT; (4) are given technical support; and (5) are given sufficient advice on selecting ICT resources (Williams et al., 2000; 1998).

Therefore, the meta-analytic and empirical findings described previously provide support for the usefulness of including *perceived behavioural control* (PBC) as another construct to predict teachers' *use of ICT* in teaching. This study theorized that both direct and indirect paths between perceived behavioural control and behaviour were predicted in the use of ICT in teaching if a teacher perceives they have control in his/her use of ICT and his/her intention to use is high.

4.1.2. Indirect factors of TPB: Salient beliefs

1. Behavioural beliefs

According to TPB, while attitude directly influences intention, attitude itself is determined by multiple salient behavioural beliefs toward the behaviour. The theory posits that attitude towards a behaviour (AB) can be estimated by the sum of all salient beliefs that performing a behaviour will lead to a particular outcome (BI), weighted by an evaluation of the importance of the outcome (EI).

$$AB \approx \sum (BI \times EI)$$

However, as explained in the previous chapter (see section 3.2) the above method of multiplicative composite will not be employed in the current study. Instead, retaining the original TPB constructs, the behavioural beliefs are decomposed into two dimensions, beliefs about outcome (BI) and evaluation of the importance of outcome (EI), and each dimension is measured independently.

Studies in the educational field using TPB/TRA as the theoretical framework usually measure only one dimension of the behavioural beliefs. For example, in a study investigating the effect of educational tools (interactive computer-based simulations, and laboratory inquiry-based experiments) on science teachers' beliefs, attitudes and intention regarding the use of these tools in their teaching, Zacharia (2003) interviewed thirteen teachers about their beliefs regarding the educational tools, and their attitudes towards the use of the those tools. Using the theory of reasoned action (TRA) model as the research framework, the findings confirmed the TRA model that teachers' attitudes towards use were influenced by their beliefs, and that beliefs and attitudes together affect their intention to use. That study, however, identified only teachers' beliefs about the advantages or disadvantages of use, which can be referred as "beliefs about outcome" dimension, but did not investigate the other dimension of "belief about the importance of outcome".

In another study that investigated teachers' beliefs in implementing a model of science education reform strands, Haney et al. (1996) did not use the measures for the two dimensions of behavioural beliefs in their analysis. Instead, they used interview data on teachers' beliefs about advantages and disadvantages of the implementation (the "outcome beliefs") as the source for developing questionnaire items for measuring the "importance of outcome belief" dimension. In their final analysis, they reported on the effect of the latter belief as a significant factor influencing teachers' attitudes towards implementing the science education reform strands model.

Therefore, in the current study, specific questionnaire items are used to assess each of the dimensions and assessment of the effect of each belief dimensions on attitude are analyzed separately. This study conceptualized each of the dimensions as follows:

1. Outcome beliefs (BI) refer to the subjective probability that teacher ICT use in teaching will produce a certain outcome.
2. Outcome evaluation (EI) refers to the teachers' assessment of the desirability of an expected outcome from using ICT in teaching.

2. Normative beliefs

TPB stipulated that normative beliefs are determinants of subjective norms. The theory proposes that subjective norms can be estimated by the sum of all the normative beliefs about referents' opinion about performing a behaviour multiplied by the motivation to comply with those referents.

$$SN \approx \sum (NK \times MK)$$

However, based on previous discussion on the abandonment of the multiplicative composite strategy, the normative beliefs are decomposed into two dimensions: beliefs about referents' expectation (NK), and motivation to comply with specific referents (MK).

Most studies report on the influence of the beliefs about expectation of significant others on intention (e.g. Czerniak et al., 1999; Lumpe & Haney, 1998; Marcinkiewicz & Regstad, 1996) but did not investigate the influence of the beliefs about the importance of those expectations in determining intention.

Thus this study conceptualized the two dimensions of normative beliefs as follows:

1. Referents' expectation belief (NK) refers to the likelihood that significant referent individual or groups approve or disapprove of teachers' use of ICT in teaching.
2. Influence of referents' expectation belief (MK) refers to the teachers' willingness to conform to the referents who either approve or disapprove of teachers' use of ICT.

3. Control beliefs

According to Ajzen (1985), perceived behavioural control is determined by control beliefs and likelihood of occurrence. The TPB postulates that perceived behavioural control is predicted by the sum of control beliefs (c) weighted by its corresponding perceived likelihood of occurrence (p).

$$PBC \approx \sum (c \times p)$$

However, following previous decision not to use multiplicative composites, the current study decomposed the control beliefs into two dimensions: beliefs about enabling factors (CB), and beliefs about the likelihood of availability of enabling factors (LO).

The efficacy of control beliefs as determinants of perceived behavioural control has been well supported in the TPB literature. Many studies in the educational research that applied the TPB also confirmed this conclusion (Czerniak et al., 1999; Haney et al., 1996; Lumpe & Haney, 1998). But in most of these studies, only one dimension of control beliefs was investigated.

Lumpe and Chambers (2001) did investigate the effect of both dimensions of control beliefs on technology use, but the scores measuring the two dimensions were summed to produce a total score representing "context beliefs" ("beliefs about the ability of external factors or people to enable a person to reach a goal plus the belief that a factor is likely to occur", p. 95). They maintained that context beliefs was similar to Ajzen's (1985) *perceived behavioural control* construct.

In the current study, the two dimensions of control beliefs are conceptualized as follows:

1. Beliefs about enabling factors (CB) refers to subjective probability of availability of certain skills, resources, and opportunities that either enable or disable ICT use in teaching.

2. Beliefs about likelihood of availability of enabling factors (LO) refers to teachers' assessment of the availability of an enabling factor in using ICT in teaching.

4.1.3. External Variables

Most information technology studies thus far have predominantly focused on the overall demographic distribution among user populations to find out how they use IT effectively. Rather than simply providing a demographic profile of users, the present study included demographic factors in the proposed research model in order to examine their effects on intention and use in the proposed model.

Although the demographic variables or external variables (such as age, sex, subject taught, teaching experience, qualification, level of class taught, and access to computers in classroom and computer laboratory) identified in the literature were shown to have some influence on teacher use of ICT, no studies were found that showed the strength of these variables in predicting or explaining intention or behaviour on a theoretical basis.

Lumpe and Chambers (2001) revealed that there was significant sex difference in context beliefs regarding teachers' use of technology in teaching, and no significant differences in context beliefs when comparing teachers' level of class responsibility or subject taught. However, prediction on use by those variables was not investigated in the study.

Therefore, this study proposes the following prediction regarding the influence of demographic variables: teachers who are considered traditionally to be "computer-savvy" – males, young, recently graduated, teaching computer-related subjects, have less number of teaching periods, more educated, teach lower class level, and have greater access to computers and Internet – are more likely to use ICT than those who do not match these descriptors.

4.1.4. ICT use in teaching (B) and Intention to use (I)

The target behaviour investigated in the current study is teachers' use of ICT in teaching. This study defined teachers' ICT use as the frequency of usage of ICT in teaching over a fixed unit of time. Information and communication technology (ICT) was defined, in this study, as teachers' use of the computer, Internet and other related technology that allows the dissemination of information and learners using it to construct their own knowledge through intra- or extra-connected computers, as well as educational software for the purposes of teaching and learning.

The TPB proposes that intention is the immediate predictor of behaviour (Ajzen, 1991). Generally, studies of TPB and information technology use found that behavioural intention was the strongest and immediate predictor of use, and other predictors of use were mostly mediated by intention (Davis, 1989; Taylor & Todd, 1995). In the current study, the *intention to use ICT* (I) was proposed as the immediate predictor of teachers' *use of ICT* (B) in teaching and was defined as the strength of a teacher's intention to use ICT in teaching in the near future.

In addition, as TPB also proposed a direct path from *perceived behavioural control* (PBC) to behaviour, the proposed ICT Use Model (ICTUM) also included the direct path from PBC to use (see detailed discussions on page 57).

The predictions were expressed in the following equation:

$$\textbf{Use} \approx \textbf{Intention + PBC}$$

In TPB, intention is determined by three antecedents, attitudes towards the behaviour (AB), subjective norms (SN), and perceived behavioural control (PBC). The current study added external variables (comprising of several demographic variables) as a fourth antecedent of intention. It is proposed that a teacher would show a stronger intention to use ICT in teaching if the teacher (1) has a more positive attitude toward using ICT in teaching, (2) thinks her/his significant others think s/he should use ICT, (3) thinks s/he possesses the resources and opportunities, and/or has the necessary personal characteristics. The predictions were expressed in the following equation:

Intention ≈ AB + SN + PBC + External variables

Behaviour (use) ≈ Intention + PBC + External variables

4.2. A Conceptual Model of Information and Communications Technology Use

The current study assessed the performance of the direct factors of the theory of planned behaviour (TPB), and the modified TPB, Information and Communication Technology Use Model (ICTUM, Figure 3.5), specifically developed for predicting and explaining teachers' use of ICT in teaching. The TPB direct factors consist of Ajzen's TPB predictor variables (*attitude towards using ICT, subjective norms,* and *perceived behavioural control*) and dependent variables (*intention* and *use of ICT*). The ICTUM model includes the TPB direct factors, dependent variables, as well as TPB indirect factors (*behavioural beliefs, normative beliefs*, and *control beliefs*) and external variables. In order to identify distinctive paths of beliefs that influence use, each of the three types of beliefs were decomposed into bi-dimensional constructs. The behavioural beliefs are decomposed into beliefs about outcome (BI), and beliefs about the importance of outcome (EI). The normative beliefs are decomposed into beliefs about referents' expectations (NK), and beliefs about influence of referents' expectation (MK). The control beliefs are decomposed into beliefs about enabling factors (CB) and beliefs about likelihood of the availability of enabling factors (LO). The external variables consisting of demographic variables (age, sex, subject taught, teaching, experience, teaching period, qualification, class level, class access, and computer room access) were added into the original TPB model as indirect predictors of *intention* and *use of ICT*. Each of these external variables is expected to have an influence on *intention* and *use of ICT* respectively. Overall, the current study proposed that *intention* to use ICT and *use of ICT* could be predicted and explained by the direct factors consisting of attitudes and perceptions, which were hypothesized to be influenced by the corresponding beliefs structures, and demographic characteristics of users.

4.3. Research propositions and hypotheses

The following research propositions and hypotheses have been stipulated based on the requirements of TPB which prescribes the demonstration of predictive relationships of the TPB constructs and the verification of hypotheses linking beliefs to behaviour (Ajzen & Fishbein, 1980). The hypotheses have been derived from the respective propositions based on the TPB. Derivation of hypotheses from a theory base should lead logically to the hypothesis as a solution to the problems and makes it clear why it should be tested (Roblyer & Knezek, 2003).

The research propositions theorized the relationships among the factors that would predict use either directly or indirectly. The propositions are adapted from Ajzen's theory of planned behaviour as well as from empirical research findings discussed in the literature review.

The propositions provided a theoretical framework from which research hypotheses were drawn. The theoretical propositions were expressed in the form of causal, not correlational, relationships supported by empirical findings of cumulated TPB findings.

Proposition 1: Teacher ICT-using behaviour is predicted by the teacher's *intention* to use and by *perceived behavioural control*.

Proposition 1 is tested by two research hypotheses:

> **Hypothesis H1:** There will be a positive relationship between teacher *use of ICT* in teaching (B) and the *intention* to use (I).
>
> **Hypothesis H2:** There will be a positive relationship between teacher *use of ICT* in teaching (B) and *perceived behavioural control* (PBC).

Proposition 2: Teacher's *intention* to use ICT in teaching is predicted by the teacher's *attitude towards use of ICT, subjective norms,* and *perceived behavioural control.*

Proposition 2 is tested by the following three research hypotheses:

> **Hypothesis H3:** There will be a positive relationship between teacher's *intention* to use ICT in teaching and *attitude towards the use of ICT*.
>
> **Hypothesis H4:** There will be a positive relationship between teacher's *intention* to use ICT in teaching and *subjective norms.*
>
> **Hypothesis H5:** There will be a positive relationship between teacher's *intention* to use ICT in teaching and *perceived behavioural control*.

Proposition 3. The direct factors of TPB model (*attitudes toward use of ICT, subjective norms*, and *perceived behavioural control*) can explain significantly teacher *use of ICT* in teaching.

The accompanying hypothesis is:

Hypothesis H6: The TPB model of direct factors (*teachers' attitudes towards use of ICT, subjective norms,* and *perceived behavioural control*) provides a significant model fit in explaining teacher *use of ICT* in teaching.

Results of the tests of hypotheses H1 to H6 would ultimately answer the first research question: **How do the direct factors of TPB *(teachers' attitudes, subjective norms, and perceived behavioural control*) predict and explain teachers' *intention* and behaviour for the *use of ICT* in their teaching?**

Proposition 4. The indirect factors (*behavioural beliefs* (ABi), *normative beliefs* (SNi), and *control beliefs* (PBCi) are antecedents of the respective direct factors (*attitude towards ICT use* (AB), *subjective norms* (SN), and *perceived behavioural control* (PBC)).

Proposition 4 is tested by the following three research hypotheses:

Hypothesis H7: There will be a positive relationship between teachers' *attitude towards use of ICT* (AB) and its antecedent factor, *behavioural beliefs* (ABi) comprising *beliefs about the outcome* (BI) of teaching using ICT and the *importance of those outcomes* (EI).

Hypothesis H8: There will be a positive relationship between *subjective norms* (SN) and its antecedent factor, *normative beliefs* (SNi) comprising *beliefs about referents' expectation* (NK) and *influence of those expectations* (MK) in their use of ICT.

Hypothesis H9: There will be a positive relationship between *perceived behavioural control* (PBC) and its antecedent factor, *control beliefs* (PBCi) comprising *beliefs about enabling factors* (CB) for effective teaching and *likelihood of availability of those factors* (LO).

Proposition 5. The indirect factors (*behavioural beliefs, normative beliefs,* and *control beliefs*) and direct factors have positive influence on teachers' *intention* and *use of ICT* in teaching.

> **Hypothesis H10:** There will be positive total influence of the direct and indirect factors on *intention* and *use of ICT*.

Proposition 6: The ICTUM provides an adequate explanation of teachers' *intention* and *use of ICT* in teaching.

Proposition 6 involves an assessment of the overall ICTUM model. The model is examined by the following hypothesis:

> **Hypothesis H11:** ICTUM provides a significant model fit in explaining teacher *intention* and *use of ICT* in teaching.

Results of testing hypotheses H7, H8, H9, H10, and H11 would answer the second research question: **How do the indirect factors *(behavioural, normative, and control beliefs)* relate to the respective direct factors *(teachers' attitudes, subjective norms, and perceived behavioural control*) of ICTUM and together explain teachers' *intention* and *behaviour for the use of ICT* in teaching?**

Proposition 7. The external variables that predict teacher intention to use ICT consist of demographic variables.

The relevant hypotheses to test this proposition are:

> **Hypothesis H12:** External variables positively influence teacher *intention* to use ICT in teaching.
>
> **Hypothesis H13:** External variables positively influence teacher *use of ICT* in teaching.

Results of testing hypotheses H12 and H13 would answer the third research question: **How do the external factors comprising demographic factors (age, sex, subject taught, and teaching level), class access, and computer laboratory access predict and explain teachers' *intention* and *behaviour for using ICT* in their teaching?**

Proposition 8. The ICTUM provides a better explanation of teacher's *intention* and *use of ICT* in teaching than the TPB model of direct factors.

The hypothesis to test this proposition is:

> **Hypothesis H14:** The proposed model, ICTUM in the current study explain teachers' *intention* and *use of ICT* in teaching better than the TPB model.

The result on testing of hypothesis H14 would ultimately answer the fourth research question: **How does the ICT Use Model (ICTUM) perform in comparison to TPB model in explaining teachers' *intention* and *use of* ICT in their teaching?**

The research questions, propositions and hypotheses are summarized in Table 4.1.

Table 4.1. *Summary of research questions, propositions and hypotheses*

Research question 1

How do the direct factors of TPB *(teachers' attitudes, subjective norms,* and *perceived behavioural control)* predict and explain teachers' *intention and* behaviour for the *use of ICT* in their teaching?

Proposition 1: Teachers' ICT-using behaviour is predicted by the teachers' intention to use and by perceived behavioural control.

Hypothesis H1	There will be a positive relationship between teacher *use of ICT* in teaching (B) and *intention* to use (I).
Hypothesis H2	There will be a positive relationship between teacher *use of ICT* in teaching (B) and *perceived behavioural control* (PBC).

Proposition 2: Teachers' *intention* to use ICT in teaching is predicted by teachers' *attitude towards the use, subjective norms,* and *perceived behavioural control*.

Hypothesis H3	There will be a positive relationship between teachers' *intention* to use ICT in teaching and *attitude towards use of ICT*.
Hypothesis H4	There will be a positive relationship between teachers' *intention* to use ICT in teaching and *subjective norms*.
Hypothesis H5	There will be a positive relationship between teachers' *intention* to use ICT in teaching and *perceived behavioural control*.

Proposition 3: The direct factors of TPB model (*teachers' attitudes, subjective norms,* and *perceived behavioural control)* can significantly explain teacher *use of ICT* in teaching.

Hypothesis H6	The TPB model of direct factors (*teachers' attitudes, subjective norms, and perceived behavioural control)* provides a significant model fit in explaining teacher *use of ICT* in teaching.

Research question 2

How do the indirect factors (*behavioural beliefs* (ABi), *normative beliefs* (SNi), and *control beliefs* (PBCi) relate to the respective direct factors (*attitude towards ICT use* (AB), *subjective norms* (SN), and *perceived behavioural control* (PBC)) of ICTUM and together explain teachers' *intention* and behaviour for the *use of ICT* in teaching?

Proposition 4: The indirect factors (*behavioural beliefs* (ABi), *normative beliefs* (SNi), and *control beliefs* (PBCi)) are the antecedents of the respective direct factors (*attitude towards ICT use* (AB), *subjective norms* (SN), and *perceived behavioural control* (PBC).

Hypothesis H7	There will be a positive relationship between *teachers' attitude towards use of ICT* (AB) and its antecedent factor, *behavioural beliefs* (ABi) comprising *beliefs about the outcome* (BI) of teaching using ICT and the *importance of those outcomes* (EI).
Hypothesis H8	There will be a positive relationship between *subjective norms* and its antecedent factor, *normative beliefs* (SNi) comprising beliefs about *referents' expectation* (NK) and *influence of those expectations* (MK) in their use of ICT.

Table 4.1. (Continued)

Hypothesis H9	There will be a positive relationship between *perceived behavioural control* and its antecedent factor, *control beliefs* (PBCi) comprising *beliefs about enabling factors* (CB) for effective teaching and *likelihood of availability of those factors* (LO).
Proposition 5: The indirect factors *(behavioural beliefs, normative beliefs,* and *control beliefs)* and direct factors have positive influence on *intention* and *use of ICT* in teaching.	
Hypothesis H10	There will be positive total influence of the direct and indirect factors on *intention* and *use of ICT*.
Proposition 6: ICTUM provides an adequate explanation of teachers' *intention* and *use of ICT* in teaching.	
Hypothesis H11	ICTUM provides a significant model fit in explaining teachers' *intention* and *use of ICT* in teaching.
Research question 3	
How do the external factors comprising of demographic variables (e.g. age, sex, subject taught, and teaching level), class access, and computer laboratory access predict and explain teachers' *intention* and behaviour for *use of ICT* in teaching?	
Proposition 7: The external variables that predict teachers' intention to use ICT consist of demographic variables.	
Hypothesis H12	External variables influence teachers' *intention* to use ICT teaching.
Hypothesis H13	External variables influence teachers' *use of ICT* in teaching.
Research question 4	
How does the ICT Use Model (ICTUM) perform in comparison to TPB model in explaining teachers' *intention* and *use of ICT* in their teaching?	
Proposition 8: The ICTUM provides a better explanation of teachers' *intention* and *use of ICT* in teaching than the TPB model of direct factors	
Hypothesis H14	The proposed model, ICTUM in the current study explain teachers' *intention* and *use of ICT* in teaching better than the TPB model.

Chapter 5 METHODOLOGY

This chapter describes the research method of the current study. The first section provides an overview of the research design: description of the study site, study population, survey instrument and the data collection procedures. In the second section, the variables in the theory of planned behaviour (TPB) model are operationalised with respect to the study objectives. In the third section, the statistical data analysis techniques, structural equation modeling and hierarchical multiple regression employed in this study are presented with a particular emphasis on structural equation modeling as the major analytic technique.

5.1 Research Design

This study employed a survey research method that has been frequently used in research on information technology and computer use. A survey research method is particularly useful for generating quantitative data that can be used to establish the basis for wider generalization. A questionnaire is administered to obtain participants' responses to the variables under investigation. The data collected on these variables can then be studied using appropriate statistical procedures. The questionnaire administered in the current study was used to test the statistical relationships among the constructs of the TPB and the modified TPB model, ICT Use Model (ICTUM) that underpin this research study: *attitude towards behaviour* (AB), *subjective norms* (SN), *perceived behavioural control* (PBC), *intention* (I) and *use of ICT* (B).

5.1.1 Study Site

The setting for this study was limited to only government secondary schools in all four districts of Brunei Darussalam. While the schools differ in many ways, such as the number of computers and networking resources, staff expertise, and number of students and teachers, researching a single administrative domain (government secondary schools) under one department (secondary section of the Department of Schools) administering all secondary schools exclusively, is considered to be advantageous in terms of controlling for extraneous variables that could be confounded with other research variables.

There are a total of twenty-six government secondary schools in Brunei Darussalam. However, two schools were excluded from this study, as one of the schools comprises only pre-university teachers teaching pre-university students, while the other has a mixture of both primary and secondary school teachers. From the remaining twenty-four schools, six schools were randomly chosen from each district for a pilot study and the remaining eighteen schools were used for the main study. Three schools from Brunei-Muara district and two schools from Tutong and Belait districts each were chosen for the pilot study. The student sample size (N = 401) for the pilot study adequately supported the use of structural equation modeling, the analytic technique employed in this study.

5.1.2 Study Population

The target population of this study consists of secondary school teachers who are employed by the government to teach the various curriculum subjects. Participants for the main study consisted of all local teachers teaching in the eighteen government secondary schools in the four districts in Brunei Darussalam. The current study assumes that by including only local teachers and excluding expatriates, the study would provide exclusive generalization about local teachers' perceptions towards the use of ICT. Consequently, any recommendations to be suggested would suitably be based on Bruneian context. Moreover, comparison of findings about teachers' use of ICT between Brunei and other countries would be justifiable.

5.1.3 Survey Instrument

A structured questionnaire, the ICT in Education (ICTE) questionnaire was used as the research instrument in the current study. Because the research constructs of this study (that is, attitudes, perceptions, and beliefs) are latent variables which are not directly observable, the use of multiple item scales is beneficial since it ensures greater variability and enhances reliability of measures because the errors of each item tend to cancel each other out (DeVellis, 1991).

The survey instrument was developed by combining items from previously validated questionnaires. Items for measures of perceptions (AB, SN, PBC, I and B), the latent variables were adopted and modified from various previous published studies. Development of items for the latent variables is discussed in detail in the next section (p. 77)

Items for expectancy-value measures of beliefs (behavioural beliefs, normative beliefs, and control beliefs) were adopted and modified from the following respective studies:

- For behavioural beliefs, items were adapted from Kwon (2002).
- Items for normative beliefs were selected from those in the questionnaire used by Marcinkiewicz (1996) in his study. In the ICTE questionnaire, *head of department, parents,* and *curriculum department* were added as "significant others", in addition to principal, colleagues, and students as used in Marcinkiewicz's questionnaire, while *profession* as in Marcinkiewicz's questionnaire was omitted.
- Items for control beliefs were replicated exclusively from Lumpe and Chambers' (2001) Beliefs About Teaching with Technology (BATT) questionnaire. Lumpe and Chambers (2001) advocated that the items in

BATT are valid and reliable to assess the perceived behavioural control construct.

- Items for intention were self-developed items seeking teacher response on their likelihood to use ICT in teaching based on a five-point Likert scale. The items were developed using the approach described by Ajzen and Fishbein (1980). A description of the development of the intention scale is discussed on page 79.

A Malay version of ICTE questionnaire was also included for the benefits of the non-English readers. The questionnaire is included in Appendix A.

5.1.4 Reliability and Validity of ICTE questionnaire

As most of the items in the questionnaire have been used elsewhere and have been tested for reliability and validity, in the context of that use, the content validity of the ICTE questionnaire has been assumed by making reference to those standard questionnaires (refer to Section 5.1.3). Statistical analysis using exploratory and confirmatory factor analyses was performed on the pilot study data as well as the main study data to further confirm construct validity and reliability of the ICTE questionnaire.

5.1.5 Data Collection Procedure

The ICTE questionnaire was distributed to the seven pilot study schools. Based on the results of analysis of the pilot study data, changes were made to the questionnaire accordingly. The revised ICT in Education questionnaires were then distributed to the eighteen main study schools.

All the teachers, except expatriates, in the eighteen schools (N = 1,453) were given the questionnaires at their respective schools. The questionnaires were collected a week after distribution with a letter of appreciation to the school principal, acknowledging the participating teachers. A total of 1,040 (72% return rate) copies of the questionnaires were returned.

5.2 Operationalisation of Variables

This section provides a detailed description of how each of the research variables is operationalised. A summary of variable operationalisation is listed in Table 5.1.

5.2.1 Variables in Theory of Planned Behaviour (TPB)

In order to construct the items to measure the constructs in TPB, Ajzen and Fishbein (1980) emphasized that we should specify the action, the target at which the action is directed, the context in which it occurs, and the time at which it is performed. Accordingly, for this study, the target was "ICT," the action was "using ICT," the context was "in the classroom," and the time is "during teaching periods". Therefore, the specific behaviour in this study is, "use of ICT in my teaching".

Applying the TPB to this study for ICT Use Model (ICTUM), the *behaviour* (B) or classroom practices of teachers in regard to use of ICT in teaching will be determined by their *intention* (I) to use ICT and their *perceived behavioural control* (PBC). Any intention to utilise ICT will be influenced by teachers' *attitudes* towards the use of ICT in teaching (AB), *subjective norms* (SN) and their *perceived behavioural control* (PBC).

The descriptions of the variables are divided into three groups. The first group, Group A consists of the five latent variables: AB, SN, PBC, I, and B. The second group, Group B consists of the beliefs variables for behavioural beliefs (ABi); normative belief (SNi); and control beliefs (PBCi), and the last group consists of demographic variables. The following sections describe each of the measures in detail.

5.2.1.1 Group A: Five Latent Variables

The following section describes the operationalizations of the five latent variables that make up Group A: Attitude *towards using ICT in teaching* (AB), *subjective norms* (SN), *perceived behavioural control* (PBC), *intention* (I), and *use of ICT* (B).

1. Attitude towards using ICT in teaching (AB)

AB is operationalised as the degree of favourable feelings towards using ICT in teaching. The items which were adapted from Kwon (2002) were measured on a Likert-type scale ranging from one being *strongly disagree* to five *strongly agree.* The exact items in the ICTE questionnaire are:

I feel that teaching using ICT is a good idea.

I feel that teaching using ICT is appropriate.

I like teaching using ICT.

I enjoy teaching using ICT.

I feel comfortable teaching using ICT.

2. Subjective norms (SN):

SN items which measured teachers' perceptions of social pressure to use ICT in teaching, that is, *subjective norms* (SN), seek responses to the question: Who would have an influence on your using ICT in teaching?

Teacher respondents then selected from the list of people and social group who might influence their use of ICT in teaching: *People with whom I work; people whom I meet socially, people who are important to me; educational researchers; and computer societies*.

These items were also measured on a Likert-type scale ranging from one being *strongly disagree* to five *strongly agree.*

3. Perceived behavioural control (PBC)

Perceived behavioural control (PBC) was measured using items that represent the teachers' perceived ease of using ICT in teaching. The items were adopted from Kwon (2002) and are shown as follows:

I am certainly able to use ICT in teaching if I want to use.

Successful use of ICT in teaching is entirely in my capabilities.

I have the resources, the knowledge, and the skills to use ICT effectively in teaching.

There are some things that I cannot control when I use ICT in teaching and they sometimes make my use of ICT in teaching difficult.

The respondents were also asked to rate these items on a Likert-type scale ranging from one being *strongly disagree* to five *strongly agree.*

4. Intention (I)

Intention (I) was measured by items adapted from those used in Taylor and Todd (1995). The construct is operationalised in terms of teachers' intentions to use ICT in teaching during the next six months. Teachers in Brunei are usually required to prepare a monthly scheme of work for that academic year at the beginning of the year and are expected to diligently follow through the prepared scheme. The use of the six-month time frame for this study was arbitrarily chosen and was expected to be a relatively stable predictor for *intention*. The specific items are shown as follows:

During the next six months, I will use ICT in presenting my lessons.

During the next six months, I am likely to use ICT for demonstrations for my lessons.

During the next six months, I will instruct students to use ICT for problem solving.

During the next six months, I will use ICT simulations in my teaching.

5. Use of ICT (B)

Use of ICT (B), the dependant variable, is operationalised in terms of the frequency of teacher use of ICT in teaching at various time frames: *this week, the last six months, and last year,* and their use of computers for teaching. The usual practices for teachers in Brunei are to write a daily lesson plan that includes their comments after the lesson was conducted. So teachers are expected to have written records and reports of their lessons. This study assumed that the teachers would be able to assess the frequency of ICT use in their lesson during those time frames. The items for frequency of use were adapted from previous study on computer technology use (Davis et al., 1989). The specific items in the questionnaire are as follows:

How often did you use ICT in your teaching this week?

How often did you use ICT in teaching in the last six months?

How often did you use ICT in teaching last year?

Do you use the computers (accessible in either classroom or computer laboratory) for teaching?

For the first three items, teacher respondents were required to select from a five-point scale from one *never* to five *always.* The last item requires a yes/no response.

5.2.1.2 Group B: Belief Variables

The following section describes the operationalizations of the beliefs variables: behavioural belief (ABi), normative beliefs (SNi) and control beliefs (PBCi). The items measuring these variables have been adapted from various previous literatures.

1. Behavioural beliefs (ABi)

In this study, teachers' *behavioural beliefs* (ABi) are operationalised in terms of the items that measure teachers' beliefs that their use of ICT may lead to certain outcomes to their lessons (BI) and teachers' evaluation of outcomes (EI). The actual question item for behavioural outcome beliefs (BI) was: How likely are the following outcome will occur when you use ICT in your teaching? Using ICT in my teaching will:

make my lessons more interesting.

improve the presentation of teaching materials.

make my lessons more diverse.

make my lessons more motivating.

help students understand the lessons quicker

develop students' problem learning skills.

The evaluation of outcomes (EI) was measured by asking teachers to assess the importance of each of the corresponding behavioural belief on a five-point scale, with one being not at all important to five being extremely important. The actual question item for evaluation of outcome was: How important are the occurrences of these outcomes when you use ICT in your teaching?

The selection of outcome when using ICT in teaching were adapted from the ICT in Education questionnaire (Preston, Cox, & Cox, 2000) and Teachers' Attitude Toward Information Technology questionnaire (Knezek and Christensen, 1997).

2. Normative beliefs (SNi)

Items on teachers' *normative beliefs* (SNi) measured teachers' beliefs about perceived pressures from the significant others such as principals, colleagues, students, profession and the government's aspiration for ICT use across the curriculum (NK) and their motivation to comply to the pressures (MK). The actual NK question item was worded as:

What would the each of the following individual or group of individuals think about your using ICT in teaching?

The items were measured on a five-point scale ranging from one being *I should not use* to five being *I should use.* The corresponding MK question item was worded as: How influential to you is each of the following people's thoughts about your use of ICT in teaching?

The items were also measured on a five-point scale ranging from one being *not at all influential* to five being *extremely influential.*

3. Control beliefs (PBCi)

Control beliefs (PBCi) was measured using items assessing the extent to which teachers perceive that the availability of resources and other factors such as support from parents, other teachers and technicians and time for planning and developing ICT resources may enable them to teach using ICT effectively (CB) and the likelihood of occurrence of those factors for utilization in the classrooms (LO). Items from Lumpe and Chambers' (2001) Beliefs About Teaching with Technology (BATT) questionnaire have been replicated for the current study.

The questionnaire asked teachers to assess the specified factors that would *enable* them to teach effectively using ICT and the *likelihood* of those factors will occur in school. The factors are: *resources; professional development opportunities; access to the Internet; quality of software; physical classroom structures; support from parents; support from other teachers; technical support; time to plan for ICT implementation; smaller class sizes; and time to let students to use ICT.*

The items were measured on a five-point scale ranging from one being *strongly disagree* to five being *strongly agree* for the control belief items; and one being *very unlikely* and five being *very likely* for the likelihood of occurrence belief items.

5.2.1.3 Demographic Variables

The following demographic variables are operationalized for the current study.

1. Age: Teacher respondents' age was operationalised by asking them to select from a series of various age groups: 18 to 25; 26-30; 31-35; 36-40; 41-45; and 46+.

2. Sex: Teacher respondents' sex was operationalised by asking them to indicate their sex from two choices: male and female.

3. Subject taught: Teacher respondents were asked to write the subject or subjects they taught in the school.

4. Teaching experience: Teachers' teaching experience was operationalised in terms of the number of years they have been teaching. The teacher respondents' were asked to select from the following: 0-1 year, 2-5 years, 6-7 years, 11-15 years, and 15+ years.

5. Number of teaching periods per week: Teacher respondents were required to write the number of teaching periods per week.

6. Highest qualification: Teacher respondents were asked to indicate their highest qualification from selecting one of the following: PhD.; Masters; Bachelor of Arts/Bachelor of Science; Diploma; and Certificate.

7. Level of students taught: Teacher respondents were required to indicate the level of students they taught from a selection of: Lower secondary; Upper secondary; Both Upper and Lower Secondary.

8. Access to computers: Teacher respondents' access to computers was operationalised by asking them to indicate if they have access to computers in the classrooms and computer laboratory respectively. They were required to provide a yes/no response to each.

Table 5.1 illustrates the summary of variables and the respective questionnaire items.

Table 5.1. *Summary of Variables and Respective Questionnaire Items*

Latent Variable	Observed variable	ICTE Questionnaire Item
AB	ab1	I feel that teaching ICT is a good idea.
	ab2	I feel that teaching using ICT is appropriate.
	ab3	I like teaching using ICT.
	ab4	I enjoy teaching using ICT.
	ab5	I feel comfortable teaching using ICT.
SN	sn1	People with whom I work with.
	sn2	People whom I meet socially.
	sn3	People who are important to me.
	sn4	Educational researcher
	sn5	Computer societies
PBC	pbc1	I am certainly able to use ICT in teaching if I want to use.
	pbc2	I am entirely capable of using ICT in teaching successfully.
	pbc3	I have the resources, the knowledge, and the skills to use ICT effectively in teaching.
	pbc4	There are some things that I cannot control when I use ICT in teaching.
	pbc5	I can teach using ICT if I have support.
I	i1	During the next six months, I will use ICT for demonstrations in my lessons.
	i2	During the next six months, I will use ICT in presenting my lessons.
	i3	During the next six months, I will instruct students to use ICT for learning.
	i4	During the next six months, I will use ICT simulations in my teaching.
B	b1	How often did you use ICT in your teaching this week?
	b2	How often did you use ICT in teaching in the last six months?
	b3	How often did you use ICT in your teaching last year?
	b4	Do you use computers for teaching?
ABi	bi1/ei1	Make my lesson more interesting
	bi2/ei2	Improve the presentations of teaching materials
	bi3/ei3	Make my lessons more diverse
	bi4/ei4	Make my lessons more motivating.
	bi5/ei5	Help students understand the lessons quicker.
	bi6/ei6	Develop students' learning skills.
SNi	nk1/mk1	Principal
	nk2/mk2	Colleagues
	nk3/mk3	Head of department
	nk4/mk4	Parents
	nk5/mk5	Students
	nk5/mk6	Curriculum department
PBCi	cb1/lo1	Resources
	cb2/lo2	Professional development
	cb3/lo3	Access to the Internet
	cb4/lo4	Quality software
	cb5/lo5	Physical classroom structure
	cb6/lo6	Support from school administrators
	cb7/lo7	Support from parents
	cb8/lo8	Support from other teachers
	cb9/lo9	Technical support
	cb10/lo10	Time to plan for ICT implementation
	cb11/lo11	Smaller class size
	cb12/lo12	Time to let students to use ICT

5.3 Overview of Statistical Data Analysis Techniques

In this study multiple statistical techniques have been used. Initially, a combination of exploratory factor analysis (EFA), and confirmatory factor analysis (CFA) analysis was used for scale assessment. When a final set of measures was determined, a full structural equation modeling (SEM) with latent variables was used to assess the ICTUM and TPB model in order to test hypotheses. Finally, hierarchical multiple regressions were employed to explore the influence of external variables on the dependent variables (*intention* and *use*). The following sections provide further details about the overall procedures for SEM incorporating CFA and preliminary EFA, and hierarchical multiple regressions.

5.3.1 Structural Equation Modeling (SEM)

1. Overview

Structural Equation Modeling (SEM) is a major statistical technique used in this study. SEM is a comprehensive statistical approach to testing hypotheses about relations among observed and latent variables (Hoyle, 1995). Specifically, SEM examines a set of relationships between one or more observed independent variables, either continuous or discrete, and one or more dependent variables, either continuous or discrete; both of which can either be factors or measured variables (Jodie, 2000) by combining factor analysis and path analysis (Kaplan, 2000).

The general structural equation model, also known as a full model consists of two parts: a *measurement model* and a *structural model* (Joreskog, 1973). The measurement model is made up of observed variables (or indicator variables) linking to latent variables via a confirmatory factor model. The measurement model is also known as a confirmatory factor analytic model. The structural model is made up of latent variables linking to each other via systems of simultaneous equations, with arrows specifying the direction of hypothesized causal paths. As such, a structural model is analogous to a path diagram, and structural modeling is likened to path analysis.

The measurement modeling process determines how well one or more of the observed variables (i.e. measurement items) measures each of the theoretical latent variables (i.e. the unobservable theoretical constructs) through confirmatory factor analysis. For instance, in this study, the measurement model shows links between *attitude towards using ICT* (a theoretical latent variable) and three or more measurement items (ab1, ab2, etc) in order to determine how well those specific observable variables measure the unobservable variable, *attitude towards using ICT*.

The structural modeling process determines the strength of the causal structure among the latent variables in the research model. For instance, in this study the structural model shows a path from *attitude towards using ICT* (a latent variable) to *intention* (another latent variable) to indicate that *intention* is predicted by *attitude towards using ICT*. The previously assessed items in the measurement model are used to assess the structural model.

SEM is chosen as the statistical technique for model testing in the present study as it offers several unique advantages compared to other classical statistical techniques, such as multiple regressions. First, in contrast to other multivariate analyses that assume no measurement errors in estimating independent variables, SEM takes into account errors in observed variables such that a more precise estimation of unobserved theoretical constructs can be obtained using the observed variables that are measured through actual specific items of a questionnaire. As the theoretical models, ICTUM and TPB that underpin this study are composed of latent variables (such as attitudes, perceptions, and beliefs) that were measured by multiple observed variables, SEM was considered a suitable statistical procedure as it would provide increased precision in estimation since it takes into account errors in observed variables.

Second, unlike other multivariate analyses that can only test a single step in a hierarchical model or cannot incorporate measurement data in the test of a model, SEM has an advantage that enables testing of a series of interrelated causal relationships simultaneously as well as incorporating the measurement data. Consequently, SEM is able to estimate the size of the total effects of each independent variable on dependent variables in the multi-stage path model by providing both direct and indirect effect.

The direct effect registers the strength of the direct path from a predictor variable to a particular dependent variable as indicated by the path coefficient, *B*. The indirect effect registers the strength of indirect paths from a predictor variable to a dependent variable through mediator variable(s) in the structural model. For instance, in this study, the direct effect of *perceived behavioural control* (PBC) on *use of ICT* (B) indicates the strength of the path from PBC to B in the TPB model. The indirect effect of PBC on B indicates the strength of the effect of PBC on B through the mediator variable, *intention* (I). Thus the total effect of both direct and indirect variables on the dependent variables in the structural model can be determined. Significantly, the use of SEM in this study should provide a complete perspective of how each of the independent variables affects the dependent variables directly or indirectly.

2. Steps for Structural Equation Model Assessment

In order to assess the ICTUM and TPB models using the SEM statistical procedure, preliminary analysis of the measurement model, which specify the relationships between the latent variables and their corresponding observed variables, was conducted. Separate testing of the measurement models is required to verify the reliability and validity of the observed variables that were used as measures of the respective latent variables. This preliminary procedure is necessary to ensure that the measurement model fits the sample data in order to proceed with the full model testing (Hoyle, 1995).

Once the reliability and validity of the measurement model are confirmed, then the evaluation of the structural model that showed causal relationships among the latent variables can be conducted. This two-stage model assessment (Anderson & Gerbing, 1988) is useful in avoiding confounding interpretation due to interactions between measurement and structural models (Segars & Grover, 1993). Items with low levels of reliability or multiple factor loadings may lead to misinterpretation of model misfit as the source of misfit could originate from within-construct (measurement model) or between-construct (structural model) estimation. Thus, the performance of the items in the measurement model must first be established so that the results of the subsequent structural modeling can be interpreted confidently.

The next two sections describe assessment of the measurement model and the structural model respectively.

5.3.1.1 Assessment of Measurement Model

Assessment of the measurement model involved exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) (Bollen, 1989). Statistical Package for Social Science (SPSS) for Windows version 10.0 software was employed for EFA as a preliminary assessment technique that extracted the number of factors from the questionnaire items. Analysis of Moment Structures (AMOS) version 5.0 software was employed for CFA that assessed the reliability and validity of the individual extracted items and the overall measurement model. Further discussions on both techniques follow below.

1. **Exploratory Factor Analysis (EFA)**

EFA is a useful technique for identifying items that belong to a factor in a multi-factor structure. First, all of the items for measuring the research construct are entered in the statistical program, SPSS, for analysis. The program extracts the number of factors and their associated items, and reports the factor loading of each item on the respective factors. Then the resulting factor structure is examined in order to determine the conformity of the structure to an *a priori* theoretical structure. Then the measurement model is specified by relating each observed variable (i.e. the measurement item) to its corresponding latent variable (i.e. the theoretical factor) using CFA.

2. **Confirmatory Factor Analysis (CFA)**

The specified measurement model is estimated using AMOS 5.0 statistical program. The validity of an item (i.e. observable or indicator variable) of a latent variable is determined by the magnitude of the standardized regression estimates (*B*) value for the path from an indicator variable to the latent variable in the measurement model. The reliability of all the items in measuring the latent variable is indicated by the magnitude of the squared multiple correlation (R^2). Items of the questionnaire used as the indicator variables that show reliability and validity below recommended threshold values are removed and the subsequent structural model is assessed using the items that survived the assessments.

Further confirmation of the overall fit of the measurement model using CFA is obtained from the Maximum Likelihood estimation Chi-Square (χ^2) statistics produced by AMOS and various other goodness-of-fit criteria (see Table 5.2).

Table 5.2. *Criteria for Model Fit Assessment, Item Reliability and Validity*

Fit	Characteristics	Recommended values for acceptable fit
Measures of Absolute Fit: the degree to which the proposed model predicts the observed covariance matrix		
Chi-square (χ^2)	$H_0: \sum = \sum(\theta)$ $H_A: \sum = \sum_\alpha$	Small chi-square ($p > .05$)
Goodness-of-Fit Index (GFI)	Overall degree of fit of the squared residuals from prediction compared with the actual data). Less influenced by sample size and normality	Over .9
Root Mean Square (RMR)	Average residuals between observed and estimated input matrices.	Lower than 1.0
Root Mean Square Error of Approximation (RMSEA)	Average discrepancy per *df* expected to occur in the population.	Lower than .08
Measures of Incremental Fit: Compares the proposed model to a realistic null or baseline model		
Adjusted Goodness-of-Fit (AGFI)	Goodness-of-fit adjusted by degrees of freedom (*df*).	Over .9
Normed Fit Index (NFI)	A relative comparison of the proposed model to the null model. $[\chi^2_{null} - \chi^2_{proposed}]/\chi^2_{null}$	Over .9
Non Normed Fit Index (NNFI) = Tucker-Lewis Index (TLI) Comparative Fit Index (CFI)	A comparative index between the proposed and the null model	Over .9
Measures of Parsimonious Fit: Diagnoses whether model fit is due to over fitting the data with too many coefficients		
Normed chi-square	(χ^2/df)	Between 1.0 and 3.0
Item assessment for reliability and validity:		
Squared Multiple Correlation (R^2)	Used as a measure of reliability of each Indicator variable Used to assess the amount of variation in latent variables explained by predictors	$R^2 > .50$
Standarized Regression Estimates	Used as a measure of validity of each indicator variables (λ) Path significance indicating the effect of One variable on another variable (ß)	$\lambda > .70$

5.3.1.2 Assessment of Structural Model

Assessment of structural model follows after the confirmation of the measurement part of the model. Using AMOS statistical program, the full structural model is specified, and estimated. The criteria for the structural model assessment includes the criteria employed for the measurement model assessment as shown in Table 5.2 as well as two other criteria: path significance or standardized regression estimates (*B*) and squared multiple correlations (R^2).

The path significance indicated by the standardized regression estimate assesses the effect of one variable on another variable. The significance level was set at .05. AMOS 5.0 is capable of assessing direct, indirect and total effects of variables in hierarchical causal relationships among variables in the research model. Standardized regression estimates are also measures of the validity of indicator variables of each construct.

The R^2 are used to assess the amount of variation in a latent variable that is explained by the predictor variables. For a well specified model such that the latent variable is associated strongly with its predictors and is measured adequately by the observed variables, the R^2 is expected to be high. The R^2 is also used as a measure of reliability of each of the indicator variables.

The final assessment of the research model was made by examining all the criteria of fit and the model was re-specified until a good fit was obtained. Table 5.2 shows the evaluation criteria of overall structural equation models.

The fit indices were used as the criteria for measurement model and the subsequent full structural model assessment. The values of the model fit indices were adopted from Bagozzi and Yi (1988) and Hair, Anderson, Tatham, and Black (2000). In this study, a combination of all fit indices was used to assess a model.

5.3.2 Hierarchical Multiple Regression

Hierarchical multiple regression was employed in this study as another statistical method for testing hypotheses relative to the influence of external variables on the dependent variables of the research model, ICTUM. Hierarchical multiple regression is a useful procedure for determining the relationships between a dependent variable and some predictor variables with the effect of other predictor variables statistically eliminated. Hierarchical multiple regression is a procedure for a covariates analysis which investigates if some critical variables contribute to a prediction equation for a dependent variable after the other predictor variables or the covariates have been eliminated from the equation.

In conducting the hierarchical multiple regression, the order of entry of variables into the regression equation was determined *a priori* on the basis of theoretical rationale. In the first step, the covariates (i.e. other predictor variables) were entered into a hierarchical equation to control for their confounding influence. Then, the variables of interest were entered into the equation. The R^2 change and its statistical significance assessed the proportion of variance uniquely accounted for by the predictors of interest.

To summarize, the present study uses both an exploratory and confirmatory approach to data analysis. This study is exploratory such that it purports to develop a new model, ICTUM to explain the phenomenon of interest, while the study is confirmatory as it purports to validate an established model, TPB, which was previously developed empirically. However, this study is exploratory, in general, as the phenomenon of interest is unknown and the items measuring the research constructs had not previously been tested. The following chapter reports on the preparations of the data for analysis and the assessment for measurement models.

Chapter 6 PREPARATION OF DATA FOR ANALYSIS AND ASSESSMENT OF MEASUREMENT MODELS

This chapter describes the preparation of the data for analysis and the assessment of the measurement models. The first section describes the initial data preparation for analysis by verifying the required assumptions about the data for structural equation modeling (SEM) and hierarchical multiple regressions which are the statistical analysis approaches used for analyzing data for the current study. The second section reports on the measurement model assessments in which the individual observed variables for each of the research constructs are examined through univariate analysis, reliability and validity tests.

6.1 Data preparation for analysis

This section describes the procedures for data preparation: testing the assumptions of structural equation modeling in terms of sample size, missing data, outliers, and normality; and managing of problematic items in the questionnaire.

6.1.1 Testing the Assumptions for Structural Equation Modeling

The following procedures are taken to ascertain that the assumptions about the data that will be analyzed using structural equation modeling (SEM) are not violated. Assumptions regarding the sample size, missing variables, absence of outliers, and normality were tested and methods of treatment of the data to minimize any violations of these assumptions are described.

6.1.1.1 Sample Size

This study employed structural equation modeling (SEM), as the major statistical analysis which is a large-sample technique. As a rule of thumb, Tabachnick and Fidell (2000) recommended to obtain at least 300 cases for a comfortable analysis.

Hair et. al. (2000) suggested multiplying 15 times the number of parameters estimated in order to ascertain that the data do not depart from normality. Normality is one of the assumptions that have to be fulfilled for analysis using SEM.

Considering that there are 48 observable variables in this study, then multiplying 48 with 15 will give a minimum of 720 cases. This sample size in this study (N = 1,040) exceeded this minimum value, indicating adequacy of sample size required for employing SEM procedures.

6.1.1.2 Missing Data

The data were also examined for missing values. For this study, the percentages of missing values were lower than 3% across all measures (see Appendix B). For a large data set, as is the case in this study, missing values of 5% or less cause less serious problems and any procedure of handling missing values can be employed (Tabachnick & Fidell, 2000).

In this study, the missing value analysis using SPSS 10.0 was conducted to determine whether the missing data occurred in random or systematic pattern. The test results showed that the 75 cases of missing data occurred and were distributed randomly within the data set. It was then decided that these cases with missing data were discarded as omitting 7.2% of data would not be a considerable loss. Deletion is a good alternative if the number of cases with missing data is small and they occur randomly (Tabachnick & Fidell, 2000).

6.1.1.3 Outliers

An outlier is a case with an extreme value on an individual variable (a univariate outlier) or a strange combination of scores on two or more variables that distort statistics (multivariate outlier). When conducting SEM analysis with ungrouped data, as is the case in the current study, both the univariate and multivariate outliers are sought among all cases at once. Once potential univariate outliers are located, the multivariate outliers are then searched. It is recommended to identify if the potential univariate outliers are also multivariate outliers. Final decision about removal of univariate outliers can be made after identifying them as multivariate outliers as well. The presence of univariate outliers can be detected using graphical methods such as scatter plots or box plots. In this study, box plots were used to inspect outlying cases as they were simpler and literal observation of extreme outliers from the median of the box plots could be made. In order to determine the extent of a problem these outlying cases were likely to be, a comparison is made between the original mean for a particular variable and the 5% trimmed mean (the new mean calculated after the top and bottom 5 percent of cases are removed from the distribution). If the similarity between the two means indicates that the outlying values are not too different from the distribution, then the outlying items will be retained.

In this study, an inspection of the box plots (see Appendix C) shows that there are variables with outlying cases. However, the mean and the 5% trimmed mean values for these cases are not very different indicating that those outlying cases are not too different from the other remaining cases in the distribution. For example, the box plot for item ab2 show that this item is an outlier but the mean (m=3.75, s.d=.903) is not very different from the 5% trimmed mean, showing a value of 3.80 (s.d=.99). Decisions about retaining or omitting these outlying items would be made after inspection for multivariate outliers.

A statistic that is used to identify multivariate outliers is Mahalanobis distance: the distance of a case from the centroid of the remaining cases where the centroid is the point created at the intersection of the means of all the variables. A multivariate outlier is a case that lies outside this concentrated area of points of intersections (the centroid). Evaluation of a multivariate outlier case is based on the critical Chi-square value obtainable from any standard set of statistical tables (see Tabachnick & Fidell, 2000, Table C.4), using the number of independent variables as the degrees of freedom at an alpha level of .001(Tabachnick & Fidell, 2000).

However, in this study, the Mahalanobis distance value for potential outlier cases was identified by inspecting the output table provided by AMOS 5.0 (see Appendix D). From the output table, one hundred cases were identified as multivariate outliers which are significant at $p < .001$. Out of these one hundred cases, a total of thirty-five cases were identified as both univariate and multivariate outliers. These 35 cases were removed from the final data set used for the subsequent analyses.

6.1.1.4 Multivariate Normality

The assumption of multivariate normality is another prerequisite in most of the estimation techniques used in SEM. As the subjects for SEM analyses are not grouped, the assumption of normality then applies only to the distributions of the variables themselves or to the residuals of the analysis (errors between predicted and obtained scores) rather than to the sampling distributions of means of variables as it would be for grouped subjects (Tabachnick & Fidell, 2000).

The assessment of multivariate normality for ungrouped data is based on the normal distribution of the individual variable and the linear relationship between pairs of variables (if present). The assumption of multivariate normality can therefore be partially determined by examining the normality and linearity of individual variables or through examination of residuals in analyses involving prediction (Tabachnick & Fidell, 2000).

Assessment of normality for the individual variable can be made either statistically or graphically. Statistical assessment of normality is provided by examining skewness and kurtosis of the measured variables. Skewness refers to the symmetry of distribution of measured variables while kurtosis refers to the peakedness of distribution of measured variables.

Graphical assessment of normality involves examination of histograms with normal distribution curves, normal probability plots and detrended expected normal probability plots. In the normal probability plots, the observed value for each score is plotted against the expected value from the normal distribution. A normal distribution is indicated by looking at all the cases that should fall along the diagonal running from lower left to upper right of the plots. In the detrended normal probability plots, the actual deviations of the scores are plotted. Normality is assessed by observing that all the cases distribute themselves evenly above and below the horizontal line that intersects the Y axis at 0.0 in the plot. Deviations from normality are indicated by points for cases falling away from the diagonal of the normal probability plots and an uneven distribution of cases above and below the horizontal line of the detrended normal probability plots respectively.

Statistical assessments using skewness and kurtosis of the measured variables were not employed for this study as the standard errors for skewness and kurtosis decrease with larger sample size such that the significance level of skewness is not as important as its actual size and the impact of departure from zero kurtosis also diminishes (Tabachnick & Fidell, 2000, p. 74). For a large sample size, Tabachnick and Fidell (2000, p. 75) recommend assessing normality using normal probability plots and detrended normal probability plots. In this study, normality was assessed graphically using normal probability and detrended normal probability plots (see Appendix E).

Inspection of the normal probability and detrended normal probability plots in Appendix E, shows that there are only a few observed variables that show deviation from the diagonal of the normal probability plots and are distributed unevenly above and below the horizontal line of the detrended normal probability plots.

The next section summarizes the steps taken to deal with cases that were identified as outliers and those departing from normality.

6.1.2 Managing Problematic Questionnaire Items

In the previous section, initial data analyses were conducted to check that the statistical assumptions for conducting SEM and hierarchical multiple regressions were met. For both statistical analyses, the requirements for the use of large sample size have been met in the current study. The problem with cases with missing variables has been dealt with by deleting those cases as there are only a few such cases.

The preliminary data analyses also reveal that there are cases, which are outliers. Those cases that were identified as both univariate and multivariate outliers were removed from the data for the subsequent analyses. After the process of deletion of cases, the number of cases for data analyses was reduced from 1,040 to 965 cases. However, the new sample size was still within the recommended size for analyses with SEM.

The preliminary data analyses also showed that some items deviated from normality. In this study, two treatments were used in an attempt to minimize the threats from non-normality. The first treatment for non-normality was to normalize the data by transforming the original scores while the original mean and standard deviation were retained. Transformations of scores were done using SPSS. The second treatment for non-normality was to select a method of SEM model estimation that would be robust to the non-normality, if the first treatment did not completely remove the threat. The current study employed the maximum likelihood (ML) method of estimation, which is known to be fairly robust to the violation of a normality assumption (Hair, Anderson, Tatham, & Black, 1998; Joreskog & Sorbom, 2000).

In summary, this section described the data preparations necessary for conducting SEM and hierarchical multiple regressions analyses to avoid violation of the assumptions required for legitimate statistical analyses. The following sections describe the model assessments based on the treated data.

6.2 Measurement Model Assessment

After conducting the preliminary data screening described in section 6.1, both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were employed to assess the measurement part of the proposed research model. A total of 71 observed variables were divided into two separate measurement models. One measurement model (Group A) was specified for the 23 observed variables that measured the five latent variables (AB, SN, PBC, I and B) and a second measurement model (Group B) was specified for the remaining 48 observed variables that measured the six types of belief latent variables (BI, EI, NK, MK, CB and LO).

6.2.1 Exploratory Factor Analysis (EFA)

Exploratory factor analysis (EFA) was employed to ascertain that the factor structure of the observed variables was the same as that in the proposed measurement model, and that the proposed latent variable-observed variable relations were supported empirically. The EFA was administered on the whole sample (N = 965).

Using SPSS 10.0 software, an *a priori* 5-factor extraction was requested on the measurement model for Group A (23 observed variables) for the five latent variables;

- Attitude towards ICT use in teaching (AB)
- Subjective norms (SN)
- Perceived behavioural control (PBC)
- Intentions to use (I)
- Use of ICT in teaching (B)

Maximum likelihood (ML) extraction method was used with Promax rotation, a method of oblique rotation that allows for correlation among variables. Oblique rotation was chosen as some correlation was expected among the variables. A factor loading of .3 was used as a lower cut-off value as recommended for exploratory analysis (Pallant, 2001). The results of the EFA show that 60.0% of total variance was accounted for in this factor solution. Table 6.1 presents the factor loadings.

Table 6.1. *Exploratory Factor Analysis (EFA) with 23 observed variables for 5 latent variables*

	Factor				
Variables	1	2	3	4	5
ab1	.566	.147	.015	.195	.133
ab2	.622	.175	.063	.181	.121
ab3	.850	.167	.204	.087	.159
ab4	.900	.192	.200	.055	.150
ab5	.843	.185	.203	.101	.199
sn1	.162	.100	.032	.562	.060
sn2	.186	.101	.077	.635	.139
sn3	.153	.065	.060	.647	.098
sn4	.183	.105	.058	.654	.051
sn5	.153	.136	.044	.635	.063
pbc1	.181	.186	.149	.141	.629
pbc2	.262	.194	.116	.048	.880
pbc3	.231	.190	.163	.073	.669
pbc4	.069	-.019	.012	.121	.126
pbc5	.221	.069	-.030	.282	.219
i1	.163	.848	.154	.372	.120
i2	.191	.873	.151	.014	.171
i3	.168	.715	.198	.063	.067
i4	.169	.792	.162	.066	.101
u1	-.116	-.159	-.530	.040	-.072
u2	.123	.140	.772	.031	.078
u3	.115	.141	.943	.022	.072
u4	.106	.137	.862	.040	.079

Extraction Method: Maximum
Rotation Method: Promax with Kaiser Normalization.

Table 6.1 shows that most of the items are loaded on their hypothesized factor (based *a priori* on the five constructs of the theory of planned behaviour: *Attitude towards behaviour* (AB), *subjective norms* (SN), *perceived behavioural control* (PBC), *intention* (I), and *use of ICT* (B). The table demonstrates that items ab1 to ab5 show factor loadings above the lower cutoff value of .3 on factor 1 (AB factor); items sn1 to sn5 load on factor 4 (SN factor); items pbc1 to pbc3 show factor loading above the lower cutoff value of .3 on factor 5 (PBC factor). The other two items (pbc4 and pbc5) that are loaded on two factors (factor 4 and 5) while item pbc5 also loads on factor 1. However, pbc4 and pbc5 loads on these factors with factor loading below the lower cutoff value. Items i1 to i4 load on factor 2 (referred as I factor), and items u1 to u4 load on factor 3 (B factor). All these items (items i1 to i4 and, u1 to u4) show factor loadings above the lower cutoff value.

The second EFA for 6-factor extraction (based *a priori* on the belief constructs of TPB) was performed on the measurement model of Group B (48 observed variables). The beliefs constructs were conceptualized in two dimensions for each of the three types of beliefs;

a) behavioural beliefs (ABi): beliefs about outcome (BI), and beliefs about importance of outcome (EI);

b) normative beliefs (SNi): beliefs about referents' expectation (NK), and beliefs about influence of referents' expectations (MK); and

c) control beliefs (PBCi): beliefs about enabling factors (CB), and beliefs about availability of enabling factors (LO).

Maximum likelihood extraction with Promax rotation was again requested, and a factor loading of .3 was used as the lower cut-off value. According to the results, 65.54% of the total variance was explained by this factor solution. The factor loadings are presented in Table 6.2. The table shows most items were loaded on their hypothesized factors except for the six items of the beliefs about outcome (BI), which are loaded onto the same factor (factor 1) as the six items of the beliefs about importance of outcome (EI). The items nk1 to nk6 showed factor loadings of more than .3 on factor 5 (which correspond to beliefs about referent's expectations, NK factor). However, items nk4 and nk5 also show factor loading of more than .3 on factor 6. Items mk1 to mk6 showed factor loadings of more than .3 on factor 4 (which corresponds to beliefs about the influence of referents' expectation, MK factor). Items mk4 and mk5 also show factor loading of more than .3 on factor 6. Items cb1 to cb12 showed factor loadings of more than .3 on factor 2 (which corresponds to beliefs about enabling factors, CB factor). However, item cb7 also loads on factor 6 with factor loading of more than .3. Items lo1 to lo12 showed factor loadings more than .3 on factor 3 (which corresponds to beliefs about availability of enabling factors, LO factor). Item lo7 also loads on factor 6 with factor loading of more than .3.

Overall, the first EFA with Group A test results indicated that all the items were loaded on to the respective hypothesized factors except for items pbc4 and pbc5 which showed factor loadings of less than the lower cutoff value of .3. The second EFA with Group B test results indicated that most the items except for the two beliefs dimensions of ABi (BI and EI) were loaded onto their respective hypothesized belief factors. The problematic items of ABi, where all the items were loaded on to one factor only (unidimensional), and items which showed double loadings (items nk4, nk5, mk4, mk6, cb7, and lo7) required further examination. The following section describes the confirmatory factor analyses (CFA) to assess unidimensionality of the behavioural belief structures (ABi) and the double-loaded items.

Table 6.2. *Exploratory Factor Analysis (EFA) with 48 observed variables for 6 beliefs dimensions*

	Factor					
	1	2	3	4	5	6
bi1	.807					
bi2	.819			-.113		
bi3	.815					
bi4	.850					
bi5	.816					
bi6	.794					
ei1	.847			.124		
ei2	.817					
ei3	.835					
ei4	.850					
ei5	.776					.128
ei6	.785					.101
nk1					.767	-.157
nk2					.843	.133
nk3					.888	
nk4					.675	.418
nk5					.623	.312
nk6				.113	.687	
mk1				.898		
mk2				.659	.153	.148
mk3				.833	.118	
mk4				.637		.535
mk5				.663		.441
mk6				.765		.145
cb1	.114	.694				-.150
cb2	.127	.692				-.112
cb3		.682				-.106
cb4		.793				-.101
cb5		.800				
cb6		.813				
cb7		.669				.394
cb8		.735				.221
cb9		.856				.134
cb10		.848				
cb11	-.103	.793				
cb12		.824				.124
lo1			.782			-.104
lo2			.704			
lo3			.530			-.103
lo4			.814			
lo5			.766			
lo6		.125	.669	.100		
lo7			.624			.349
lo8		.139	.603	.129		.207
lo9			.803			.141
lo10			.821			
lo11		-.131	.809			
lo12		-.107	.809			

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalization.

6.2.2 Assessment of problematic items

The items (bi1 to bi6 and ei1 to ei6) for measuring the two dimensions for behavioural belief, ABi: beliefs about outcome (BI) and beliefs about importance of outcome (EI) respectively were assessed using confirmatory factor analysis by specifying a one-factor model and two-factor model, and then comparing the two models based on the model fit indices. Further discussion on the results of this analysis is presented in the next section (refer to page 107).

6.2.3 Confirmatory Factor Analysis (CFA)

The *a priori* measurement models assessed initially with EFA were then assessed using confirmatory factor analysis (CFA). The CFA of the measurement models was conducted using AMOS 5.0 software. The following steps were employed to assess the measurement models (Kwon, 2002).

1. Sample split: The total study sample was split into test and validation sub-samples.

2. Measurement Model Specification: The behavioural belief models (One-factor versus Two-factor Model), and the two measurement models (Group A and Group B) were specified using AMOS Graphics software.

3. Assessment of overall model fit: The specified measurement models were assessed using maximum likelihood estimation.

4. Assessment of observed variables: Each of the observed variables in the measurement model was assessed for validity and reliability.

5. Validation of measurement model: The re-specified measurement models with the test sample were reassessed with the second sub-sample for validation.

Further discussions on each of the above steps are detailed below.

1. Sample Split

By requesting "approximately 50% of the sample at random" using SPSS 10.0 software, the total sample (N = 965) was split into two samples: test sample (N = 483) and validation sample (N = 482). The test sample was assigned for the assessment of the initially specified measurement model, while the validation sample was assigned for the re-specified measurement model.

The two sub-samples were first compared statistically to ascertain that there were no differences between the two independent samples. The test results presented in Table 6.3 indicated that there were no statistical significant differences between the test and validation samples in any of the demographic variables or the major dependent variables at $p < .05$.

Table 6.3. *Independent samples t-test for the difference between Test sample (N = 482) and Validation Sample (N = 483)*

	Df	Mean difference	Probability (2-tailed)
Age	960	-0.05	.648
Sex	944	0.03	.648
Subject	957	-0.31	.093
Experience	955	-0.02	.850
Period	885	-.004	.207
Qualification	962	-0.05	.368
Level	957	-0.06	.245
Class access	957	0.001	.953
Computer room access	949	-.05	.076
Attitude	963	0.02	.930
Subjective norms	963	.19	.395
Intention	963	.28	.118

Note. Mean difference = Scores of Test Sample – Scores of Validation Sample

2. Measurement Model Specification

Four measurement models were specified using Amos 5.0 Graphic. The first two confirmatory models were for a one-factor model (One-factor), and a two-factor model (Two-factor) for the behavioural belief (ABi) dimension. The third confirmatory model was for the 5 latent variables (Group A) and the fourth for the beliefs dimensions (Group B): behavioural, normative and control beliefs. The models were specified using the items with factor loading above .3 identified in the EFA. The specified models for One-factor and Two-factor behavioural beliefs are shown in Figure 6.1 and Figure 6.2 respectively. The specified models for Group A and Group B are shown in Figure 6.3 and Figure 6.4 respectively.

3. Assessment of Overall Measurement Model Fit

The four CFA models for One-factor, Two-Factor, Groups A and B were assessed for their overall fit using fit indices provided by AMOS. The results of the model assessments are presented with the criteria of acceptable model fit in Table 6.4 and Table 6.5.

1. One-factor versus Two-factor Models

Table 6.4 indicates that most of the fit indices of the One-factor and Two-factor models did not meet the criteria. For the One-factor model, all the fit indices except one (RMR) did not reach the recommended acceptable fit.

In the case of the measurement model of Two-factor model only three (NFI, CFI and RMR) of the fit indices meet the recommended acceptable fit.

Table 6.4. *Comparison of Model Fits between One-Factor and Two-Factor Models for Behavioural Beliefs*

Fit measure	One-factor Model	Two-factor Model	Recommended values for fit
Chi-square (χ^2)	1113.05 p=.000	570.834 p=.000	p>.05
Degrees of freedom (df)	54	53	
Normed χ^2	20.61	10.77	Between 1.0 and 3.0
GFI	.667	.831	Over .90
AGFI	.518	.751	Over .90
NFI	.820	.907	Over .90
TLI	.788	.894	Over .90
CFI	.826	.915	Over .90
RMR	.055	.033	Lower than .10
RMSEA	.202	.142	Lower than .08

The models specified for the One-factor and Two-factor behavioural beliefs are shown in Figure 6.1 and Figure 6.2 respectively. The numbers next to the arrows are values of standardized regression estimates, λ, which indicate measures of reliability. The numbers at the top right hand corner are the squared multiple correlations (R^2), which indicate measures of validity. (Detailed discussions on indicators of measures of validity and reliability are found on page 115).

Examination of the reliability and validity of each of the observed variables showed that all variables are reliable and valid as indicated by values of λ and R^2 above the threshold values ($\lambda > .7$, and $R^2 > .5$). Since all the observed variables in both models were reliable and valid, re-specifications of the models were not initiated, and the determination of the best model was based on meeting the criteria of model fit indices.

In summary, the Two-factor model showed more indices (NFI, CFI and RMR) closer to the recommended values for model fits than the One-factor model (RMR). Based on this result, the behavioural belief construct will be assessed as a two-dimensional factor for the subsequent CFA measurement model analysis for Group B.

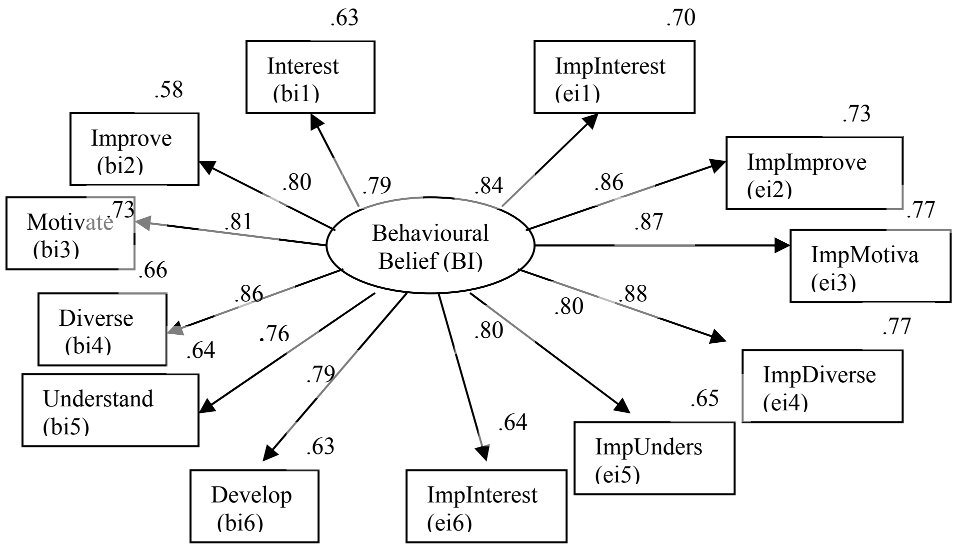

Figure 6.1. One-Factor Model.

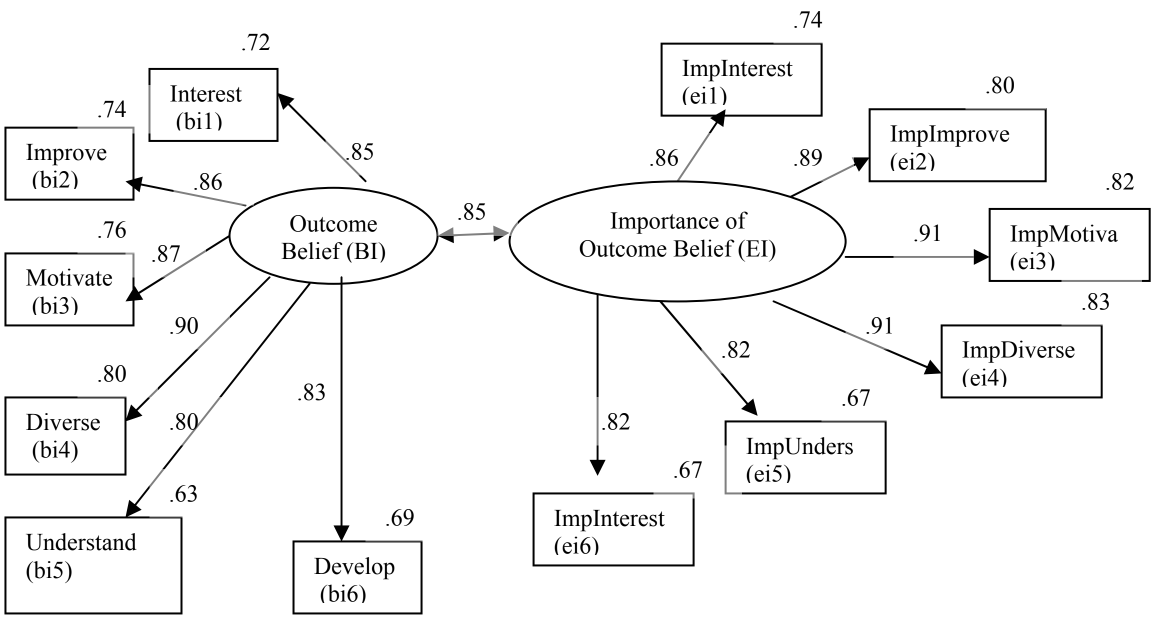

Figure 6.2. Two-factor Model.

2. Measurement Models for Group A and Group B

Table 6.5 presents the assessment for model fits for Group A (the five latent variables) and Group B (the six belief dimensions).

Table 6.5. *Assessment of Measurement Model Fit of Group A and Group B*

Fit	Measurement Model of Group A	Measurement Model of Group B	Recommended values for acceptable fit
Chi-square (χ^2)	796.83 (p = .000)	5144.00 (p = .000)	Small chi-square (p > .05)
Degrees of Freedom (df)	220	1065	
Normed chi-square (χ^2/df)	3.62	4.83	Between 1.0 and 3.0
Goodness-of-Fit Index (GFI)	.865	.651	Over .9
Adjusted Goodness-of-Fit (AGFI)	.831	.615	Over .9
Normed Fit Index (NFI)	.889	.758	Over .9
Non Normed Fit Index (NNFI) = Tucker-Lewis Index (TLI)	.904	.785	Over .9
Comparative Fit Index (CFI)	.917	.797	Over .9
Root Mean Square (RMR)	.062	.068	Lower than .1
Root Mean Square Error of Approximation (RMSEA)	.074	.089	Lower than .08

As Table 6.5 indicates, most fit indices of both models did not meet the criteria. Only four (TLI, CFI, RMR and RMSEA) of the fit indices meet the recommended acceptable fit for the measured model for Group A.

In the case of the measurement model of Group B (6 beliefs-dimensions), all of the fit indices except one (RMR) did not meet the recommended acceptable fit.

The models specified for Group A and Group B are illustrated in Figure 6.3 and Figure 6.4 respectively. Examinations of the measures of reliability and validity showed that there were items that did not meet the threshold values for validity ($\lambda > .7$) and reliability ($R^2 > .5$).

Because of the poor fit and the presence of invalid and unreliable items, re-specification of the initial measurement model was performed for both models. For this purpose, the individual observed variables of the two measurement models (Group A and Group B) were examined for reliability and validity. Those variables that did not meet the cut-off values for validity ($\lambda > .7$) and reliability ($R^2 > .5$) were removed. Re-specifications of the models were initiated using the remaining valid and reliable observed variables. The resulting improved set of variables from the re-specification processes was used to test hypotheses and assess the structural equation models.

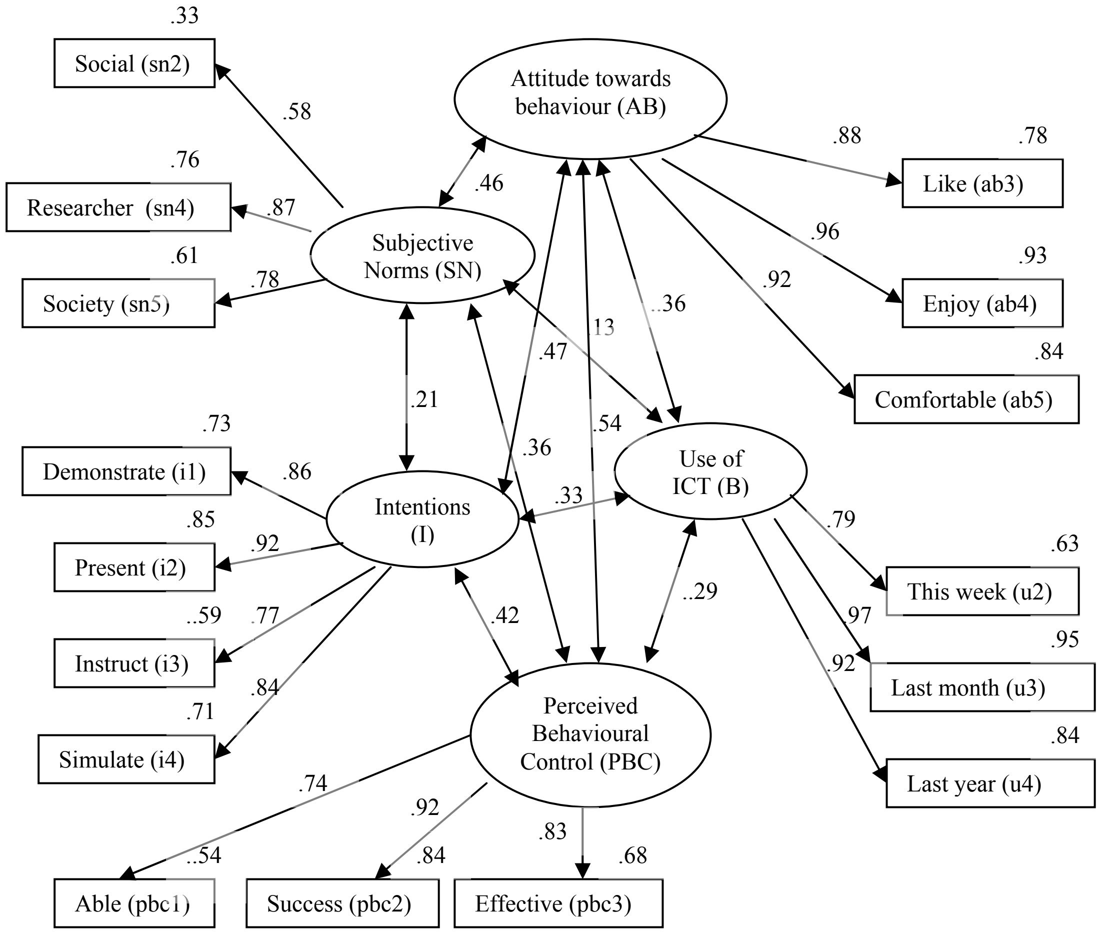

Figure 6.3. Measurement model re-specified for Group A (5 latent variables) for test sample.

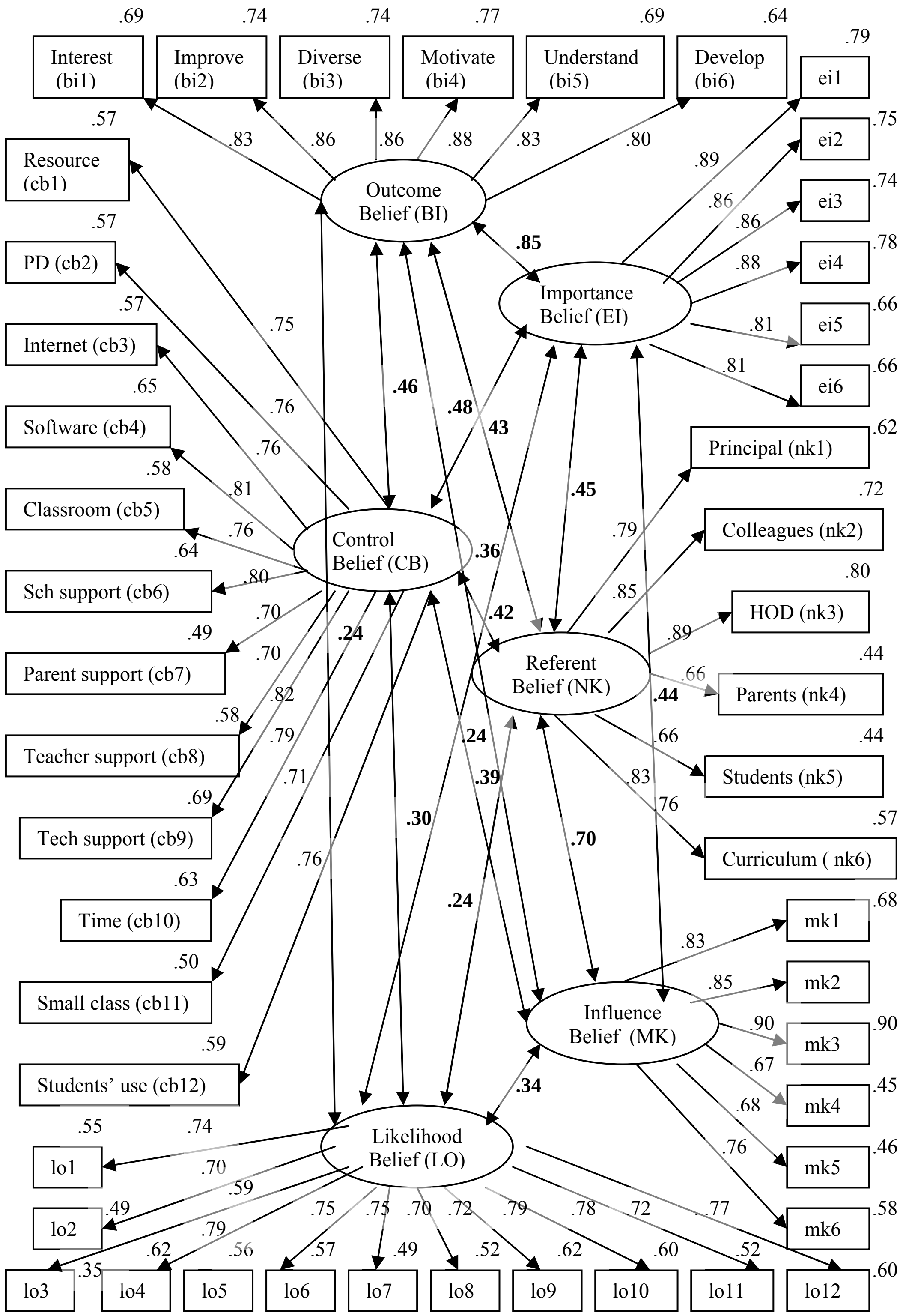

Figure 6.4. Measurement model specified for Group B (6 belief latent variables) for test sample.

4. Assessment of Individual Observed Variables

The validity and reliability of each observed variable in the measurement model were also assessed, in complement to the overall model fit. In addition to meeting the overall model fit criteria, the observed variables that met the validity and reliability criteria were used for the subsequent structural model assessments.

Validity

Validity of an observed variable refers to the extent to which it measures what it is supposed to measure, that is, the latent variable. Validity of observed variables in SEM, is assessed by the magnitude of standardized regression weights estimates (Bollen, 1989). Items with estimates of .7 or higher were considered to show sufficient validity (Stangor, 1998). Test results are presented in the third column in Table 6.6. According to these test results, seven observed variables did not reach the lower cut-off value of .7 in the 5-latent variable measurement model (Group A):

ab1, ab2, sn1, sn3, pbc4, pbc5, and u1.

In the case of the 6-beliefs dimensions measurement model (Group B), five observed variables did not meet the criteria of validity:

nk4, nk5, mk4, mk5, and lo3.

Item Reliability

Item reliability refers to the consistency of measurement among a set of observed variables. In SEM, reliability is assessed by the magnitude of the square multiple correlations (R^2) between the items and the constructs (Bollen, 1989). Items with R^2 of above .5 indicates sufficient reliability (Bagozzi & Yi, 1988). Items that show SMC above the cut-off value of .5 indicate more than 50% of the variance is explained by the item, and that the measurement error in the item is less than 50% of the variance. The test results are presented in the fourth column of Table 6.6. The same seven items in Group A that lacked validity were identified as unreliable. In the case of group B, in addition to the five items identified as lacking in validity, another three items (cb7, lo2, and lo7) were shown to lack reliability.

Table 6.6. *Validity and Reliability Assessment (Group A and Group B) of Initial Measurement Models for Test Sample*

Original 23 Observed Variables (Group A)			
Latent Variable	Observed variable	Validity (λ)	Item reliability (R^2)
Attitude towards Behaviour (AB)	ab1	.61	.37
	ab2	.69	.48
	ab3	.89	.79
	ab4	.95	.91
	ab5	.92	.85
Subjective norms (SN)	sn1	.59	.35
	sn2	.73	.53
	sn3	.68	.46
	sn4	.75	.56
	sn5	.71	.50
Perceived Behavioural Control (PBC)	pbc1	.74	.55
	pbc2	.91	.83
	pbc3	.82	.68
	pbc4	.20	.04
	pbc5	.36	.13
Intentions (I)	i1	.86	.73
	i2	.92	.85
	i3	.77	.59
	i4	.84	.71
Use of ICT (B)	u1	-.53	.28
	u2	.79	.63
	u3	.97	.94
	u4	.92	.85
Original 48 Observed Variables (Group B)			
Latent Variable	Observed variable	Validity (λ)	Item reliability (R^2)
Beliefs about outcome (BI)	bi1	.83	.69
	bi2	.86	.74
	bi3	.86	.74
	bi4	.88	.77
	bi5	.83	.69
	bi6	.80	.64
Beliefs about importance of outcome (EI)	ei1	.89	.79
	ei2	.86	.75
	ei3	.86	.74
	ei4	.88	.78
	ei5	.81	.66
	ei6	.81	.66

Table 6.6 (continued)

Latent Variable	Observed variable	Validity(λ)	Item reliability SMC)
Beliefs about referents expectations (NK)	nk1	.79	.62
	nk2	.85	.72
	nk3	.89	.80
	nk4	.66	.44
	nk5	.66	.44
	nk6	.76	.57
Beliefs about influence of referents expectations (MK)	mk1	.83	.68
	mk2	.85	.72
	mk3	.90	.90
	mk4	.67	.45
	mk5	.68	.46
	mk6	.76	.58
Beliefs about enabling factors (CB)	cb1	.75	.57
	cb2	.76	.57
	cb3	.76	.57
	cb4	.81	.65
	cb5	.76	.58
	cb6	.80	.64
	cb7	.70	.49
	cb8	.76	.58
	cb9	.82	.68
	cb10	.79	.63
	cb11	.71	.50
	cb12	.76	.59
Beliefs about availability of enabling factors (LO)	lo1	.74	.55
	lo2	.70	.49
	lo3	.59	.35
	lo4	.79	.62
	lo5	.75	.56
	lo6	.75	.57
	lo7	.70	.49
	lo8	.72	.52
	lo9	.79	.62
	lo10	.78	.60
	lo11	.72	.52
	lo12	.77	.60

Unidimensionality.

Unidimensionality is an assessment of the internal and external consistency of scale items. Unidimensionality was assessed by observing that all items pertaining to a latent variable have similar measures of validity (λ). In this study, the criterion of unidimensionality is indicated by a minimum validity of .7 (Segars, 1997). Hoyle (1995) suggested that for all CFA models, large and statistically significant estimates provide an indication of convergent validity (i.e. the extent of a construct is related to other construct). Looking at the third column of Table 6.6, all items across all research constructs met this criterion. Although all the items (except pbc4 and pbc5) were above the threshold value of .7, there were some items (ab1 and ab2 vs. ab3, ab4 and ab5) that showed possible presence of multi-dimensional constructs. This problem and problems identified in the validity and reliability assessments are discussed below.

Table 6.7. *Validity and Reliability Assessment (Group A and Group B) of Re-specified Measurement Models for Test Sample*

Group A		Initial 23 indicators		Re-specified 15 indicators	
Latent Variable	Observed variable	Validity (λ)	Item reliability (R^2)	Validity (λ)	Item reliability (R^2)
Attitude towards Behaviour (AB)	ab1	.61	.37	Removed	removed
	ab2	.69	.48	removed	removed
	ab3	.89	.79	.88	.78
	ab4	.95	.91	.96	.93
	ab5	.92	.85	.92	.84
Subjective norms (SN)	sn1	.59	.35	removed	removed
	sn2	.73 (.58)	.53 (.33)	removed	removed
	sn3	.68	.46	removed	removed
	sn4	.75 (.87)	.56 (.76)	.93	.86
	sn5	.71 (.78)	.56 (.78)	74	.55
Perceived Behavioural Control (PBC)	pbc1	.74	.55	.74	.54
	pbc2	.91	.83	.92	.84
	pbc3	.82	.68	.82	.68
	pbc4	.20	.04	removed	removed
	pbc5	.13	.13	removed	removed
Intention (I)	i1	.86	.73	.86	.73
	i2	.92	.85	.92	.85
	i3	.77	.59	.77	.77
	i4	.84	.71	.84	.71
Use of ICT (B)	u1	-.53	.28	removed	removed
	u2	.79	.63	.79	.63
	u3	.97	.94	.97	.95
	u4	.92	.85	.92	.84
Group B		**Initial 48 indicators**		**Re-specified indicators**	
Latent Variable	**Observed variable**	**Validity (λ)**	**Item reliability (R^2)**	**Validity (λ)**	**Item reliability (R^2)**
Beliefs about outcome (BI)	bi1	.83	.69	.83	.69
	bi2	.86	.74	.86	.74
	bi3	.86	.74	.86	.74
	bi4	.88	.77	.88	.77
	bi5	.83	.69	.83	.66
	bi6	.80	.64	.80	.64
Beliefs about importance of outcome (EI)	ei1	.89	.79	.89	.74
	ei2	.86	.75	.86	.80
	ei3	.86	.74	.86	.82
	ei4	.88	.78	.89	.83
	ei5	.81	.66	.81	.67
	ei6	.81	.66	.81	.67

Table 6.7 (continued)

Latent Variable	Observed variable	Validity (λ)	Item reliability (R^2)	Validity (λ)	Item reliability (R^2)
Beliefs about referents expectations (NK)	nk1	.79	.62	.81	.65
	nk2	.85	.72	.83	.69
	nk3	.89	.80	.93	.86
	nk4	.66	.44	removed	removed
	nk5	.66	.44	removed	removed
	nk6	.76	.57	.73	.54
Beliefs about influence of referents expectations (MK)	mk1	.83	.68	.83	.69
	mk2	.85	.72	.84	.70
	mk3	.90	.81	.94	.88
	mk4	.67	.45	removed	removed
	mk5	.68	.45	removed	removed
	mk6	.76	.58	.73	.53
Beliefs about enabling factors (CB)	cb1	.75	.57	.78	.61
	cb2	.76	.57	.79	.62
	cb3	.76	.57	.77	.60
	cb4	.81	.65	.84	.70
	cb5	.76	.58	.77	.59
	cb6	.80	.64	.79	.63
	cb7	.70	.49	removed	removed
	cb8	.76	.58	.74	.54
	cb9	.82	.68	.81	.66
	cb10	.79	.63	.77	.59
	cb11	.71(.70)	.50 (.49)	removed	removed
	cb12	.76	.59	.73	.53
Beliefs about availability of enabling factors (LO)	lo1	.74 (.59)	.55 (.49)	Removed	Removed
	lo2	.70	.49	removed	removed
	lo3	.59	.35	removed	removed
	lo4	.79(69)	.62 (.48)	removed	removed
	lo5	.75(.69)	.56 (.59)	removed	removed
	lo6	.75(.65)	.57(.42)	removed	removed
	lo7	.70	.49	removed	removed
	lo8	.72 (.69)	.52(.47)	removed	removed
	lo9	.79 (.68)	.62 (.47)	removed	removed
	lo10	.79	.60	.81	.65
	lo11	.72	.52	.86	.73
	lo12	.77	.65	.95	.90

Note. Numbers in parentheses are obtained after subsequent re-specifications.

Discussions of problematic items

For the purpose of explaining the lack of model fit for Group A and Group B measurement models, each of the 15 problematic items (ab1, ab2, sn1, sn3, pbc4, pbc5, u1, nk4, nk5, mk4, mk5, cb7, lo2, lo3, and lo7) was examined closely in terms of the wording in the survey questionnaire (see Appendix A for ICTE questionnaire), EFA results (Table 6.1 and Table 6.2), and validity and reliability test statistics (refer to Table 6.6).

In the case of the five items measuring *attitude towards use of ICT in teaching* (AB), ab1 (*I feel that teaching using ICT is a good idea)* and ab2 (*I feel that teaching using ICT is appropriate)* were found to be problematic items, showing EFA factor loadings of .566 and .622 respectively (values slightly lower than the other three items (.850 for ab3, .900 for ab4, and .843 for ab5). The low performance of ab1 and ab2 could be due to the difference in what was asked. The AB scale consisted of items asking about how teachers feel about teaching with ICT. Items ab1 and ab2 described opinions about using ICT, such as teaching using ICT is “a good idea” (ab1) and “appropriate” (ab2), while the other three items described actual feelings such as “like” (ab3), “enjoy” (ab4), and “comfortable” (ab5) when using ICT in teaching. The two items also showed values of validity (λ = .61 for ab1 and λ = .69 for ab2) and reliability (R^2 = .37 for ab2 and R^2 = .48 for ab2) lower than the threshold values of .7 and .5 respectively. On these bases, the two items were dropped from the scale and hence the AB scale was unidimensional *viz.* the three remaining items were measuring the same construct.

In the case of five items of *subjective norms* (SN), item sn1 (*people with whom I work*) and sn3 (*people who are important to me*) were found to be problematic. Although these two items (factor loadings of .562 and .647 respectively) showed similar EFA factor loadings with the other three items (.635, .654, and .635), sn1 and sn3 showed validity and reliability lower than the threshold value (λ = .59 and R^2 = .35 for sn1; and λ = .68 and R^2 = .46 for sn3). On the bases of lacking validity and reliability, these two items were removed from the SN scale.

In the case of the five items of *perceived behavioural control* (PBC), item pbc4 (*there are some things I cannot control when I use ICT in teaching)* and item pbc5 (*I can teach using ICT if I have support)* were found to be problematic. EFA revealed that the two items have lower than .3 factor loadings (.126 and .219 respectively). Therefore they were omitted from the PBC scale.

In the case of the four items of *use of ICT* (B), the problematic item u1 (*Do you use computers for teaching?)* showed EFA factor loading of -.530. This item was omitted from the scale as it lacks validity (λ = -.53) and reliability (R^2 = .28). The low performance of this item may be due to inconsistency in the question which asked if teachers use computers for teaching, while the other three items asked for the frequency of ICT use in teaching.

In the case of the six items of beliefs about referents' expectations (NK), two items (nk4 and nk5) were found to be problematic: Item nk4 (*what do parents think about teacher use of ICT*), and item nk5 (*what do students think about teacher use of ICT)*. These two items load on two factors. However, these items show smaller values of factor loading (.675 for nk4 and .623 for nk5) on the same factor which they shared with the other four NK items (.767 for nk1, .843 for nk2, .888 for nk3 and .687 for nk6). Nevertheless, items nk4 and nk5 show low validity (λ = .66 for nk4, and λ = .66 for nk5) and reliability (R^2 = .44 for nk4, and R^2 = .44 for nk5). Due to the lack of validity and reliability, these two items were dropped from the NK scale.

In the case of the six items of beliefs about influence of referents' expectation (MK), two items (mk4 and mk5) were found to be problematic. Item mk4 (*what parents think influences teacher use of ICT)* and item mk5 (*what students think influences teacher use of ICT)* showed factor loadings of .637 and .663 respectively on the same factor shared with the other four MK items (.898 for mk1, .659 for mk2, .833 for mk3, and .765 for mk6), and factor loadings of .535 and .441 respectively on another factor in EFA. However, both items lack validity (λ = .67 for mk4, and λ = .68 for mk5) and reliability (R^2 = .45 for mk4, and R^2 = .46 for mk5). Therefore, these two items were dropped from the MK scale.

In the case of the twelve items for the beliefs about enabling factors scale (CB), only one item, cb7 (*parent as one of the factors that would enable teacher to teach effectively using ICT)* was found to be problematic. Item cb7 showed similar factor loading (.669) to the other eleven items (.694 for cb1, .692 for cb2, .682 for cb3, .793 for cb4, .800 for cb5, .813 for cb6, .735 for cb8, .856 for cb9, .848 for cb10, .793 for cb11, and .824 for cb12) and a factor loading of .394 on another factor in EFA. However, cb7 was found to be unreliable (R^2 = .49) and was therefore dropped from the CB scale.

Finally, in the case of the twelve items for the beliefs about the availability of the enabling factors scale (LO), three items were found to be problematic. Item lo2 (*professional development opportunities*), lo3 (*access to the Internet*), and item lo7 (*support from parents*) showed similar factor loadings (.704 for lo2, .530 for lo3, and .624 for lo7) to the other eight items (.782 for lo1, .814 for lo4, .766 for lo5, .669 for lo6, .603 for lo8, .803 for lo9, .821 for lo10, .809 for lo11, and .809 for lo12). Item lo7 also showed a factor loading of .349 on another factor in EFA. However, item lo3 was found to be invalid and unreliable (λ = .59; R^2 = .35) and items lo2 and lo7 were found to be unreliable (R^2 = .49 for lo2, and R^2 = .49 for lo7). Based on the lack of validity and reliability, these three items are dropped from the LO scale.

In conclusion, the problematic items that showed values of validity and reliability below the threshold values were removed from the initial measurement models of Group A and Group B. Consequently, the re-specified five latent variables measurement model (Group A) was constructed with the remaining 16 items by removing the 7 items (ab1, ab2, sn1, sn2, pbc4, pbc5, and u1) from the initial 23 items.

The re-specified measurement model for the six belief dimensions, Group B, was constructed with the 40 items by removing 8 items (nk4, nk5, mk4, mk5, cb7, lo2, lo3, and lo7) from the original 48 items.

The fifth and sixth column of Table 6.7 present the reassessed validity and reliability of all 16 remaining observed variables for Group A and 40 observed variables for Group B. After re-specification, there are items that show validity and reliability below the lower cutoff values. The numbers in parentheses in Table 6.7 present the values of validity and reliability after re-specification. Items that do not have parentheses show the same validity and reliability values as the initial specifications.

With reference to Table 6.7, only one item (sn2) from Group A showed validity (λ = .58) and reliability (R^2 = .33) below the lower cutoff values. This item was removed from the final measurement model. For Group B, one item (cb11) that showed reliability lower than the threshold value (R^2 = .49) was removed from the CB scale, and six items (lo1, lo4, lo5, lo6, lo8, and lo9) were removed from the LO scale. These items showed validity and reliability below the lower cutoff values (λ = .59, R^2 = .49 for lo1; λ = .69, R^2 = .48 for lo4; λ = .69, R^2 = .49 for lo5; λ = .65, R^2 = .42 for lo6; λ = .69, R^2 = .47 for lo8; λ = .68, and R^2 = .47 for lo9). Several model re-specifications were performed for Group B in order to obtain the best model with improved fit indices. Through these numerous re-specification processes, more items from the LO scale were removed.

The model fit indices before and after the model re-specifications are compared in Table 6.8. The third and fifth columns of Table 6.8 show the reassessed model fit.

Table 6.8. *Comparison of Measurement Model Fits Before and After Re-specification of Test Sample*

Fit measure	Group A (5 Latent Variables)		Group B (10 Latent Variables)		Recommended values for fit
	Initial Measurement Model	Re-specified Measurement Model	Initial Measurement Model	Re-specified measurement Model	
Chi-square (χ^2)	778.00 p=.000	116.84 p=.005	5144.00 p=.000	2211.43 p=.000	p>.05
Degrees of freedom (df)	220	80	1065	480	
Normed χ^2	3.54	1.46	4.83	4.61	Between 1.0 and 3.0
GFI	.868	.969	.651	.777	Over .90
AGFI	.834	.953	.615	.739	Over .90
NFI	.894	.979	.758	.848	Over .90
TLI	.909	.991	.785	.864	Over .90
CFI	.921	.993	.797	.876	Over .90
RMR	.069	.033	.068	.047	Lower than .10
RMSEA	.073	.031	.089	.087	Lower than .08

Table 6.8 shows that measurement model for Group A was improved through re-specifications, although the chi-square statistics still indicated lack of fit (p = .005). However, all of the other fit indices in Group A were improved from the initial model and were above the lower cutoff value, indicating acceptable fit. The

measurement model for Group B improved through re-specification as indicated by most fit indices that improved from the initial model but all indices are below the recommended values of acceptable fit criteria except for RMR. Although the measurement model for Group B showed marginal model fit, it was retained for analysis with SEM in the present study, since all the indicator variables of the measurement model showed acceptable levels of reliability and validity.

5. Validation of the measurement model using the untested sample

The final re-specified measurement models for Group A and Group B were reassessed with an untested sample (referred to as the validation sample) to determine the consistency of model performance across different samples. For the present study, the two re-specified measurement models were tested with the test sample (N = 482) and validated with the validation sample (N = 483). The overall model fit assessments for the test and validation samples are presented in Table 6.9 and validities and reliabilities of indicator variables for Group A and Group B are presented in Table 6.10. Since the purpose of the validation procedure is to determine whether the measurement model used in the test sample is replicable, the detailed discussion of the statistics in the tables is not repeated here.

Table 6.9. *Validation of the Re-specified Measurement: Overall Model Fit Assessment*

Fit measure	Group A (5 Latent Variables)		Group B (6 Beliefs Dimensions)		Recommended values for fit
	Test Sample	Validation Sample	Test Sample	Validation Sample	
Chi-square (χ^2)	116.84 p=.005	153.12 p=.000	2211.43 p=.000	2147.76 p=.000	p>.05
Degrees of freedom (df)	80	80	480	480	
Normed χ^2	1.46	1.91	4.61	4.48	Between 1.0 and 3.0
GFI	.969	.960	.777	.781	Over .90
AGFI	.953	.939	.739	.744	Over .90
NFI	.979	.971	.848	.858	Over .90
TLI	.991	.982	.864	.874	Over .90
CFI	.993	.986	.876	.886	Over .90
RMR	.033	.040	.047	.041	Lower than .10
RMSEA	.031	.044	.087	.085	Lower than .08

Table 6.9 presents the results of the overall fit model assessment administered with the validation sample. Compared with the test sample, the assessments with the validation sample generally showed fit indices slightly lower or higher but still compatible with those of the test sample. For Group A, the measurement model showed acceptable fit for most indices except for Chi-square fit measure (χ^2_{80} = 116.84, p = .000) that show a significant p value, violating the recommended value of above .5 for acceptable fit.

For group B, most of the fit indices show marginal acceptable fit except for RMR, which is well below the recommended fit value. Table 6.10 shows the results of the assessment for validity and reliability conducted with the validation sample. The table indicated that all the items were above the lower cutoff values for validity and reliability.

Table 6.10. *Validation of Re-specified Measurement Model: Validity and Reliability*

Group A		Test sample (N=482)		Validation sample (N=483)	
Latent Variable	Observed Variable	Validity (λ)	Item reliability (R^2)	Validity (λ)	Item reliability (R^2)
Attitude towards Behaviour (AB)	ab3	.88	.78	.92	.86
	ab4	.96	.93	.96	.92
	ab5	.92	.84	.93	.86
Subjective norms (SN)	sn4	.93	.86	.77	.60
	sn5	.74	.55	.85	.71
Perceived Behavioural Control (PBC)	pbc1	.74	.54	.73	.53
	pbc2	.92	.84	.93	.86
	pbc3	.82	.68	.74	.55
Behavioural Intentions (BI)	I1	.86	.73	.91	.83
	i2	.92	.85	.92	.84
	i3	.77	.77	.76	.57
	i4	.84	.71	.83	.69
Use of ICT (B)	U2	.79	.63	.82	.68
	u3	.97	.95	.97	.94
	u4	.92	.84	.80	.63

Group B		Test sample		Validation sample	
Latent Variable	Observed variable	Validity (λ)	Item reliability (R^2)	Validity (λ)	Item reliability (R^2)
Beliefs about outcome (BI)	bi1	.83	.69	.85	.72
	bi2	.86	.74	.86	.74
	bi3	.86	.74	.87	.76
	bi4	.89	.77	.90	.80
	bi5	.83	.66	.80	.63
	bi6	.80	.64	.83	.69
Beliefs about importance of outcome (EI)	ei1	.89	.74	.86	.74
	ei2	.86	.80	.89	.80
	ei3	.86	.82	.91	.82
	ei4	.89	.83	.91	.83
	ei5	.81	.67	.82	.67
	ei6	.81	.67	.82	.67
Beliefs about referents expectations (NK)	nk1	.81	.65	.81	.66
	nk2	.83	.69	.82	.68
	nk3	.93	.86	.91	.82
	nk6	.73	.54	.77	.60

Table 6.10 (continued)

Latent Variable	Observed variable	Validity (λ)	Item reliability (R^2)	Validity (λ)	Item reliability (R^2)
Beliefs about influence of referents expectations (MK)	mk1	.83	.69	.85	.73
	mk2	.84	.70	.76	.57
	mk3	.94	.88	.93	.86
	mk6	.73	.53	.81	.66
Beliefs about enabling factors (CB)	cb1	.78	.61	.74	.54
	cb2	.79	.62	.78	.61
	cb3	.77	.60	.75	.56
	cb4	.84	.70	.78	.61
	cb5	.77	.59	.80	.65
	cb6	.79	.63	.86	.74
	cb8	.74	.54	.75	.56
	cb9	.81	.66	.81	.66
	cb10	.77	.59	.84	.70
	cb12	.73	.53	.77	.60
Beliefs about availability of enabling factors (LO)	lo10	.81	.65	.86	.75
	lo11	.86	.73	.82	.68
	lo12	.95	.90	.96	.91

In conclusion, the results of the measurement model assessments provide the foundation for further assessment with structural equation modeling for the proposed research model and the related hypotheses testing. Most of the indicator variables in the measurement models showed robust validities and reliabilities. However, the measurement scales based on the total sample (N = 965) were used for the subsequent test of the structural component of the proposed research model. Using the whole sample was considered appropriate, as a larger sample size would provide greater statistical power when compared with each of the split-half independent samples. The final measurement scales calculated for the total sample (N = 965) is presented in Table 6.11. As shown in the table, all the items reached the recommended lower threshold value of validity and item reliability.

Table 6.11. *Final Measurement Scale from Total Sample (N = 965): Validity and Reliability*

Latent Variable	Observed Variable	Validity (λ)	Item reliability (R^2)
Attitude towards Behaviour (AB)	ab3	.90	.82
	ab4	.96	.92
	ab5	.92	.85
Subjective norms (SN)	sn4	.83	.69
	sn5	.81	.66
Perceived Behavioural Control (PBC)	pbc1	.73	.54
	pbc2	.92	.84
	pbc3	.78	.61
Behavioural Intentions (BI)	i1	.88	.78
	i2	.92	.84
	i3	.76	.58
	i4	.84	.70
Use of ICT (B)	u2	.79	.63
	u3	.97	.95
	u4	.87	.76
Beliefs about outcome (BI)	bi1	.84	.70
	bi2	.86	.74
	bi3	.86	.75
	bi4	.89	.78
	bi5	.81	.66
	bi6	.81	.66
Beliefs about importance of outcome (EI)	ei1	.87	.76
	ei2	.88	.77
	ei3	.89	.78
	ei4	.90	.80
	ei5	.82	.67
	ei6	.81	.66
Beliefs about referents expectations (NK)	nk1	.81	.66
	nk2	.83	.68
	nk3	.92	.84
	nk6	.75	.57
Beliefs about influence of referents' expectations (MK)	mk1	.84	.71
	mk2	.80	.63
	mk3	.93	.86
	mk6	.77	.59

Table 6.11 (continued)

Latent Variable	Observed Variable	Validity (λ)	Item reliability (R^2)
Beliefs about enabling factors (CB)	cb1	.76	.58
	cb2	.78	.61
	cb3	.76	.58
	cb4	.81	.66
	cb5	.79	.62
	cb6	.83	.68
	cb8	.74	.55
	cb9	.81	.65
	cb10	.80	.64
	cb12	.75	.56
Beliefs about availability of enabling factors (LO)	lo10	.70	.84
	lo11	.71	.84
	lo12	.91	.95

Chapter 7 RESULTS

This chapter presents the results of the analyses that provide answers to the four research questions posed by the current study. The chapter begins with the reports on the demographic characteristics of the research participants. The next section reports on the results of hypotheses tests that assess the research propositions. This section is divided into four sub-sections addressing each of the research questions. Each sub-section begins with a reference to the research question that is followed by statements of research propositions and the related hypotheses, and proceeds with the descriptions of the hypotheses tests results. Each sub-section ends with discussions and conclusions of the research findings. The chapter ends with a brief summary of the major findings and conclusions drawn from the findings.

The tests results reported in this chapter were obtained from analyses using two statistical software packages, AMOS 5.0 (for structural equation modeling) and SPSS 10.0 (for hierarchical multiple regressions analyses).

7.1 Participant Characteristics

A total of 1,040 teachers from eighteen secondary schools in the four districts in Brunei Darussalam responded to the survey employed in the present study. The numbers of participating schools were eight from Brunei-Muara (district 1), four from Tutong (district 2), five from Belait (district 3), and one from Temburong (district 4).

From the total number of teacher respondents, 531 were from schools in district 1 (51.1%), 238 from district 2 (22.9%), 209 from district 3 (20.1%), and 62 were from schools in district 4 (6.0%). The data show that more than half of the teacher respondents were from district 1 (the most densely populated district) and only a small proportion of teachers were from district 4 (the least populated district). About equal proportions of teacher respondents (about 20%) were from the other two remaining districts.

The teachers taught at different levels of classes and had different numbers of teaching periods per week (a teaching week is equivalent to five teaching days). The lower secondary level classes are made up of form 1 through form 3 students (ages between 11 and 14 years) while upper secondary level classes consist of form 4 and form 5 students (ages between 14 to 16 years). From the total sample of teacher respondents, 521 taught at lower secondary level (50.4%), 318 at upper secondary (30.8%), and 194 taught at both lower and upper secondary (18.8%). A majority of the teachers (78.6%) taught between 15 and 25 teaching periods per week (a teaching period is 35 minutes), while only a small proportion of teachers have less than 15 periods per week (6.1%), and about fifteen percent (15.3%) taught more than 25 periods per week. Generally, the data shows that most of the teachers taught at lower secondary level and an average of 20 teaching periods per week.

From the above profile descriptions of the sample, it is noted that the data for the present study are representative of the variable characteristics of teachers who use ICT in teaching. Table 7.1 presents the descriptive statistics of valid cases (N) and valid percentages for the demographic variables (i.e. sex, age, teaching experience, qualifications and teaching subjects), their access to computers (that is, classroom and computer laboratory), and their use of ICT for teaching.

Table 7.1. *Demographic Background of Teacher Respondents (N = 1,040).*

	Group	Valid N	Valid Per Cent
Sex	Male	1021	33
	Female		67
Age	18-25	1037	18.8
	26-30		30.0
	31-35		17.5
	36-40		11.6
	41-45		9.5
	46+		12.6
Teaching	0-1 year	1032	19.6
Experience	2-5 years		31.2
	6-10 years		13.8
	11-15years		13.1
	15+ years		22.4
Qualification	PhD.	1039	1.2
	Masters		4.6
	BA/BSc		69.8
	Diploma		6.8
	Certificate		18.2
Subject	Maths	1032	14.2
	Science		18.2
	History		5.6
	Geography		9.9
	Malay		14.9
	English		8.0
	Religious		14.1
	Phy. Ed.		2.8
	Economy		5.1
	Computer		2.1
	Art		4.7
	Sociology		0.3
Class Access	Yes	959	11.9
	No		88.1
Computer Lab. Access	Yes	951	73.4
	No		26.6
Use computer	Yes	965	26.2
	No		73.8

The above table shows the demographic characteristics of respondents. For the categorical variable of sex, the female to male ratio among the participants is similar to that among the whole population of teachers.

An independent t-test was conducted on the whole sample (valid N = 1,021) to investigate if significant sex differences occur in three dependent variables considered to be relevant as an assessment of teacher ICT use in teaching: classroom computer access, computer laboratory access, and use of computer in teaching.

The results of the independent t-tests revealed that there was no significant sex difference among respondents at $p < .01$ for the variables (1) classroom computer access (mean difference = -.013, t = - .58 at p= .28, eta squared = .0003), (2) computer room access (mean difference = -.058, t = 1.91 at p = .3, eta squared = .0039), and (3) use of computer (mean difference = .034, t = 1.12 at p = 0.13, eta squared = .0013). The effect sizes (indicated by the eta squared values) that provided indications of the magnitude of the sex differences in means for all three variables are small. For example, only .03% of the variance in classroom computer access is explained by sex.

Table 7.1 also indicates that more than half of the respondents (66.3%) were aged between 18 and 35 years old and had less than ten years of teaching experience (64.6%). A majority of the respondents (79.0%) held at least one degree (BA, BSc, Masters or Ph.D.) while the rest held either diplomas or certificates (25%).

Teachers who taught at least one of the sciences (biology, physics, chemistry, combined science, lower secondary science, home science, or agricultural science) are grouped together and represented 18.2% of the respondents. Likewise, teachers who taught religious studies, Arabic language, and Malay, Islam and Monarchy (MIB) were grouped together and made up 14.1% of the total respondents. Teachers who taught economy, commerce, accounting, commercial studies and business studies were also grouped together and made up 5.1% of the respondents. Responses from another three subjects: art, design and technology, and woodwork were also grouped together and represented 4.7% of respondents. There were a small percentage of respondents representing the other single subjects such as mathematics (14.2%), history (5.6%), geography (9.9%), Malay language (14.9%), English language (8.0%), physical education (2.8%), computer studies (2.1%), and sociology (0.3%).

With regard to respondents' computer use and access to computers, only about twenty-six percent used computer for teaching, about twelve percent had computer access in the classrooms and a majority (73.4%) had access to computer laboratory computers. This finding indicates that overall, teachers had high access to computers but showed low use of the technology in teaching. This observation of high access and low computer use is also reported elsewhere in the literature (Cuban, 1999, 2001; Cuban et al., 2001)

In summary, according to the findings of the present study, the respondents of the ICT in education survey represented female teachers in greater proportion, were aged between 18 to 35 years old, had less than 10 years of teaching experience, attained high levels of education, and had access to computers mostly in the computer laboratory, but use less ICT for teaching.

7.2 Results of Hypotheses Testing and Assessment of the Structural Model with Latent Variables

This section presents the results of hypotheses tests and overall structural model assessments. Most of the research hypotheses were tested using structural equation modeling (SEM) while two hypotheses (H12 and H13) were tested using hierarchical multiple regressions. Conclusions were drawn from the results of hypotheses tests to assess the research propositions and ultimately answer the research questions. In the following sub-sections, the four research questions are dealt with by stating the research propositions, testing the hypotheses related to the propositions, and the discussions on the test results that provide answers to the research questions. The chapter ends with a summary of research findings and conclusions drawn from these findings. The results discussed in this chapter were obtained from analyses of data collected from the ICT in education (ICTE) questionnaire.

7.2.1 Influence of Direct Factors on Intention and Use of ICT: Assessment of Theory of Planned Behaviour (TPB) model for direct factors

The first research question was: *How do the direct factors of TPB (teachers' attitudes, subjective norms, and perceived behavioural control) predict and explain teachers' intentions and behaviour for the use of ICT in their teaching?*

In order to answer this research question, three research propositions were suggested and the associated research hypotheses were formulated to provide statistical assessments of the propositions that are required for answering the research question.

7.2.1.1 Proposition 1

Proposition 1 states that teachers' *ICT-using behaviour* is predicted by the teachers' *intention* to use and by *perceived behavioural control.*

The first proposition is assessed by testing the research hypotheses H1 and H2 which are stated below:

Hypothesis H1: There will be a positive relationship between teacher *use of ICT* in teaching (B) and the *intention* to use (I).

Hypothesis H2: There will be a positive relationship between teacher *use of ICT* in teaching (B) and *perceived behavioural control* (PBC).

7.2.1.2 Proposition 2

Proposition 2 states that teachers' *intention* to use ICT in teaching is predicted by the teacher's *attitude towards the use, subjective norms*, and *perceived behavioural control*.

The second proposition is assessed by testing the research hypotheses H3, H4 and H5 as stated below:

Hypothesis H3: There will be a positive relationship between teachers' *intention* to use ICT in teaching and *attitude towards use of ICT*.

Hypothesis H4: There will be a positive relationship between teachers' *intention* to use ICT in teaching and *subjective norms*.

Hypothesis H5: There will be a positive relationship between teachers' *intention* to use ICT in teaching and *perceived behavioural control*.

Hypotheses H1 to H5 were tested by assessing the significance of the path coefficients, *B* for paths between the respective latent variables in structural equation model specified for the five latent variables in TBP (refer to Figure 7.1). The values of the path coefficients, *B*, indicate the strength of relationships between latent variables. The results of the hypotheses tests are presented in Table 7.2.

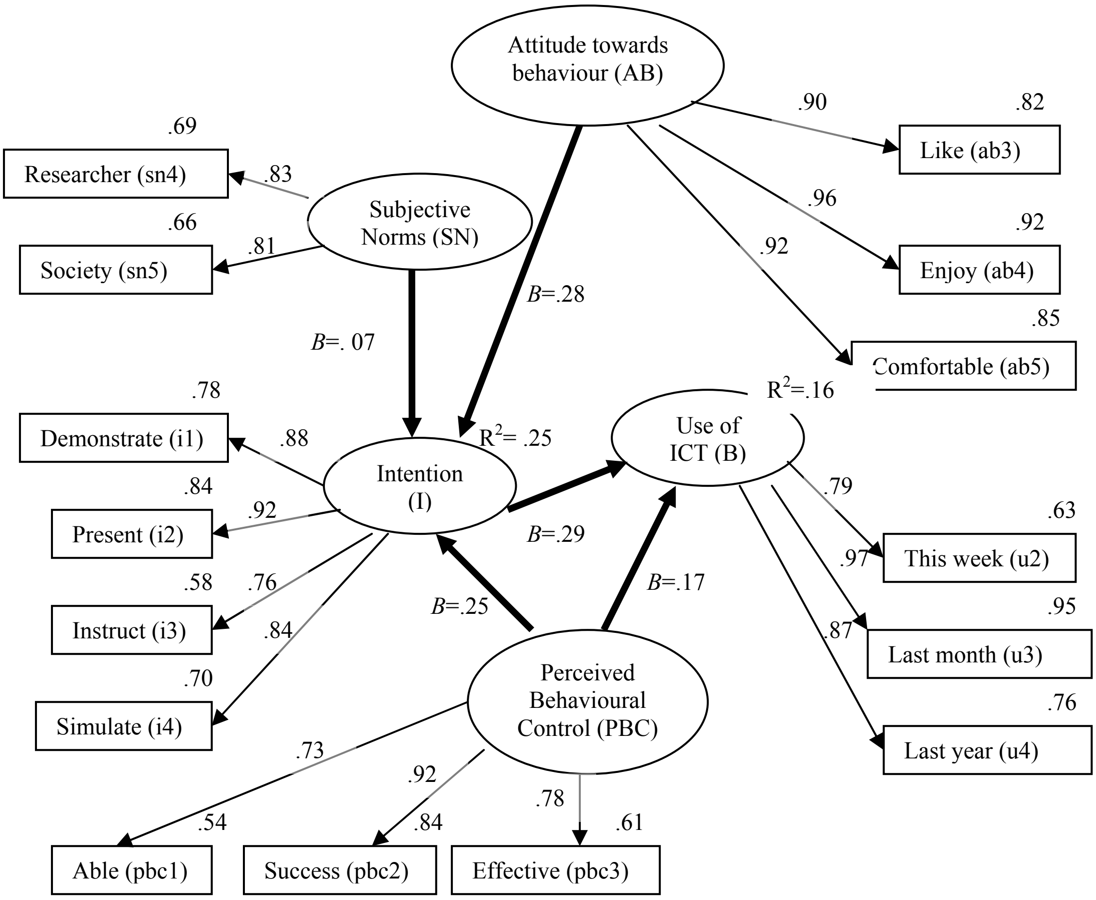

Figure 7.1. SEM Model for five latent variables in TPB.

First, Table 7.2 shows that coefficients for the paths from *intention* to *use of ICT* (B = .29, p < .001); and from *perceived behavioural control* to *use of ICT* (B = .17, p < .001) are positive and statistically significant. These test results respectively support hypotheses H1 and H2.

Second, Table 7.2 also shows that that the coefficients for the paths from *attitude towards use of ICT* to *intention* (B = .28, p < .001); from *subjective norms* to intentions (B = .07, p < .05); and from *perceived behavioural control* to *intention* (B

= .25, $p < .001$) are all positive and statistically significant at their respective p levels. These test results support hypotheses H3, H4 and H5. However, from Table 7.2, the strength of the predicting power of *subjective norms* (*B* = .07) is the weakest when compared with the other two predictor variables, *attitude towards use of ICT* (*B* = .28) and *perceived behavioural control* (*B* = .25).

Failure to reject the research hypotheses H1 to H5 provides statistical evidence to support the first two propositions in this study.

Table 7.2. *Path coefficients (B) for direct factors on Intention and Use Of ICT: Whole Sample (N = 965)*

Dependant variable	Path	Direct factor (latent variable)	*B*	Significance
Intention	<----	Attitude Towards Use of ICT	.28	p = .000
Intention	<----	Subjective Norm	.07	p = .046
Intention	<----	Perceived Behavioural Control	.25	p = .000
Use of ICT	<----	Perceived Behavioural Control	.17	p = .000
Use of ICT	<----	Intention	.29	p = .000

7.2.1.3 Proposition 3

Proposition 3 states that the direct factors of the TPB model (*teachers' attitudes, subjective norms, and perceived behavioural control)* can explain a significant part of teacher *use of ICT* in teaching.

The third proposition is assessed by testing research hypothesis, H6 as stated below:

Hypothesis H6: The TPB model of direct factors (*teachers' attitudes, subjective norms, and perceived behavioural control)* provides a significant model fit in explaining teacher *use of ICT* in teaching.

Hypothesis H6 was tested by assessing the performance of the TPB model of direct factors. The model was assessed by the significance of each of path coefficient (*B*); the model fit indices and squared multiple correlations (R^2) of the two dependent variables, *intention* and *use of ICT*. The results of model fit indices and R^2 presented in Table 7.3 are used to assess the TPB model of direct factors in explaining teacher ICT-using behaviour.

Table 7.3. *Results of TPB Model of Direct Factors: Fit and Squared Multiple Correlations*

	Fit Indices	Fit Statistics	Recommended Fit Criteria
Overall Model Fit	Chi-square (χ^2)	213.323 p=.000	p>.05
	Degrees of freedom (df)	82	
	Normed χ^2	2.602	Between 1.0 and 3.0
	GFI	.972	Over .90
	AGFI	.959	Over .90
	NFI	.980	Over .90
	TLI	.984	Over .90
	CFI	.988	Over .90
	RMR	.045	Lower than .10
	RMSEA	.041	Lower than .08
		Intention	Use
R^2	Explained variance in Dependent Variables (R^2)	25%	16%

First, the above table shows that the fit statistics for the TPB model of direct factors provide a good fit with all but one the fit indices, conforming to the recommended threshold values for all except for the chi-square value.

Second, the squared multiple correlation (R^2) that measures the extent to which the variance in the dependent variable is explained by the research model, show that the

TPB model of direct factors explains 25% of variance in *intention* and 16% in *use of ICT*.

The indices of good fit for the model imply that it should not be rejected and hence support H6 and provide statistical verification of proposition 3.

7.2.1.4 Indicator variables in TPB model of direct factors

Figure 7.1 also identifies the indicator variables that measure the latent variables a*ttitude towards use of ICT* (AB*), subjective norms* (SN), *perceived behavioural control* (PBC), *intentions* (I) and *use of ICT* (B).

Each of those indicator variables is statistically valid (as indicated by the value of λ next to the thin arrows which are above the lower cut-off value of .7) and reliable (as indicated by the value of R^2 at the top right corner of the rectangles which are above the lower cut-off value of .5) in measuring their respective latent variables (AB, SN, PBC, I and PBC). Table 7.4 presents a summary of the valid and reliable indicator variables.

Table 7.4. *A summary of indicator variables measuring the latent variables.*

Latent Variable	Indicator variable	Statement of questionnaire item	λ	R^2
AB	ab1	I feel that teaching ICT is a good idea	.90	.82
	ab2	I feel that teaching using ICT is appropriate	.96	.92
	ab3	I like teaching using ICT	.92	.85
SN	sn4	Educational researcher would influence my use of ICT in teaching	.83	.69
	sn5	Computer societies would influence my use of ICT in teaching	.81	.66
PBC	pbc1	I am certainly able to use ICT in teaching if I want to use	.73	.54
	pbc2	I am entirely capable of using ICT in teaching successfully	.92	.84
	pbc3	I have the resources, knowledge, and skills to use ICT effectively	.78	.61
I	i1	I am likely to use ICT for demonstrations in my lessons	.88	.78
	i2	I will use ICT in presenting my lessons	.92	.84
	i3	I will instruct students to use ICT for learning	.76	.58
	i4	I will use ICT simulations in my lessons	.84	.70
B	u2	How often did you use ICT in teaching this week?	.79	.63
	u3	How often did you use ICT in teaching in the last six months?	.97	.95
	u4	How often did you use ICT in your teaching last year?	.87	.76

7.2.1.5 Discussions and conclusions

The evidence presented by the statistically supported research propositions provide the answer to the first research question, namely that the direct factors of TPB model: *attitudes towards the use of ICT*, *subjective norms,* and *perceived behavioural control* are able to predict teachers' *intention* and *use of ICT* in teaching significantly. The current study found that teachers' use of ICT in teaching is predicted by *intention* (B = .29) and *perceived behavioural control* (B = *.17*), and the variables; *attitudes towards the use of ICT* (B = .28) and *perceived behavioural control* (B = .17) are stronger predictors of *intention* than *subjective norms* (B = .07). This finding indicates an agreement with Notani's (1998) meta-analytic study that the path in attitude-intention relation is positive and the strength of the path from attitude to intention is second strongest, following the intention-behaviour path (see Figure 7.1). The current study also concurred with the TPB literature that attitude is a strong predictor of intention (Davis, 1989; Taylor & Todd, 1995).

The weak predicting power of *subjective norms* on *intention* (B = .07) adds further evidence to the TPB literature that has generally found *subjective norms* as a weak predictor of *intention* (Armitage & Conner, 2001). The current study's use of multi-item scales as one means to rectify the problem (Armitage & Conner, 2001) failed to improve the strength of subjective norms-intention relationship.

This study also provides support to the general finding in the TPB literature that *perceived behavioural control* is a strong predictor of behaviour (*use of ICT*) directly (B = .17) as well as indirectly through the mediation of intention (Armitage & Conner, 2001).

The findings of the current study indicate that the TPB is a statistically good-fit model to explain teachers' *intention* and *use of ICT* in teaching although the amount of variances explained by the model in *intention* and *use of ICT* are small. The three predictors of TPB (AB, SN, and PBC) together explain 25% of variance in *intention*, and together with *intention* explains 16% of variance in *use of ICT*. These values are slightly below the reported range of percentage in variance in intention (33% to 50%) and behaviour (19% to 38%) respectively (Armitage & Conner, 2001; Hagger et al., 2002; Notani, 1998; Sheeran, Trafimow, Finlay, & Norman, 2002; Sutton, 1998). However, the current study's finding adds further evidence for the adaptability and applicability of TPB in explaining behaviour, in this case, teachers' use of ICT in teaching.

In conclusion, the current study provides evidence that the direct factors of TPB (AB, SN, and PBC) can be used to predict teachers' *intention* and *use of ICT* in teaching, and the TPB model of direct factors can explain *intention* and *use of ICT* adequately.

7.2.2 Influence of Indirect Factors on Intention and Use of ICT: Assessment of ICT Use Model (ICTUM) for direct and indirect factors.

The second research question was: *How do the indirect factors (behavioural beliefs, normative beliefs, and control beliefs) relate to the respective direct factors (attitude, subjective norms, and perceived behavioural control) of ICTUM and together explain teachers' intention and behaviour for the use of ICT in teaching?*

In order to answer this research question, three research propositions were suggested and the associated research hypotheses were formulated to provide statistical support to the propositions, which ultimately answer the research question.

7.2.2.1 Proposition 4

Proposition 4 states that the indirect factors (*behavioural beliefs* (ABi)*, normative beliefs* (SNi)*,* and *control beliefs* (PBCi)) are the antecedents of the respective direct factors (*attitude towards ICT use* (AB)*, subjective norms* (SN)*,* and *perceived behavioural control* (PBC).

Proposition 4 was assessed by testing hypotheses H7 to H9 as stated below:

Hypothesis H7: There will be a positive relationship between *teachers' attitude towards use of ICT* (AB) and its antecedent factor, *behavioural beliefs* (ABi) comprising *beliefs about the outcome* (BI) of teaching using ICT and the *importance of those outcomes* (EI).

Hypothesis H8: There will be a positive relationship between *subjective norms* and its antecedent factor, *normative beliefs* (SNi) comprising beliefs about *referents' expectation* (NK) and *influence of those expectations* (MK) in their use of ICT.

Hypothesis H9: There will be a positive relationship between *perceived behavioural control* and its antecedent factor, *control beliefs* (PBCi) comprising *beliefs about enabling factors* (CB) for effective teaching and *likelihood of availability of those factors* (LO).

7.2.2.2 Proposition 5

Proposition 5 states that the indirect factors *(behavioural beliefs, normative beliefs,* and *control beliefs)* and direct factors have positive influence on *intention* and *use of ICT* in teaching.

Proposition 5 was assessed by testing hypothesis H10 as stated below:

Hypothesis H10: There will be positive total influence of the direct and indirect factors on *intention* and *use of ICT*.

Hypotheses, H7 to H9 were tested by assessing the significance of the path coefficients, *B* for paths between the respective indirect and direct factors in the structural equation model specified for ICTUM (refer to Figure 7.2). The value of path coefficients, *B* (numbers next to the thick arrows) indicates the strength of relationships between the factors. The results for tests for hypotheses H7 to H9 are presented in Table 7.5.

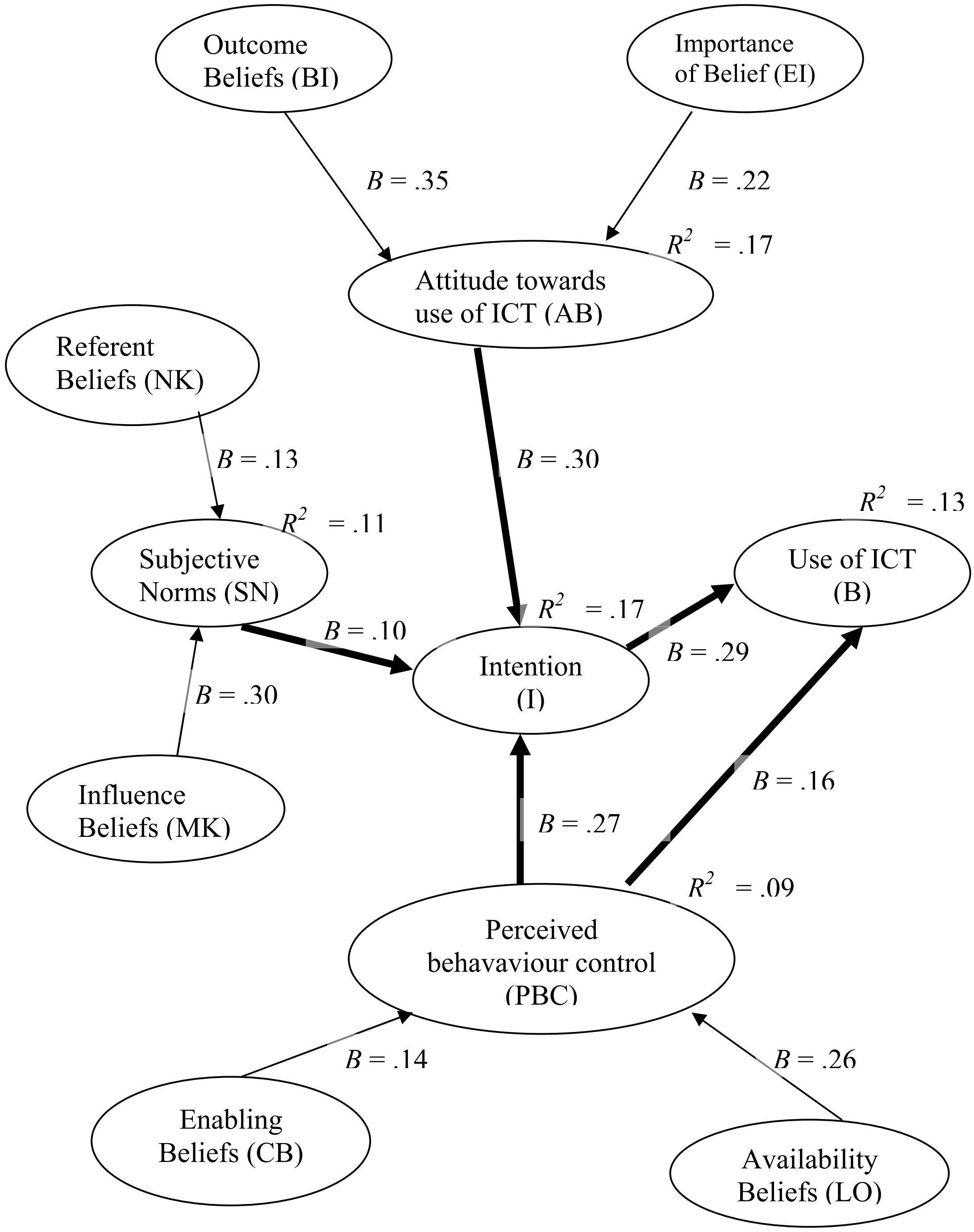

Figure 7.2. The ICT Use Model (ICTUM): SEM Assessment Results.

Table 7.5. *Path coefficients (B) for indirect factors in ICTUM: Whole Sample (N = 965)*

MODEL PATH			*B*	Significance
Attitude	<- - -	Beliefs about Outcome (BI)	.*35*	p = .000
Attitude	< - - -	Beliefs about Importance of Outcome (EI)	.22	p = .000
Subjective Norms	< ----	Beliefs about Referents' expectation (NK)	.13	p = .003
Subjective Norms	<- - -	Beliefs about Influence of referents' expectations (MK)	.30	p = .000
Perceived Behavioural Control	< ----	Beliefs about Enabling factors (CB)	.14	p = .000
Perceived Behavioural Control	< ----	Beliefs about Availability of Enabling Factors (LO)	.26	p = .000

First, Table 7.5 shows the coefficients for the paths, *B* from the two dimensions of behavioural beliefs (indirect factor): *beliefs about outcome* (BI) and, *beliefs about importance of outcome* (EI) to the direct factor, *attitude towards use of ICT.* The result shows that the path coefficients are positive and significant hence supporting hypothesis H7.

Second, Table 7.5 also shows that the path coefficients, *B* from two dimensions of the normative beliefs (indirect factor), *beliefs about referents' expectation*s (NK) and, *beliefs about the influence of referents' expectations* (MK) to the direct factor, *subjective norms* are positive and significant thus supporting hypothesis H8.

Third, it is shown in Table 7.5 that the path coefficients, *B* from the two dimensions of the indirect factor, control beliefs: *beliefs about enabling factors* (CB) and, *beliefs about likelihood of availability of the enabling factors* (LO), to the direct factor, *perceived behavioural control* are positive and significant. The test results support hypothesis H9.

From Figure 7.2, the amount of variance accounted for by *behavioural beliefs* (*outcome* and *importance of outcome*) in AB is 17%. *Normative beliefs* (*referents' expectations* and *their importance*) explained 11% of variance in SN. Lastly, *control* *beliefs* (*enabling factors* and *their availability*) explained only 9% of variance in PBC.

The failure to reject the research hypotheses H7 to H9 provides statistical evidence to support proposition 4.

Hypothesis H10 is assessed by the total effects of indirect factors (the six beliefs dimensions) and direct factors on the dependent variables, *intention* and *use of ICT*. The results to test H10 are presented in Table 7.6, which shows that there are positive total effects due to the direct and indirect factors on *intention* and *use of ICT.* This finding supports hypothesis H10 and provides statistical evidence to confirm proposition 5.

7.2.2.3 Proposition 6

Proposition 6 posits that the ICTUM provides an adequate explanation of teachers' *intention* and *use of ICT* in teaching.

The adequacy of the ICTUM was examined by testing the following hypothesis H11:

Hypothesis H11: ICTUM provides a significant model fit in explaining teachers' *intention* and *use of ICT* in teaching.

The ICTUM model adequacy (H11) in explaining teachers' *intention* and their *use of ICT* in teaching was assessed primarily by (1) fit indices, and (2) squared multiple correlation (R^2) of the two ultimate dependent variables, *intention* (I) and *use of ICT* (B). The results are summarized Table 7.6 below.

Table 7.6. *Results of Proposed Model Assessment: Fit, Squared Multiple Correlations, and Total Effects*

	Fit Indices	Fit Statistics	Recommended Fit Criteria
	Chi-square (χ^2)	7169.86 p=.000	p>.05
	Degrees of freedom (df)	1069	
Overall Model Fit	Normed χ^2	6.707	Between 1.0 and 3.0
	GFI	.745	Over .90
	AGFI	.719	Over .90
	NFI	.824	Over .90
	TLI	.837	Over .90
	CFI	.846	Over .90
	RMR	.226	Lower than .10
	RMSEA	.077	Lower than .08
		Intention	Use
R^2	Explained variance in Dependent Variables (R^2)	17%	13%
		Total effects on Intention	Total effects on Use
Total Effects	Outcome (BI)	.138	.030
	Importance (EI)	.086	.018
	Expectation (NK)	.018	.004
	Influence (MK)	.035	.007
	Enable (CB)	.049	.032
	Availability (LO)	.080	.052
	AB	.349	.075
	SN	.109	.023
	PBC	.355	.229
	Intention	-	.215

First, the fit statistics for the proposed model, ICTUM provided a marginally acceptable model fit where three of the fit indices (NFI, TLI and CFI) are close to the recommended fit criteria and only the index, RMSEA (.077) complies with the recommended fit criterion.

Second, the squared multiple correlations (R^2) that measures the extent to which the variance in the dependent variable is explained by the research model, indicate that the model (ICTUM) accounted for only 17% of variance in *intention* and 13% in *use of ICT.*

However, a direct comparison of the magnitude of the explained variance in the dependent variables (*intention* and *use of ICT)* in this study to previous studies on teacher ICT use in teaching is not possible due to lack of empirical results. Hence, comparisons were made with a study on teacher educational technology use (Czerniak et al., 1999). The model developed by Czerniak et al. was able to explain 62% of variance in *intention* to use educational technology and 17% of variance in *use.* The lower amount of explained variance in this study in comparison to Czerniak et al.'s indicates the poor performance of the ICTUM model and thus suggests the need for further improvement of the model.

The fits statistics and the small amount of explained variance together fail to provide statistical evidence to support H11. Thus proposition 6 is not statistically supported.

7.2.2.4 Indicators of the beliefs dimensions

Table 7.7 presented the indicator variables that measure each of the beliefs dimensions: *beliefs about outcome (*BI*), beliefs about importance of outcome (*EI*), beliefs about referents' expectations (*NK*), beliefs about influence of referents' expectation (*MK*), beliefs about enabling factors (*CB*),* and *beliefs about likelihood of availability of enabling factors (*LO*).*

Each of those indicator variables is statistically valid (as indicated by the value of λ which are above the lower cut-off value of .7) and reliable (as indicated by the value of R^2 which are above the lower cut-off value of .5) in measuring their respective beliefs dimensions (BI, EI, NK, MK, CB, and LO).

Table 7.7. *A summary of indicator variables measuring the six beliefs dimensions*

Latent variable	Indicator variable	Statement of questionnaire item	λ	R^2
BI		Using ICT in my teaching will		
	bi1	make my lessons more interesting	.84	.71
	bi2	improve the presentations of teaching materials	.87	.76
	bi3	make my lessons more diverse	.86	.75
	bi4	make my lessons more motivating	.88	.77
	bi5	help students understand the lesson better	.81	.66
	bi6	develop students' learning skills	.81	.66
EI		Using ICT in my teaching should		
	ei1	Make my lessons more interesting	.87	.76
	ei2	improve the presentations of teaching materials	.88	.78
	ei3	make my lessons more diverse	.90	.78
	ei4	make my lessons more motivating	.88	.80
	ei5	Help students understand the lesson better	.82	.67
	ei6	develop students' learning skills	.82	.67
NK		What would the following people think about my use of ICT		
	nk1	Principal	.81	.65
	nk2	Colleagues	.82	.68
	nk3	Head of department	.93	.86
	nk6	Curriculum department	.75	.56
MK		What the following people thinks about use of ICT influence me		
	mk1	Principal	.85	.73
	mk2	Colleagues	.79	.62
	mk3	Head of department	.92	.85
	mk6	Curriculum department	.78	.60
CB		Factors would enable me to teach effectively using ICT		
	cb1	Educational software resources	.76	.57
	cb2	Professional development opportunities	.78	.61
	cb3	Access to the internet	.76	.57
	cb4	Quality software	.81	.66
	cb5	Physical classroom structures	.79	.62
	cb6	Support from school administrators	.83	.68
	cb8	Support from other teachers	.74	.55
	cb9	Technical support	.81	.66
	cb10	Time to plan for ICT implementation	.80	.65
	cb12	Time to let students use ICT	.75	.57
LO		The likelihood of the following factors being available in my school		
	lo10	Time to plan for ICT implementation	.84	.70
	lo11	Smaller class sizes	.84	.71
	lo12	Time to let students use ICT	.95	.90

7.2.2.5 Discussions and conclusions

The evidence presented by the statistically supported research propositions (except proposition 6) provides answers to the second research question *viz.* the indirect factors of ICTUM relate significantly but weakly with the respective direct factors. This study is able to show that the direct factors (AB, SN, and PBC) are related to their respective indirect factors or antecedent beliefs (ABi, SNi, and PBCi), which are consequently decomposed to their respective dimensions (BI and EI for ABi, MK and NK for SNi, and CB and LO for PBCi). This is indicated by the positive and significant path coefficients, *B* from the respective dimensions of the beliefs factors. However, the amount of variances explained in the belief factors by the respective dimensions is small.

Nevertheless, the direct and indirect factors of the ICTUM together explain only a small amount of variance in *intention* and *use of ICT.* The small total effects due to the direct and indirect factors of the model on *intention* and *use of ICT* (see Table 7.6) and the statistically unsupported proposition 6 reflect this. This finding indicates a requirement for further study on improving the explaining power of the research model.

In conclusion, the current study provides evidence that the direct factors are weakly related to the indirect factors, and the research model, ICTUM cannot explain *intention* and *use of ICT* adequately.

7.2.3 Influence of External variables on *Intention* and *Use of ICT*

The third research question was: *How do the demographic factors (age, sex, subject taught, teaching experience, teaching level, qualification, level of class, class access, and computer laboratory access) predict and explain teachers' intention and behaviour for using ICT in their teaching?*

In order to answer this research question, a research proposition was suggested and the associated research hypotheses were formulated to provide statistical support to the proposition and ultimately answer the research question.

7.2.3.1 Proposition 7

Proposition 7 posits that the external variables that predict and explain teacher *intention* and *use of ICT* consist of demographic variables. The relevant hypotheses to assess this proposition are stated below:

Hypothesis H12: External variables positively influence teachers' *intention* to use ICT teaching.

Hypothesis H13: External variables positively influence teachers' *use of ICT* in teaching.

Hypotheses H12 and H13 were tested using a two-step hierarchical multiple regression for testing the influence of each of the external variables on *intention* and *use of ICT* (as the dependent variables) respectively. In the first step, all the intervening variables between external variables and the dependent variable are entered. In the second step, the external variables are entered.

Table 7.8 and Table 7.10 show the results of the hierarchical multiple regression analyses for the assessment of H12 and H13. Table 7.9 and Table 7.11 show the regressions coefficients of the external variables on *intention* and *use of ICT* respectively.

Influence of external variables on *Intention*

Table 7.8 indicates that external variables explain an additional 1.5% of the variance in total *intention* after controlling for the other intervening variables. This small but significant (at $p < .05$) effect of external variables on *intention* supports H12.

Table 7.8. *Hierarchical multiple regressions test for influence of external variables on Intention.*

Model	R	R^2	Adjusted R^2	Std. Error of Estimate	Change Statistics				
					R^2 - change	F change	df1	df2	Sig. F change
1	.495	.245	.238	.96	.245	35.003	8	863	.000
2	.510	.260	.245	.95	.015	1.954	9	854	.042

Table 7.9 shows the regression coefficients of the various external variables on *intention* after controlling all intervening variables. *Class access* (*B* = -.091; p = .003) is the only external variable that shows statistically significant prediction on *intention*.

Table 7.9. *Influence of external variables on intention after controlling for all intervening variables.*

	Unstandardized Coefficients *B*	Std. Error	Standardized Coefficients *B*	t	Sig.
Age	-.046	.045	-.067	-1.010	.313
Sex	-.077	.071	-.033	-1.085	.278
Subject taught	.014	.012	.035	1.116	.265
Teaching Experience	.035	.051	.046	.695	.487
Teaching Period	-.055	.073	-.022	-.753	.451
Qualification	.0003	.041	.000	.009	.993
Level of class	.061	.043	.043	1.394	.164
Class access	-.308	.102	-.091	-3.022	.003
Computer room access	-.060	.076	-.024	-.786	.432

Influence of external variables on *Use of ICT*

Table 7.10 indicates that external variables explain an additional 9.4% of the variance in *use of ICT* after controlling for the other intervening variables. Although the effect of external variables on *use of ICT* is small, it is significant at $p < .01$, hence supporting H13.

Table 7.10. *Hierarchical multiple regressions tests for influence of external variables on Use of ICT*

Model	R	R^2	Adjusted R^2	Std. Error of Estimate	Change Statistics				
					R^2 -change	F change	df1	df2	Sig. F change
1	.336	.113	.105	.66	.113	13.746	8	863	.000
2	.455	.207	.191	.63	.094	11.246	9	854	.000

Table 7.11 shows the regression coefficients of the various external variables on *use of ICT* after controlling all intervening variables. *Subject taught* (B = .088; p = .007), *class access* (B = -.226; p = .000), and *computer laboratory access* (B = -.159; p = .000) are the three external variables that show significant prediction on teachers' *use of ICT* in teaching.

Table 7.11. *Influence of external variables on Use of ICT after controlling for all Intervening Variables*

	Unstandardized Coefficients *B*	Std. Error	Standardized Coefficients *B*	t	Sig.
Age	.016	.030	.038	.553	.580
Sex	-.019	.047	-.013	-.408	.683
Subject Taught	.022	.008	.088	2.719	.007
Teaching Experience	-.050	.033	-.103	-1.494	.135
Teaching Period	.038	.048	.025	.800	.424
Qualifications	-.028	.027	-.034	-1.029	.304
Level of class	.04.2	.029	.045	1.411	.159
Class access	-.487	.067	-.226	-7.254	.000
Computer room access	-.254	.050	-.159	-5.077	.000

In order to identify which subjects are associated with greater use, the two variables, *class access* and *computer laboratory access* were cross-tabulated with *subject* and *use of ICT*. Table 7.12 presents the results of the cross-tabulation for teachers' positive responses to all the four variables.

Previously, Table 7.1 showed that a total of about twelve percent of teachers (n = 114) had class access to computers, and a total of about seventy-three percent (n = 698) had access to computer laboratory. Table 7.12 shows that the teachers who had class access to computers all reported using ICT for teaching (n = 114). Among the teachers who had class access to computers, teachers of religious studies (19.3%), sciences (14.9%), mathematics (14.0%), Malay language (14.0%) and computer studies (10.5%) reported more use of ICT in teaching. The above table also shows that among those who had access to computer laboratory, only about twenty-five percent (n = 236) reported using ICT in teaching. Among those teachers who have computer laboratory access, teachers of sciences (18.9%), mathematics (15.7%), and religious studies (13.4%) reported more use of ICT in teaching.

Table 7.12. *Cross-tabulation of subject teachers' use of ICT with class access and computer laboratory access*

	Class access (Valid N=959)		Computer Lab Access (Valid N=951)	
Subject	n	% Use of ICT	n	% Use of ICT
Mathematics	16	14.0	111	15.7
Science	17	14.9	134	18.9
History	7	6.1	38	5.4
Geography	8	7.0	85	12.0
Malay Language	16	14.0	83	11.7
English Language	4	3.5	60	8.5
Religious Studies	22	19.3	95	13.4
Physical Education	2	1.8	16	2.3
Economy	5	4.4	36	5.1
Computer Studies	12	10.5	19	2.7
Art & Design	5	4.4	29	4.1
Sociology	0	0	2	0.3
Total	114	100	236	100

7.2.3.2 Discussions and conclusions

The evidence presented by the statistically supported research proposition provide answers to the third research question *viz.* some of the external variables are able to significantly predict teacher's *intention* and *use of ICT* although the amount of increase in variances explaining *intention* and *use of ICT* respectively are small.

The current study is able to show that only one external variable, *class access* can significantly predict *intention*; and three external variables, *subject taught, class access,* and *computer laboratory access* can significantly predict *use of ICT.* Previous literatures have shown that the demographic variables have some influence on teacher use of ICT (see detailed discussions in Section 3.2). The current study is able to show that some of these variables can be used to predict intention and explain behaviour on a theoretical basis. However, further study is required in order to improve the weak predicting and explaining power of these variables.

In conclusion, the current study provides evidence that the some of the external factors are able to significantly predict and explain teachers' *intention* and *use of ICT* in teaching.

7.2.4 Multidimensionality vs. Unidimensionality: ICTUM vs. TPB

The fourth research question was: *How does the ICT Use Model (ICTUM) perform in comparison to TPB Model in explaining teachers' intention and use of ICT in their teaching?*

In order to answer this research question, the following research proposition was suggested:

7.2.4.1 Proposition 8

Proposition 8 states that the ICTUM provides a better explanation of teachers' *intention* and *use of ICT* in teaching than the TPB model of direct factors. The adequacy of the ICTUM was examined by testing the following hypothesis:

Hypothesis H14: The proposed model, ICTUM in the current study explain teachers' *intention* and *use of ICT* in teaching better than the TPB model.

The performances of the two competing models were compared using the test criteria for SEM assessment: fit indices; squared multiple correlations, and standardized path coefficients of the hypothesised paths in the structural models. Superiority of the proposed research model, ICTUM across the test criteria would support H14. Figure 7.1 and Figure 7.2 presented the TBP model and ICTUM respectively.

Table 7.13 shows the comparisons between ICTUM and TPB model in terms of model fit indices, squared multiple correlations and path coefficients.

First, comparison between the fit indices for the two models show that the TPB model is superior to ICTUM as the former showed a good-fit of the model fit criteria while the latter showed marginal-fit of the model fit criteria.

Second, comparisons of the amount of variance explained for *intention* and *use of ICT* by the TPB model are slightly more than the amount of variance explained by ICTUM for both variables.

Third, the differences in the strength of path coefficients, *B*, for the various paths among the direct variable to *intention* and *use of ICT* (that is from AB, SN, and PBC to I, and from I and PBC to B) between the two models are small.

The results of the above comparisons show that the ICTUM fails to show superiority to the TBP in two aspects, model fit and explanatory power. This finding fails to provide statistical support to hypothesis H14 and proposition 8.

Table 7.13. *Comparisons between ICTUM and TPB: Fit Statistics, Squared Multiple Correlations and Path Coefficients*

A. Comparison of Fit Indices			
Fit Indices	ICTUM	TPB	Recommended Fit Criteria
Chi-square (χ^2)	7169.86 p=.000	213.323 p=.000	p>.05
Degrees of freedom (df)	1069	82	
Normed χ^2	6.707	2.602	Between 1.0 and 3.0
GFI	.745	.972	Over .90
AGFI	.719	.959	Over .90
NFI	.824	.980	Over .90
TLI	.837	.984	Over .90
CFI	.846	.988	Over .90
RMR	.226	.045	Lower than .10
RMSEA	.077	.041	Lower than .08
N	965	965	
B. Comparisons of Explained Variances (R^2)			
R^2 Use	.13	.16	
R^2 Intention	.17	.25	

C. Comparison of Path Coefficients, B

Model	Path		ICTUM	TBP
Intention	<----	Attitude Towards Use of ICT	.30	.28
Intention	<----	Subjective Norm	.10	.07
Intention	<----	PBC	.27	.25
Use	<----	PBC	.16	.17
Use	<----	Intention	.29	.25

7.2.4.2 Discussions and Conclusions

The above evidence of failing to support proposition 8 provides the answer to the third research question *viz.* ICT Use Model (ICTUM) did not perform well in comparison to TPB model of direct factors in explaining teachers' *intention* and *use of ICT* in their teaching. Further study is required to improve the performance of the ICTUM.

In conclusion, the current study's modification efforts through beliefs decompositions, and external variable incorporation into the TPB model was unsuccessful in showing a good model fit for the research model, ICTUM. However, the effort was meaningful as it breaks on new ground by initiating investigations on using a theoretical approach to predict and explain teachers' use of ICT in teaching.

7.3 Summary of Research Findings

Structural equation modeling (SEM) and hierarchical multiple regression have been employed in the current study to assess the ability of the proposed model, ICT Use Model (ICTUM) to predict and explain teacher *intention* to use and actual *use of ICT* in teaching. Eight research propositions were suggested in order to answer the four research questions posed in the previous chapter. Fourteen research hypotheses were tested in order to evaluate these research propositions. A summary of the results of propositions and hypotheses tests is presented in Table 7.14. As shown in Table 7.14, all the research propositions except propositions 6 and 8 were supported statistically. The research findings provide answers to the four research questions formulated for the current study. First, teachers' *use of ICT* can be predicted from their *intention* and *perceived behavioural control*, and their *intention* can be predicted *by attitude towards ICT use, subjective norms,* and *perceived behavioural control*, although *subjective norms* was found to be the weakest predictor when compared with *attitude* *towards ICT use* and *perceived behavioural control*. The predictor variables (AB, SN, and PBC) together explain twenty-five percent of the variance in *intention*, while sixteen percent of variance in behaviour (*use of ICT*) is explained by *intention* and the predictor variables.

Second, the indirect factors or antecedent beliefs of ICTUM (ABi, SNi, and PBCi) relate significantly but weakly with the respective direct factors (AB, SN, and PBC). The indirect factors are decomposed to their respective dimensions (BI and EI for ABi, MK and NK for SNi, and CB and LO for PBCi) but the amount of variances explained in each of the beliefs factors by the respective dimensions is small. The direct and indirect factors of the ICTUM together explain only a small amount of variance in *intention* (17%) and *use of* ICT (13%).

Third, the external factors consisting of demographic variables (i.e. age, sex, teaching experience, teaching period, qualification, and level of class) do not statistically significantly predict teachers' *intention* and *use of ICT.* The only external variable that significantly predict teachers' *intention* is class access. Three external variables (subject taught, class access, and computer laboratory access) statistically significantly predict teachers' *use of ICT*. However, the amount of increased variance in *intention* (1.5%) and *use of ICT* (9.4%) respectively is small. This study also found that teachers have high access to computers either in the classroom or computer laboratory, but they reported low use of ICT in teaching. Among the teachers who have access to the classroom computers, teachers of religious study, science, mathematics, and Malay language use ICT in teaching more than the other teachers. Similarly, among those teachers who have access computer laboratory, teachers of science, mathematics, and religious studies use more ICT in teaching than the other teachers.

Fourth, the current study's research model, ICTUM fails to show superiority to TPB model in explaining teachers' *intention* and *use of ICT* in teaching.

In conclusion, the current study's attempt to apply the modified theory of planned behaviour (TPB) model, ICTUM to predict and explain teacher's ICT use in teaching, by using the multi-dimensional beliefs-based attitudes, subjective norms, and perceived behavioural control, was meaningful. This is evidenced by the fact that the tests were able to identify more salient sources of influence affecting attitude, subjective norms, and perceived behavioural control of using ICT in teaching. However, further exploration of belief sources is required considering the low amount of explained variance in *attitude*, *subjective norms*, and *perceived behavioural control* and the lack of good-fit of the model in explaining teacher's *intention* to use and *use of ICT* in their teaching.

Another elaboration of the TPB model through external variables was successful although the amount of increase in explained variance in *intention* and *use of ICT* was small. However, the study was able to identify the salient external variables that predict teacher's *intention* and *use of ICT* in teaching.

Finally, the research model, ICTUM failed to demonstrate its superiority to the TPB model in its ability to include the indirect factors, that is, the beliefs antecedents of attitudes, subjective norms, and perceived behavioural control; and the external variables to predict and explain *intention* and *use of ICT*. However, this study was able to provide further support of the wide applicability of the direct factors of TPB model in predicting and explaining behaviour, as in this case, teachers' use of ICT in teaching.

Table 7.14. *Summary of Results of Propositions and Hypothesis Tests*

Hypothesis	Tested Components	Test Results	Statistical Techniques
Proposition 1: Teachers' ICT-using behaviour is predicted by the teachers' intention to use and by perceived behavioural control.			
H1	There will be a positive relationship between teacher *use of ICT* in teaching (B) and the *intention* to use (I).	Supported	Structural Equation Modelling (SEM)
H2	There will be a positive relationship between teacher *use of ICT* in teaching (B) and *perceived behavioural control* (PBC).	Supported	SEM
Proposition 2: Teachers' *intention* to use ICT in teaching is predicted by the teachers' *attitude towards the use, subjective norms,* and *perceived behavioural control*.			
H3	There will be a positive relationship between teachers' *intention* to use ICT in teaching and *attitude towards use of ICT*.	Supported	SEM
H4	There will be a positive relationship between teachers' *intention* to use ICT in teaching and *subjective norms*.	Supported	SEM
H5	There will be a positive relationship between teachers' *intention* to use ICT in teaching and *perceived behavioural control*.	Supported	SEM
Proposition 3: The direct factors of TPB model (*teachers' attitudes, subjective norms, and perceived behavioural control)* can significantly explain teachers' *use of ICT* in teaching.			
H6	The TPB model of direct factors (*teachers' attitudes, subjective norms, and perceived behavioural control)* provides a significant model fit in explaining teacher *use of ICT* in teaching.	Supported	SEM
Proportion 4: The indirect factors (*behavioural beliefs* (ABi), *normative beliefs* (SNi), and *control beliefs* (PBCi)) are the antecedents of the respective direct factors (*attitude towards ICT use* (AB), *subjective norms* (SN), and *perceived behavioural control* (PBC).			
H7	There will be positive relationship between attitude towards use of ICT (AB) and its antecedent factor, teacher behavioural beliefs (ABi) comprising beliefs about the outcome (BI) of teaching using ICT and the importance of those outcomes (EI).	Supported	SEM
H8	There will be positive relationship between *subjective norms* and its antecedent factor, *normative beliefs* (SNi) comprising beliefs about *referents' expectation* (NK) and *influence of those expectations* (MK) in their use of ICT.	Supported	SEM
H9	There will be positive relationship between *perceived behavioural control* and its antecedent factor, *control beliefs* (PBCi) comprising *beliefs about enabling factors* (CB) for effective teaching and *likelihood of availability of those factors* (LO).	Supported	SEM

Table 7.13 (Continued)

Hypothesis	Tested Components	Test Results	Statistical Techniques
Proposition 5: The indirect factors *(behavioural beliefs, normative beliefs,* and *control beliefs)* and direct factors have positive influence on *intention* and *use of ICT* in teaching.			
H10	There will be positive total influence of the direct and indirect factors on *intention* and *use of ICT*.	Supported	SEM
Proposition 6: ICTUM provides an adequate explanation of teacher's *intention* and *use of ICT* in teaching.			
H11	ICTUM provides a significant model fit in explaining teachers' *intention* and *use of ICT* in teaching.	Not supported	SEM
Proposition 7: The external variables that predict teacher intention to use ICT consist of demographic variables.			
H12	External variables influence teachers' *intention* to use ICT teaching.	Supported	Hierarchical Multiple Regression
H13	External variables influence teachers' *use of ICT* in teaching.	Supported	Hierarchical Multiple Regression
Proposition 8: The ICTUM provides a better explanation of teachers' *intention* and *use of ICT* in teaching than the TPB model of direct factors			
H14	The proposed model, ICTUM in the current study explain teachers' *intention* and *use of ICT* in teaching better than the TPB model.	Not supported	SEM

Chapter 8 DISCUSSIONS AND CONCLUSIONS

This final chapter discusses the findings of the current study and uses them as a basis for the formulation of a number of conclusions and recommendations. The chapter begins with a brief summary of the current study, followed by a discussion on the major findings of the study in relation to the aims of the current research that guided this study. A number of theoretical implications as well as some practical implications on the teachers' use of Information and Communication Technology (ICT) in teaching in secondary schools in Brunei resulting from the findings will also be discussed in this chapter. As with most studies, this investigation has its limitations and strengths and these are also discussed. The chapter then outlines several recommendations for further research in ICT use in education.

8.1. Summary of Research Study and Major Findings

1. Summary of Research

An important step in developing a unique model for the prediction of teacher use of ICT in the classroom is to understand teachers' attitudes/perceptions and their influence on behaviours. The current study attempted to provide such an understanding by applying and elaborating Ajzen's theory of planned behaviour (TPB), a widely applied model for investigating social behaviour. According to TPB, behaviour is explained as the result of three direct factors: *attitude towards behaviour* (AB), *subjective norms* (SN), and *perceived behavioural control* (PBC). Each of the direct factors is influenced by their respective indirect factors or salient beliefs: *behavioural*, *normative*, and *control beliefs*. In order to accommodate the TPB, this study elaborates the TPB by (1) decomposing each of the beliefs factors into its respective dimensions, and (2) incorporating external variables.

Behavioural beliefs are decomposed into *beliefs about outcome* (BI), and *beliefs about importance of outcome* (EI). Normative beliefs are decomposed into *beliefs about referents' expectations* (NK), and *beliefs about influence of referents' expectations* (MK). Control beliefs are decomposed into *beliefs about enabling factors for effective use of ICT in teaching* (CB), and *beliefs about availability of those enabling factors in the classroom* (LO).

The external variables incorporated into the TPB model are age, sex, subject taught, teaching experience, teaching period, qualification, level of class, classroom access, and computer laboratory access.

By using these predictor variables, an ICT Use Model (ICTUM) was proposed for assessment. By assessing the proposed ICTUM model, this study attempted to identify factors predictive of teachers' ICT use in teaching. The proposed research model, ICTUM is grounded on the assumption that certain beliefs about ICT usage in the classroom affect teachers' perceptions about ICT use, and such perceptions, in turn, would affect their intentions or actual use of ICT in their teaching. If this assumption is correct, this model that predicts teachers' use of ICT based on teachers' perceptions should be able to demonstrate its ability to characterize the specific factors influencing teachers' use of ICT in teaching.

The study employed a survey questionnaire to collect the required data. The ICT in Education (ICTE) questionnaires were distributed to eighteen government secondary schools where 1,040 teachers responded. The return rate was 72%. The collected data was analysed using multiple statistical techniques, including

- both exploratory and confirmatory factor analyses for measurement model assessments to test the validity and reliability of measures; and

- structural equation modeling and hierarchical multiple regression for testing research hypotheses and the hypothesized paths in the model.

The computer software for statistical analyses, Statistical Package for Social Science (SPSS) version 10.0 and Analysis of Moment Structures (AMOS) version 5.0 were used to analyse the data for the current study.

2. Major findings

The major findings discussed in this section are based on the aims of the current research. The aims were to test the proposed research model, ICTUM's ability in predicting and explaining teachers' use of ICT in teaching, and compare its performance with the original TPB model. The ICTUM was a modified TPB model that elaborated the beliefs structures (indirect factors) of TPB into their respective dimensions through decomposition, and incorporated external variables.

The current study's elaboration of beliefs through belief decomposition was found to be useful, where the decomposed dimensions of behavioural, normative, and control beliefs significantly but weakly predicted attitude, subjective norms, and perceived behavioural control respectively, and their total effects on intention and ICT use were also significant statistically but weak.

Another model elaboration effort through inclusion of external variables into the research model was successful although the amount of additional variance in the total intention and ICT use explained by the model was small. The external variable, *class access* was the only external variable that could predict teachers' intentions significantly while three external variables (*subject taught, class access and computer laboratory access*) could predict teachers' use of ICT in teaching significantly.

Nevertheless, the overall performance of the research model, ICTUM did not show an indication of superiority to Ajzen's TPB model (1985) statistically. The ICTUM was found to be a marginally fitting model in predicting and explaining intention and behaviour. The ICTUM model explained only 17% of variance in *intention* and 13% in *use of ICT.*

However, the results did indicate that the TPB model of direct factors was a good fit model for predicting and explaining teachers' use of ICT in teaching. Teacher's *use of ICT* in teaching was predicted by *intention* and *perceived behavioural control*; and *intention* was predicted by *attitude towards the use of ICT* and *perceived behavioural control. Subjective norms* made weak prediction on *intention*. The TPB model of direct factors explained 25% of variance in *intention* and 16% in *use of ICT.*

8.2. Significance of the study: Theoretical and Practical Implications

The present study sought to contribute to research studies in information and communication technology use in the classrooms with its theoretical and practical implications.

8.2.1. Theoretical Implications

The current investigation of information and communication technology use was prompted by the observation that a prominent gap exists between the government initiatives to implement the use of ICT in the classroom and the marginal level of usage by teachers. This gap prompts two key questions: how is ICT perceived and used by teachers, and what factors can be used to predict and explain teachers' use of ICT in their teaching?

This study takes a theoretical modeling approach, based on a survey assessing psychological variables (such as teachers' beliefs, attitudes, and perceptions) to discover a basic mechanism that could explain teachers' use of ICT in the classroom. The theoretical approach of this study is new within studies of computer technology use, which have normally been limited to reporting user demographic characteristics and/or factors influencing its use among users. This study attempted to develop measurement models that might be replicated by other researchers interested in the influencing factors for teachers' ICT use in education.

The current study's review of related literature found that Ajzen's theory of planned behaviour, as a generic social psychological model, may serve as a useful theoretical framework for predicting the specific behaviour of teachers' use of ICT in the classroom. The current study found that teachers' intentions to use ICT received stronger influence from the *attitude towards use of ICT* line, as well as from *the perceived behavioural* control line. Influence from the *subjective norms* line was found to be weaker (refer to Figure 7.1). Ultimately, teachers' *use of ICT* is strongly influenced by their *intention*s rather than *perceived behavioural control* (also refer to Figure 7.1). This finding may indicate that, in the case of ICT use in the classroom by teachers in this study, attitudes towards the usefulness of ICT use in teaching and the influence of perception of control are more important than the influences of social norms.

Among the two efforts at theoretical elaboration, the attempt to decompose the TPB's behavioural, normative, and control beliefs was found to be unsuccessful in showing a good model fit (refer to Table 7.6), and explained only a small amount of variances in *intention* and *use* (17% and 13% respectively). The poor performance of the ICTUM may be assumed to be the result of model mis-specification and violating the theoretical TPB framework may develop a better model. For example, the beliefs sets may not be mediated by the respective TPB constructs (*attitude, subjective norms,* and *perceived behavioural control*), and may have direct paths from beliefs to *intention* or behaviour *(use of ICT)*. For example, studies that investigated information technology use using the Technology Acceptance Model (TAM) showed that beliefs directly influence intention. These studies showed that the two fundamental beliefs about "usefulness" and "ease of use" had two direct paths, one to *attitude* and the other to *intention* (Adam, Nelson, & Todd, 1992; Davis, 1989).

The second theoretical elaboration effort, which involved incorporating external variables into the model, was found to be successful in increasing the explained variance in *intention* (refer to Table 7.8) and in *use of ICT* (refer to Table 7.10) although the amount of increase was small (1.5% and 9.4% respectively). The influence of these variables should be further investigated by using different approaches to further improve their performances. One approach might involve treating them as moderators in their influence on *use*, instead of treating them as predictors in the model. Nevertheless, this result is in agreement with Ajzen's assertion about the sufficiency of TPB as a theory.

The current study was able to propose a specific model for predicting teacher use of ICT in the classroom that is composed of three major predictors of ICT use. Multiple statistical analysis techniques have been used to assess the model that demonstrated the model's lack of adequacy in explaining sufficient amount of variance in teacher intention and behaviour. This implies the need for improvement of the model, particularly in the measures for each of the beliefs structures. Nonetheless, this study is significant in that it strived to develop items that could measure teachers' beliefs and perceptions about using ICT in the classroom. The developed items are shown to be statistically valid and reliable for measuring teachers' attitudes towards ICT use, their perceptions of the influence of subjective norms, and control factors for using ICT effectively in teaching.

8.2.2. Practical implications

The most notable reported characteristic of computer technology use in school is that it is highly accessible yet underused (Cuban, 2001; Cuban et al., 2001). Accordingly, relevant authorities initiating ICT implementation across the curriculum endeavour to focus upon identifying factors encouraging teachers to use more computer technology, particularly ICT in their teaching. Thus, the current study attempted to answer the following question: to what extent do teachers use ICT in their teaching, and how do they perceive ICT use in teaching?

An attempt was made to answer the first part of the question by examining teachers' responses about the accessibility of computers in their schools and whether or not they use ICT in teaching. Two observations were made from the analyses of data. First, this study made the same observation reported by Cuban and others that computers are highly accessible to teachers but they are underused in teaching (refer to Table 7.12.). Second, this study also observed that teachers who taught religious studies, sciences, computer studies, mathematics, and Malay languages used ICT in teaching more than the other teachers (such as geography, history, and English languages). Thus in response to the question on the extent to which ICT was used in teaching; this study answered that in fact teachers mostly did not use ICT in their teaching and among those who did use ICT, only a few groups of teachers used ICT more than the others. However, more evidence from other sources such as observations and interviews with teachers, students and principals are required in order to support the second observation.

In order to answer the second part of the question about how teachers' perceptions influence their use of ICT in teaching, the presence of variables that uniquely characterize teacher use of ICT was examined. This study identified that teachers' attitude towards use of ICT, and their perceptions of personal ability to use ICT, to a greater extent than their perceptions of social pressure – were the major predictors of ICT use. Thus, in response to the question on how teachers perceived their use of ICT in teaching, this study answered that mediated by their intention to use, teachers' attitudes and perceptions of personal ability predicted their use of ICT in teaching more strongly than their perceptions of social pressure (Refer to Table 7.2).

The findings provide several implications for administrators (such as the Department of ICT and principals) who seek effective means to encourage more use of ICT in teaching. Observing that teacher' attitudes and perceptions of personal ability were found to be fundamental in predicting use, one means is to provide incentives and more personal developments for teachers with respect to ICT use and pedagogical applications. Most of all, in providing technical support, an emphasis on the availability of "on call" services would help to improve teachers' expectation of help being available whenever it is required.

Considering the above practical implications of the current study, the fundamental model of theory of planned behaviour could be used as an evaluation tool in practice. The three predictors of the theory indicate major expectations involved in the teachers' use of ICT in teaching. Administrators could assess their programmes (such as professional development or ICT implementation programmes) in meeting teachers' needs for personal improvements and providing appropriate support for their sustained use of ICT. Professional development strategies that may promote personal improvement and sustainability could include hands-on activities or workshops that encourage teachers to practise the acquired skills in preparing ICT resources for teaching or learning purposes, and demonstrate strategies for using the prepared resources.

8.3. Limitations of the study

Studies conducted in the form of a survey research in a natural setting are normally accompanied by multiple limitations. Some of the limitations are avoidable while others are not, due to the dynamics of the field study setting. The current study is no exception. One of the limitations was the reliance of the research on self-reported measures in the form of a questionnaire survey method as the main source of gathering data. However, based on the discussions about the dependability of self-report of socially desirable behaviours to an extent (such as the case in this study), the current study depended and presumed mostly on teachers' openness and sincerity when responding to the questionnaire.

Another limitation specific to the current study is in relation to representation of population. Although the current study presents the whole population of government secondary schools in Brunei, it is equally important to obtain information on non-government secondary teachers' attitudes and perceptions towards ICT in teaching. However, the non-government secondary schools were not included in the study because the main aim of the current study was to obtain perceptions of those teachers teaching in the government schools as these schools were recently upgraded structurally for ICT implementation projects.

Another limitation of the study is the paucity of research with regard to secondary school teachers' attitudes and perceptions towards the use of ICT in teaching in Brunei that could be used as a baseline for reference. The current study has to refer to literature from different cultural contexts such as the United States, United Kingdom, Australia, and New Zealand. This entails careful interpretations and comparisons of the findings of the current study.

8.4. Strengths of the Study

The main strength of the current study is that it is the first local study that provides the national profile of government secondary school teachers' perceptions about the use of ICT in teaching. Unlike an earlier study (e.g. Buntar, 2002) that used a sample of primary science teachers only, this study surveyed the perceptions of all secondary teachers teaching all subjects across the curriculum about their use of ICT in teaching. The current study has yielded up-to-date information on teachers' perceptions about the use of ICT in the classroom and adds to the limited literature on ICT use in the Brunei schools. This information will inform education planners in Brunei regarding the current perceptions of secondary school teachers, and some implications for professional development for teachers, and some control factors that need to be asserted to encourage teachers to use ICT in teaching.

Another strength of the current study is that it is able to adapt various researcher-designed instruments to suit the Bruneian context and hence reflects the actual local teachers' attitudes and perceptions. The adapted instrument should be more appropriate for use than other instruments produced outside Brunei.

8.5. Suggestions for Future Research

The current study attempted to utilize a theoretical approach in an exploratory research area and revealed some unexpected findings that have not been reported in previous literature. The following suggestions are made for future research studies based on the unexpected findings.

Lack of Sufficient Influence of Salient beliefs (Indirect factors)

From the theoretical perspective, an attempt to examine teachers' behavioral, normative, and control beliefs as predictors of teachers' attitude, and perceptions of social control and personal control regarding their intention and use of ICT in teaching, failed to provide satisfactory results. Future studies could examine whether those salient beliefs have direct paths to intention and behaviour, and are not mediated by attitudes and perceptions.

Different Amount of ICT Use Among Subject Teachers And Influence of Demographic variables

As discussed earlier, the use of ICT among teachers do not seem to be homogenous but confined to certain groups of teachers according to the subjects they teach. For example, teachers teaching religious studies, geography, science and mathematics seemed to use ICT more in teaching than other subject teachers. Future research could investigate if the differences in ICT use in teaching are possibly due to differences in their perceptions of the use, and the types of use. Thus, research identifying different types of ICT use due to different perceptions among subject teachers would provide more information about use of ICT in teaching of different groups of teachers. The study would be meaningful if the relations were assessed in conjunction with demographic variables that might possibly distinguish different patterns of use among different groups of teachers. With regard to demographic variables, this study identified that some variables are predictors of intention and use, while others are not. Future studies could examine the role of those demographic variables as moderators instead of predictors in the model.

As a closing remark, teachers must have positive attitudes and perceptions regarding the usefulness of using ICT in teaching and possess computer and ICT skills to effectively implement ICT in their teaching.

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APPENDICES

Appendix A Information and Communication Technology in Education (ICTE) questionnaire

Dear Teachers,

Thank you for taking a short time off your busy schedule to respond to this rather lengthy questionnaire. This questionnaire examines teachers' attitude and competence in using ICT in teaching. The questionnaire is one of the instruments that I use for my PhD research on teachers' use of ICT in teaching.

I would like to advice you that I have obtained permission from the Director of Schools, Ministry of Education to conduct the research. I have also obtained ethical clearance for the research project at University of Southern Queensland. If you have concern regarding the implementation of the questionnaire, you should contact The Secretary, Human Research Ethics Committee, USQ, Toowoomba, Queensland 4350, Australia or telephone 6174631 2956.

Thank you for your participation.

Best wishes,

Sallimah Mohd. Salleh

ICT IN EDUCATION QUESTIONNAIRE

For the purpose of this questionnaire, the term ICT (Information and Communication Technologies) refers to the use of the **Internet, E-mail, video conferencing and other forms of communication technologies** as well as the use of **computer software applications such as Powerpoint.**

The information from this questionnaire will be used to develop a guide to effective ICT professional developments programmes for staff in schools. The schools of the respondents will be cited in the acknowledgements but no names or institutions will be linked to particular comments in any publications and consequently no individuals or no institutions will be identifiable.

Your responses to the questionnaire are important; please respond to ALL the items. Thank you.

1. Personal Information (Please mark an "X")

Age: 18-25 ☐ 26-30 ☐ 31- 35 ☐
36-40 ☐ 41-45 ☐ 46+ ☐

Sex : M ☐ F ☐

Name of school: ____

Subject(s) that you teach:

____

How long have you been teaching?

☐ 0-1 year ☐ 2-5 years ☐ 6-10 years ☐ 11-15 years ☐ 15+ years

What is your number of teaching periods/week? _______________________

Your Highest qualification

☐ PhD ☐ Masters ☐ BA/BSc ☐ Diploma ☐ Certificate

Which level(s) do you teach? ☐ Lower secondary ☐ Upper secondary

☐ Both upper and lower secondary

Do you have access to computers in the classroom? ☐ Yes ☐ No

Do you have access to computers in the computer laboratory? ☐ Yes ☐ No

2. How do you feel about using ICT in your teaching? Circle your response.

	Strongly Disagree				**Strongly Agree**
I feel that teaching using ICT is a good idea.	1	2	3	4	5
I feel that teaching using ICT is appropriate.	1	2	3	4	5
I like teaching using ICT.	1	2	3	4	5
I enjoy teaching using ICT.	1	2	3	4	5
I feel comfortable teaching using ICT.	1	2	3	4	5

3. Who would have an influence on your using ICT in teaching? Circle your response.

The following people (or social group) would influence my use of ICT in teaching:	**Strongly Disagree**				**Strongly Agree**
People with whom I work.	1	2	3	4	5
People whom I meet socially.	1	2	3	4	5
People who are important to me.	1	2	3	4	5
Educational researchers.	1	2	3	4	5
Computer societies.	1	2	3	4	5

4. How do you agree with each of the following statements? Circle your response.

	Strongly Disagree				**Strongly Agree**
I am certainly able to use ICT in teaching if I want to use.	1	2	3	4	5
I am entirely capable of using ICT in teaching successfully.	1	2	3	4	5
I have the resources, the knowledge, and the skills to use ICT effectively in teaching.	1	2	3	4	5
There are some things that I cannot control when I use ICT in teaching.	1	2	3	4	5
I can teach using ICT if I have support.	1	2	3	4	5

5. With respect to your future use, please indicate the number that best represents the likelihood of your using ICT in teaching during the next six months.

During the next six months,	**Very Unlikely**				**Very Likely**
I am likely to use ICT for demonstrations in my lessons.	1	2	3	4	5
I will use ICT in presenting my lessons.	1	2	3	4	5
I will instruct students to use ICT for learning.	1	2	3	4	5
I will use ICT simulations in my lessons.	1	2	3	4	5

6. Please indicate the frequency of your use of ICT in teaching. Circle your response.

	Never				**Always**
How often did you use ICT in your teaching this week?	1	2	3	4	5
How often did you use ICT in your teaching in the last six months?	1	2	3	4	5
How often did you use ICT in your teaching last year?	1	2	3	4	5

7. How likely are the following outcomes will occur when you use ICT in your teaching? Circle your response.

Using ICT in my teaching will:	**Not Likely**				**Very Likely**
Make my lessons more interesting.	1	2	3	4	5
Improve the presentations of teaching materials.	1	2	3	4	5
Make my lessons more diverse.	1	2	3	4	5
Make my lessons more motivating.	1	2	3	4	5
Help students understand the lessons better.	1	2	3	4	5
Develop students' learning skills.	1	2	3	4	5

8. How important are the occurrence of these outcomes when you use ICT in your teaching? Circle your response.

Using ICT in my teaching should:	**Not important**				**Very Important**
Make my lesson more interesting.	1	2	3	4	5
Improve the presentation of teaching materials.	1	2	3	4	5
Make my lessons more diverse.	1	2	3	4	5
Make my lessons more motivating.	1	2	3	4	5
Help students understand the lessons quicker.	1	2	3	4	5
Develop students' learning skills.	1	2	3	4	5

9. What would each of the following individual or group of individuals think about your using ICT in teaching? Circle your response.

The following people thinks about my use of ICT in teaching:	**Should not use**				**Should use**
Principal	1	2	3	4	5
Colleagues	1	2	3	4	5
Head of department	1	2	3	4	5
Parents	1	2	3	4	5
Students	1	2	3	4	5
The curriculum department	1	2	3	4	5

10. How influential to you is each of the individual(s)'s thoughts about your use of ICT in teaching? Circle your response.

What the following people thinks about my use of ICT in teaching influence me:	**Not at all influential**				**Very influential**
Principal	1	2	3	4	5
Colleagues	1	2	3	4	5
Head of department	1	2	3	4	5
Parents	1	2	3	4	5
Sudents	1	2	3	4	5
The curriculum department	1	2	3	4	5

11. Indicate your opinion about the following factors that would enable you to teach effectively using ICT. Circle your response.

The following factors would **enable** me to teach effectively using ICT.	1 – Strongly disagree (SD) 5 – Strongly agree (SA)			
FACTORS:	SD			SA
Resources (educational software)	1	2	3	4	5
Professional development opportunities on using ICT in teaching	1	2	3	4	5
Access to the Internet	1	2	3	4	5
Quality software	1	2	3	4	5
Physical classroom structures (electrical outlets, moving tables, etc)	1	2	3	4	5
Support from school administrators	1	2	3	4	5
Support from parents	1	2	3	4	5
Support from other teachers	1	2	3	4	5
Technical support (technician)	1	2	3	4	5
Time to plan for ICT implementation	1	2	3	4	5
Smaller class sizes	1	2	3	4	5
Time to let students use ICT	1	2	3	4	5

12. Indicate your opinion about the likelihood of the following factors being available at your school. Circle your response.

How **likely** is that these factors will occur in your school?	1 – Very Unlikely (VU) 5 – Very likely (VL)				
FACTORS:	VU				VL
Resources (educational software)	1	2	3	4	5
Professional development opportunities on using ICT in teaching	1	2	3	4	5
Access to the Internet	1	2	3	4	5
Quality software	1	2	3	4	5
Physical classroom structures (electrical outlets, moving tables, etc)	1	2	3	4	5
Support from school administrators	1	2	3	4	5
Support from parents	1	2	3	4	5
Support from other teachers	1	2	3	4	5
Technical support (technician)	1	2	3	4	5
Time to plan for ICT implementation	1	2	3	4	5
Smaller class sizes	1	2	3	4	5
Time to let students use ICT	1	2	3	4	5

Thank you.

(ICTE questionnaire in Malay translation)
KAJI SELEDIK ICT DALAM PENDIDIKAN

Untuk tujuan kaji seledek mengenai ICT dalam pendidikan ini, istilah ICT (Teknologi informasi dan maklumat) merangkumi pengunaan **Internet, E-mel, persidangan video** dan **bentuk lain teknologi komunikasi** di samping **aplikasi perisian komputer seperti Powerpoint.**

Hasil maklumat kaji seledik ini akan digunakan untuk merumus satu garis pandu ke arah program pembangunan profesional yang berkesan bagi para guru di sekolah. Nama sekolah responden yang terlibat akan dicatat dalam rekod pemberitahuan. Walau bagaimanapun, sebarang komen yang bersangkutan sebarang penerbitan tidak akan membabitkan mana-mana sekolah ataupun individu.

Respon awda kepada kaji seledik ini sangat penting. Sila jawab semua soalan. Terima kasih.

1. Butir-butir maklumat peribadi (Sila tanda "X")

Umur: ☐ 18-25 ☐ 26-30 ☐ 31-35
☐ 36-40 ☐ 41-45 ☐ 46+

Jantina: : ☐ Lelaki ☐ Perempuan

Nama sekolah : ____

Mata pelajaran diajar:____

Kelamaan mengajar:

☐ 0-1 tahun ☐ 2-5 tahun ☐ 6-10 tahun ☐ 11-15 tahun ☐ 15+ tahun

Jumlah waktu mengajar dalam masa seminggu: __________

Kelulusan tertinggi

☐ Ph.D ☐ Sarjana ☐ Sarjana Muda ☐ Diploma ☐ Sijil

Peringkat apakah awda mengajar?

☐ Menengah bawah ☐ Menengah Atas ☐ Menengah bawah dan atas

Adakan awda dapat menggunakan komputer di bilik darjah? ☐ Ya ☐ Tidak

Adakan awda dapat menggunakan komputer di makmal komputer? Ya ☐ Tidak ☐

2. Bagaimana perasaan awda mengenai pengunaan ICT dalam pengajaran? Sila bulatkan pada jawapan yang dipilih.

	Sangat tidak setuju				**Sangat setuju**
Saya rasa penggunaan ICT dalam pengajaran sebagai ide yang baik.	1	2	3	4	5
Saya rasa penggunaan ICT dalam pengajaran adalah patut.	1	2	3	4	5
Saya suka menggunakan ICT dalam pengajaran.	1	2	3	4	5
Saya gembira menggunakan ICT dalam pengajaran.	1	2	3	4	5
Saya rasa selesa menggunakan ICT dalam pengajaran.	1	2	3	4	5

3. Siapa yang boleh mempengaruhi awda untuk menggunakan ICT dalam pengajaran? Bulatkan pada jawapan yang di pilih.

Individu-individu di bawah boleh mempengaruhi saya untuk menggunakan ICT dalam pengajaran	**Sangat tidak setuju**				**Sangat setuju**
Orang yang bekerja dengan saya.	1	2	3	4	5
Orang yang saya kenali sewaktu perjumpaan social.	1	2	3	4	5
Orang yang penting bagi saya.	1	2	3	4	5
Ahli-ahli kaji seledik pendidikan	1	2	3	4	5
Persatuan computer	1	2	3	4	5

4. Bagaimanakah pendapat awda mengenai kenyataan di bawah? Bulatkan pada jawapan yang dipilih.

	Sangat tidak setuju				**Sangat setuju**
Saya pasti dapat menggunakan ICT dalam pengajaran jika saya mau.	1	2	3	4	5
Saya pasti mempunyai keupayaan untuk menggunakan ICT dalam pengajaran dengan jaya.	1	2	3	4	5
Saya mempunyai sumber, pengetahuan, dan keupayaan untuk menggunakan ICT dalam pengajaran dengan berkesan.	1	2	3	4	5
Ada beberapa perkara yang tidak dapat saya kuasai sewaktu menggunakan ICT dalam pengajaran.	1	2	3	4	5
Saya boleh menggunakan ICT dalam pengajaran jika ada bantuan.	1	2	3	4	5

5. Apakah kemungkinan awda bercadang untuk menggunakan ICT dalam pengajaran dalam jangka waktu enam bulan akan datang? Bulatkan pada jawapan yang dipilih.

Dalam jangka waktu enam bulan akan datang,	**Sangat tidak mungkin**				**Sangat mungkin**
Saya bercadang akan menggunakan ICT untuk demonstrasi isi pelajaran.	1	2	3	4	5
Saya bercadang akan menggunakan ICT untuk penyampaian isi pelajaran.	1	2	3	4	5
Saya bercadang akan mengarahkan penuntut saya untuk menggunakan ICT sewaktu belajar.	1	2	3	4	5
Saya bercadang akan mengunakan simulasi ICT dalam pelajaran.	1	2	3	4	5

6. Sila bulatkan pilihan awda mengenai kekerapan awda menggunakan ICT dalam pengajaran.

	Langsung tidak pernah				**Selalu**
Berapa kerapkah awda menggunakan ICT dalam pengajaran minggu ini?	1	2	3	4	5
Berapa kerapkah awda menggunakan ICT dalam pengajaran dalam jangka waktu enam bulan yang lepas?	1	2	3	4	5
Berapa kerapkah awda menggunakan ICT dalam pengajaran pada tahun lepas?	1	2	3	4	5

7. Bagaimana dengan kemungkinan kesan pada pengajaran jika awda menggunakan ICT dalam pengajaran? Sila bulatkan jawapan yang dipilih.

Penggunaan ICT sewaktu saya mengajar akan:	**Sangat tidak mungkin**				**Sangat mungkin**
Menghasilkan pengajaran yang lebih menarik.	1	2	3	4	5
Memperelokkan penyampaian bahan pelajaran.	1	2	3	4	5
Menghasilkan pengajaran yang lebih pelbagai.	1	2	3	4	5
Mempertingkatkan motivasi penuntut untuk belajar.	1	2	3	4	5
Membantu penuntut untuk lebih faham isi pelajaran.	1	2	3	4	5
Membentuk skil belajar penuntut.	1	2	3	4	5

8. Bagaimanakah kepentingan kesan pada pengajaran jika awda menggunakan ICT dalam pengajaran. Sila bulatkan jawapan yang dipilih.

Penggunaan ICT sewaktu saya mengajar mesti	**Sangat tidak penting**				**Sangat penting**
Menghasilkan pelajaran yang lebih menarik.	1	2	3	4	5
Memperelokkan penyampaian bahan pelajaran.	1	2	3	4	5
Menghasilkan pengajaran saya lebih pelbagai.	1	2	3	4	5
Mempertingkatkan motivasi penuntut untuk belajar.	1	2	3	4	5
Membantu penuntut untuk cepat faham isi pelajaran.	1	2	3	4	5
Membentuk skil belajar penuntut.	1	2	3	4	5

9. Apakan fikiran individu-individu tersebut di bawah untuk awda menggunakan ICT dalam pengajaran. Sila bulatkan jawapan yang dipilih.

Individu-individu tersebut di bawah berfikir saya menggunakan ICT dalam pengajaran.	**Jangan sesekali gunakan**				**Mesti gunakan**
Pengetua	1	2	3	4	5
Rakan sejawat	1	2	3	4	5
Ketua Jabatan	1	2	3	4	5
Ibu bapa penuntut	1	2	3	4	5
Penuntut	1	2	3	4	5
Jabatan kurikulum	1	2	3	4	5

10. Bagaimanakah pengaruh fikiran individu-individu tersebut tentang awda menggunaan ICT dalam pengajaran kepada awda? Sila bulatkan jawapan yang dipilih.

Pengaruh fikiran individu-individu tersebut di bawah tentang saya menggunakan ICT dalam pengajaran.	**Sangat tidak berpengaruh**				**Sangat berpengaruh**
Pengetua	1	2	3	4	5
Rakan sejawat	1	2	3	4	5
Ketua Jabatan	1	2	3	4	5
Ibu bapa penuntut	1	2	3	4	5
Penuntut	1	2	3	4	5
Jabatan kurikulum	1	2	3	4	5

11. Sila bulatkan pendapat awda mengenai faktor yang membolehkan awda mengajar dengan menggunakan ICT dengan efektif. Sila bulatkan jawapan yang dipilih.

Faktor di bawah **membolehkan** saya mengajar dengan menggunakan ICT dengan efektif:	**Sangat tidak setuju**				**Sangat setuju**
Sumber (perisian pendidikan).	1	2	3	4	5
Peluang untuk mengikuti pembangunan profesional mengenai penggunaan ICT dalam pengajaran.	1	2	3	4	5
Laluan ke Internet.	1	2	3	4	5
Perisian berkualiti.	1	2	3	4	5
Struktur fiszikal bilik darjah (saluran keluar letrik, meja mudah alih, dll).	1	2	3	4	5
Sokongan sekolah.	1	2	3	4	5
Sokongan ibu bapa.	1	2	3	4	5
Sokongan guru lain.	1	2	3	4	5
Sokongan teknikal (Juruteknik).	1	2	3	4	5

12. Sila bulatkan pendapat awda mengenai kemungkinan faktor yang membolehkan awda mengajar dengan ICT dengan efektif berlaku atau tersedia di sekolah awda. Sila bulatkan jawapan yang dipilih.

Kemungkinan factor tersebut di bawah akan berlaku atau tersedia di sekolah saya:	**Sangat tidak mungkin**				**Sangat mungkin**
Sumber (perisian pendidikan).	1	2	3	4	5
Peluang untuk mengikuti pembangunan profesional mengenai penggunaan ICT dalam pengajaran.	1	2	3	4	5
Laluan ke Internet.	1	2	3	4	5
Perisian berkualiti.	1	2	3	4	5
Struktur fiszikal bilik darjah (saluran keluar letrik, meja mudah alih, dll).	1	2	3	4	5
Sokongan sekolah.	1	2	3	4	5
Sokongan ibu bapa.	1	2	3	4	5
Sokongan guru lain.	1	2	3	4	5
Sokongan teknikal (Juruteknik).	1	2	3	4	5

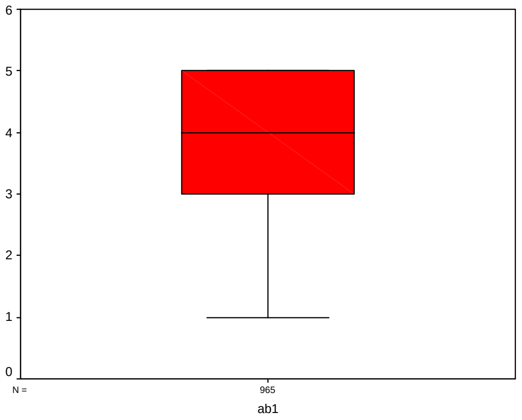
Terima kasih.

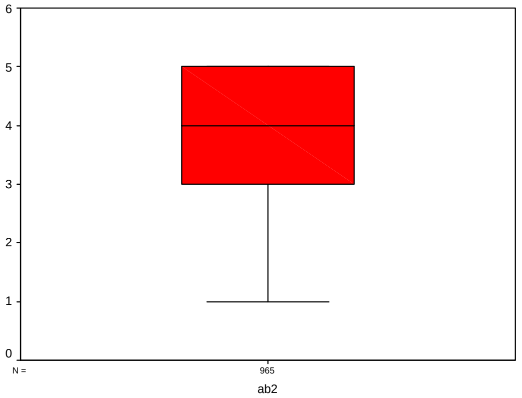
Appendix B Analysis of missing variables

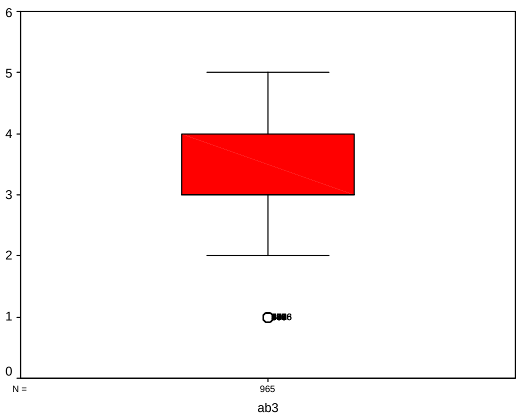
Variable	N	Mean	Std. Deviation	Missing	
				Count	Percent
GOODIDE	1028	3.99	1.02	12	1.2
APROPRIT	1023	3.74	1.00	17	1.6
LIKE	1012	3.42	1.02	28	2.7
ENJO	1009	3.40	1.03	31	3.0
COMFORT	1009	3.36	1.05	31	3.0
WORK	1022	3.61	1.04	18	1.7
MEET	1013	3.01	1.10	27	2.6
IMPTANT	1013	3.20	1.13	27	2.6
RESEARCH	1015	3.37	1.13	25	2.4
SOCIETY	1014	3.19	1.20	26	2.5
ABLE	1031	3.50	1.11	9	.9
CAPABLE	1031	3.22	1.07	9	.9
SKILLS	1033	2.99	1.09	7	.7
CONTROL	1031	3.39	1.13	9	.9
SUPPORT	1034	3.92	1.03	6	.6
DEMONSTR	1028	2.99	1.29	12	1.2
PRESENT	1029	2.98	1.26	11	1.1
INSTRUCT	1028	2.93	1.19	12	1.2
SIMULATE	1024	2.87	1.21	16	1.5
USE	1030	1.73	.45	10	1.0
WEEK	1034	1.52	.99	6	.6
MONTH	1033	1.73	1.08	7	.7
YEAR	1034	1.85	1.14	6	.6
INTEREST	1029	4.00	.96	11	1.1
IMPROVE	1028	3.98	.91	12	1.2
DIVERSE	1029	3.98	.91	11	1.1
MOTIVATE	1030	4.04	.90	10	1.0
UNDERSTA	1029	3.83	.95	11	1.1
DEVELOP	1030	3.83	.94	10	1.0
SDINTERE	1026	4.05	.93	14	1.3
SDIMPROV	1025	4.03	.90	15	1.4
SDDIVERS	1024	3.99	.91	16	1.5
SDMOTIVE	1026	4.04	.92	14	1.3
SDUNDERS	1027	3.86	.97	13	1.3
SDDEVELO	1024	3.90	.94	16	1.5
PRINCPAL	1015	3.95	.97	25	2.4
COLEAGUE	1013	3.58	.91	27	2.6
HOD	1011	3.80	.93	29	2.8
PARENT	1009	3.35	.92	31	3.0
STUDENT	1010	3.59	.95	30	2.9
CURRICUL	1010	3.87	.97	30	2.9
INPRINCI	1012	3.74	1.04	28	2.7
INCOLEAG	1012	3.51	.96	28	2.7
INHOD	1009	3.66	.97	31	3.0
INPARENT	1006	3.14	1.02	34	3.3
INSTUDEN	1008	3.34	1.03	32	3.1
INCURR	1010	3.66	1.05	30	2.9
RESOURCE	1017	4.30	.92	23	2.2
PD	1021	4.20	.94	19	1.8
INTERNET	1018	4.14	.97	22	2.1
SOFTWARE	1019	4.20	.94	21	2.0
PHYSICAL	1019	4.16	1.02	21	2.0
ADMIN	1019	4.26	.95	21	2.0
PRENT	1017	3.73	1.09	23	2.2
TEACH	1017	3.97	.99	23	2.2
TECH	1019	4.12	1.02	21	2.0

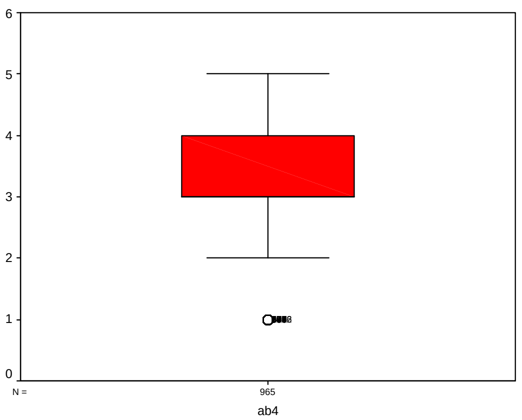
PLAN	1017	4.09	.98	23	2.2
SMAL	1015	4.07	1.01	25	2.4
TUSE	1015	4.06	1.00	25	2.4
LIRESOUR	1018	3.28	1.17	22	2.1
LIPD	1021	3.46	1.09	19	1.8
LINTERNE	1020	3.70	1.15	20	1.9
LISOFT	1017	3.29	1.11	23	2.2
LIPHY	1016	3.16	1.28	24	2.3
LIADMIN	1018	3.62	1.06	22	2.1
LIPRENT	1014	3.11	1.11	26	2.5
LITEACH	1014	3.47	1.00	26	2.5
LITECH	1017	3.10	1.23	23	2.2
LIPLAN	1012	3.15	1.10	28	2.7
LISMAL	1014	2.85	1.30	26	2.5
LIUSE	1013	3.05	1.19	27	2.6

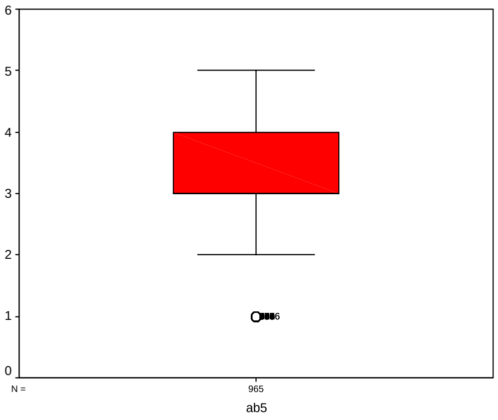
Appendix C Box Plot











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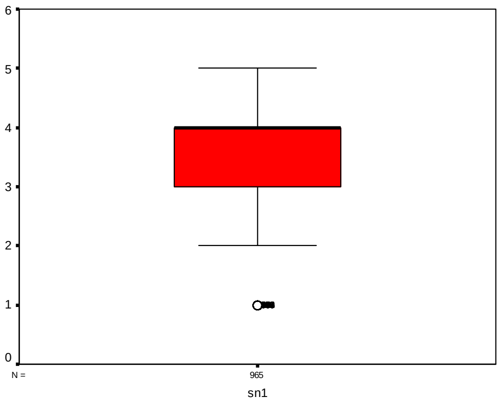

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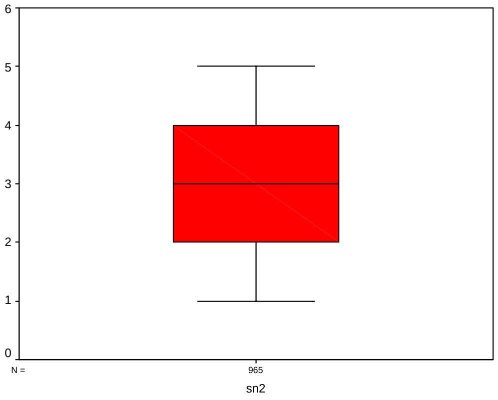

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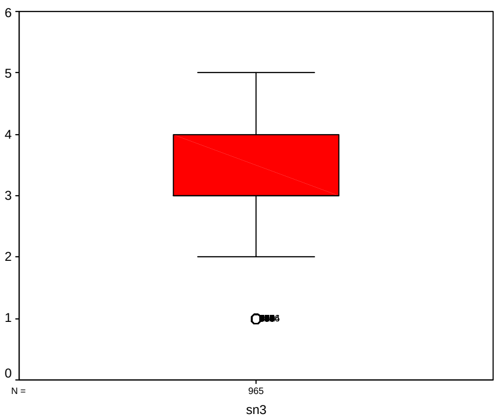

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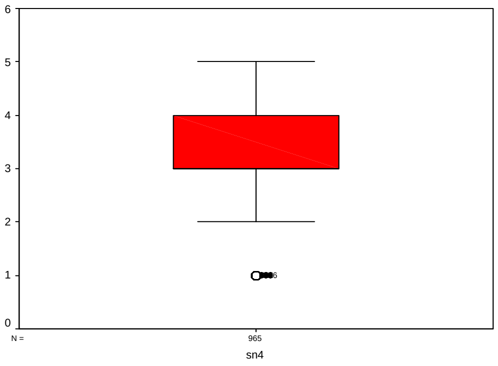
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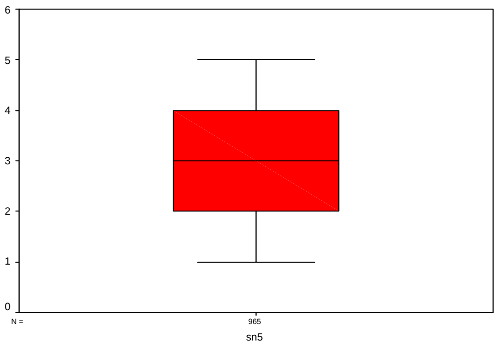
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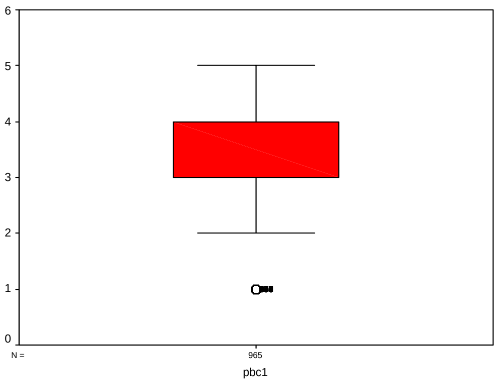
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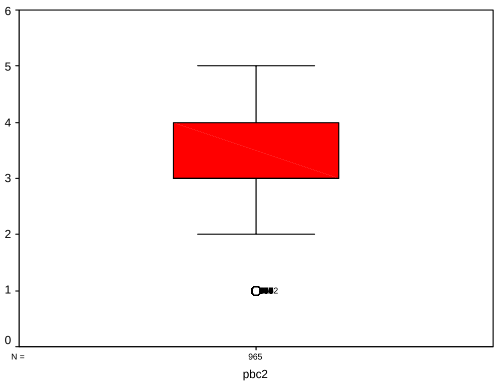
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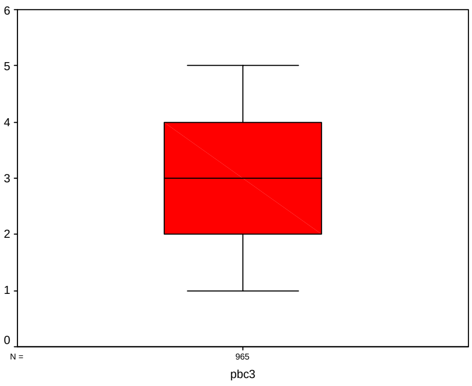
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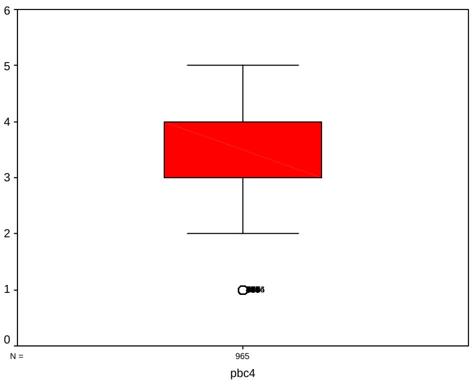
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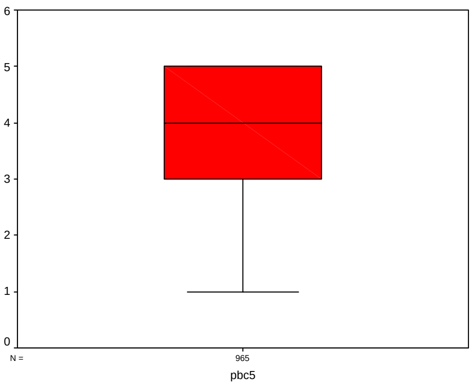
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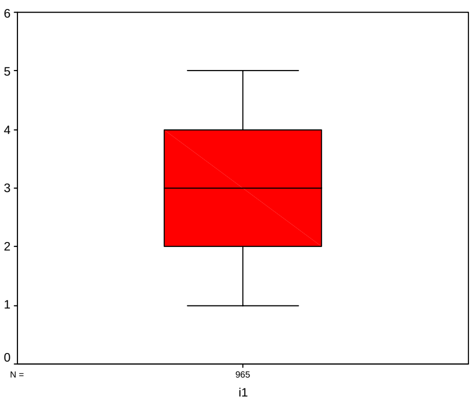
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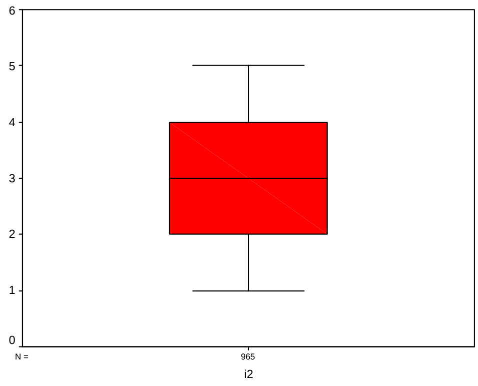
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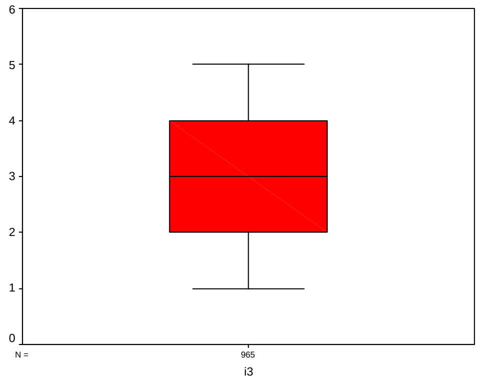
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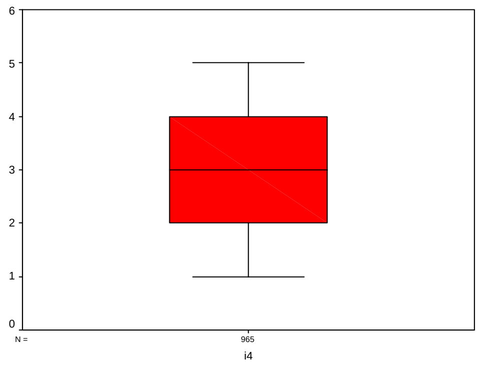
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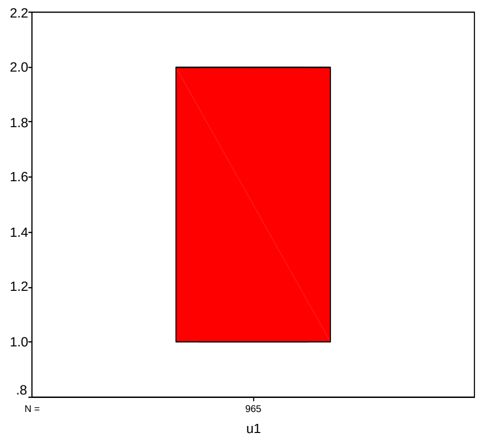
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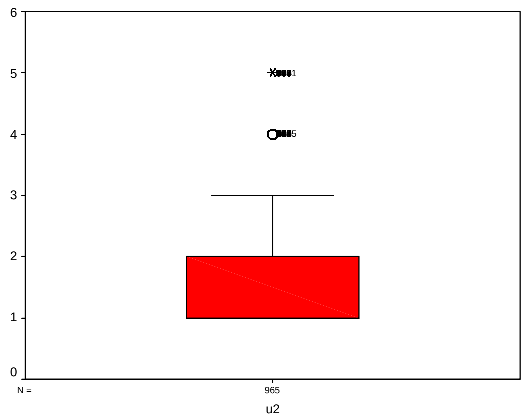
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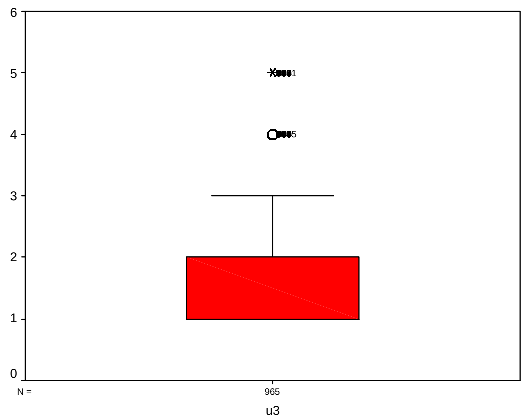
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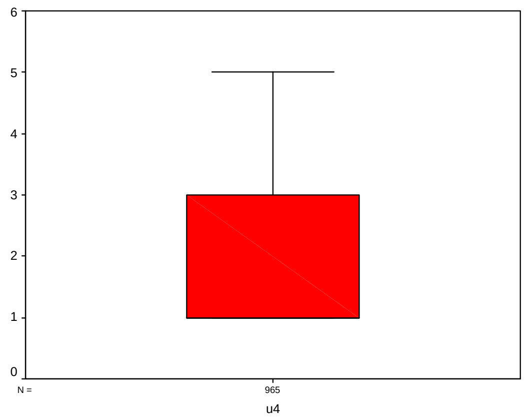
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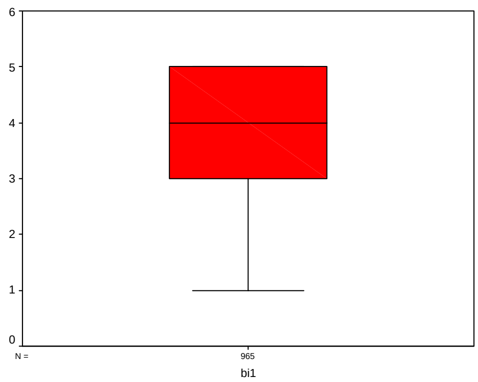
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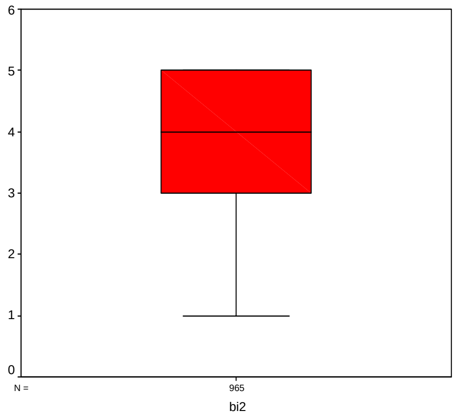
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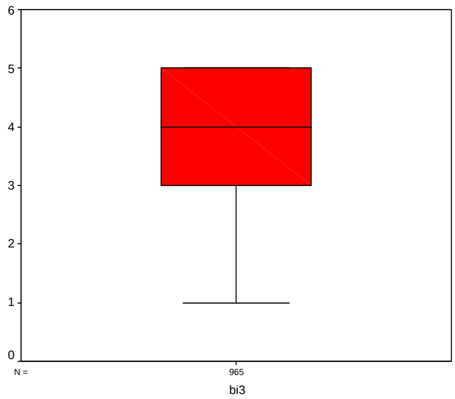
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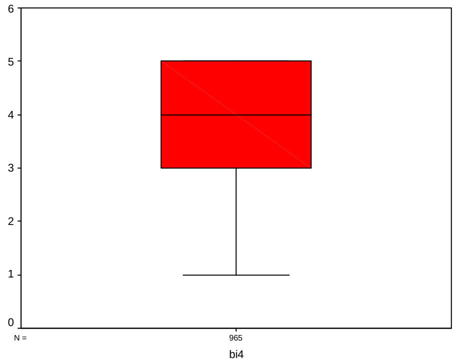
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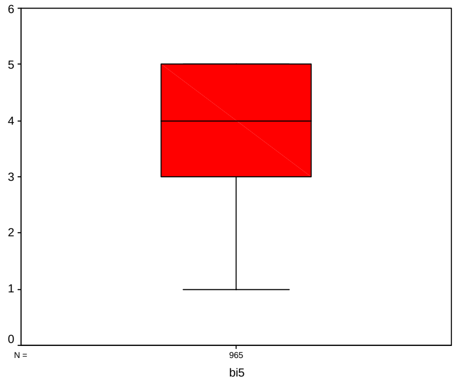
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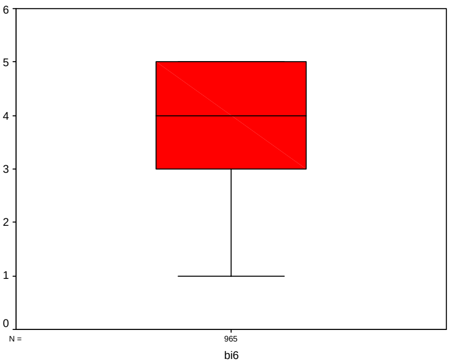
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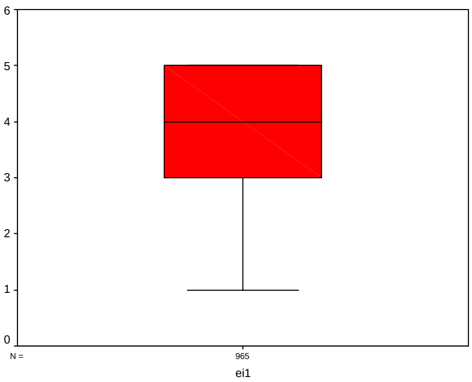
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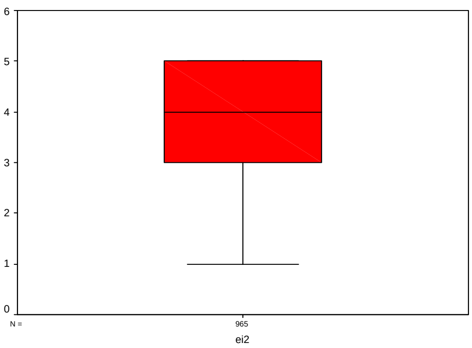
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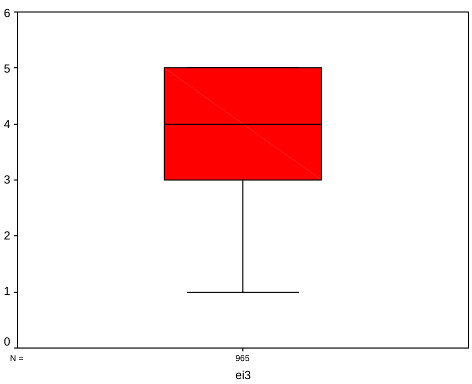
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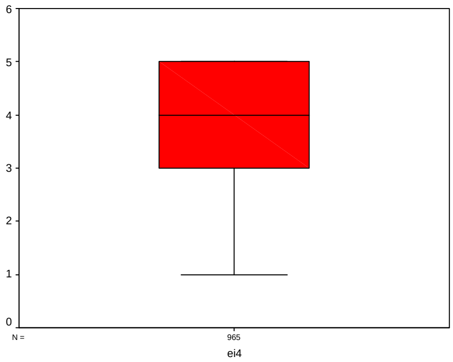

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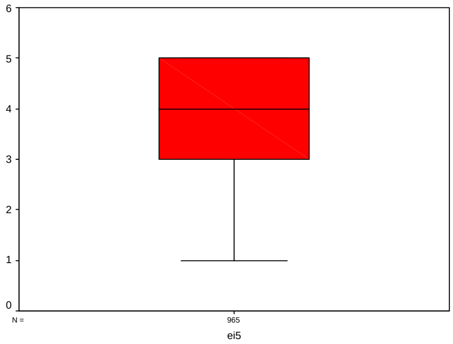

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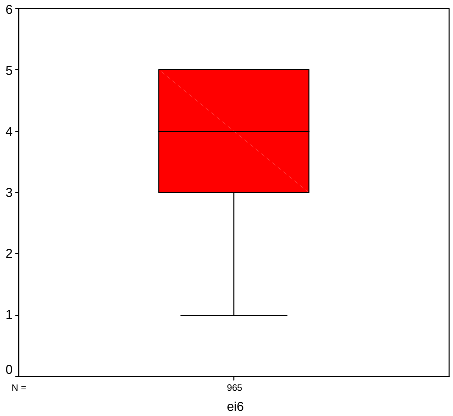

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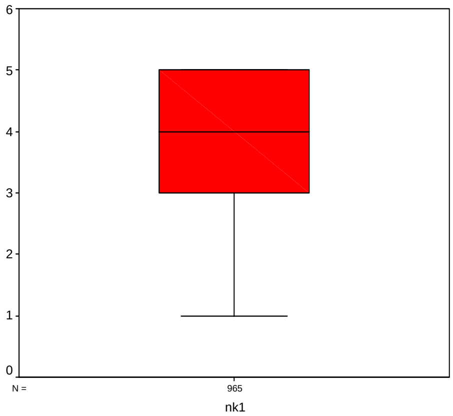

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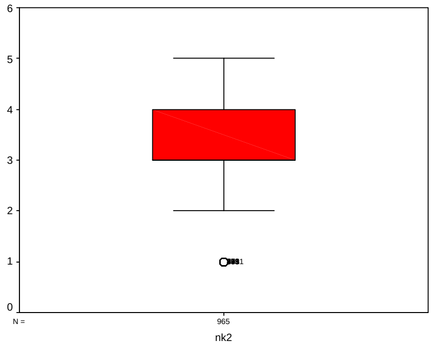
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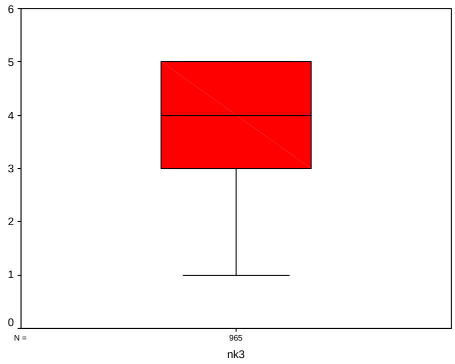
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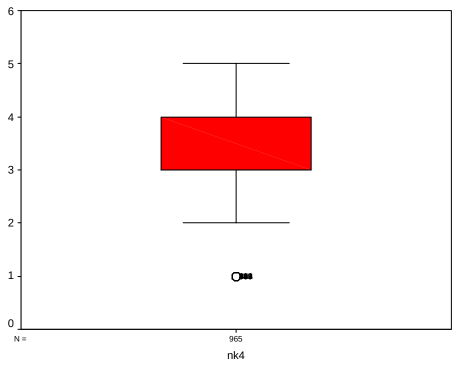
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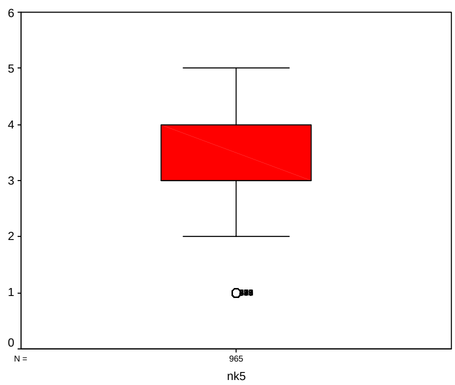
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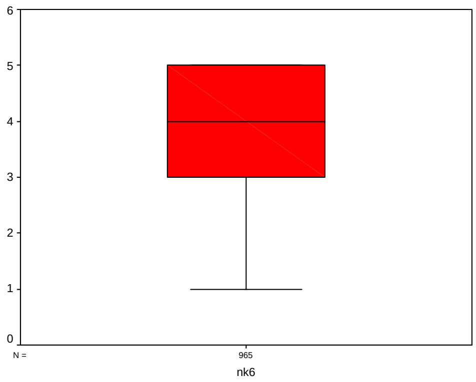
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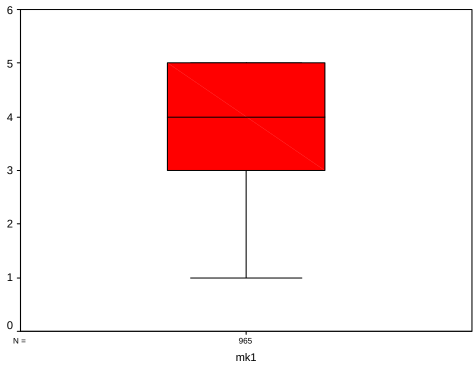
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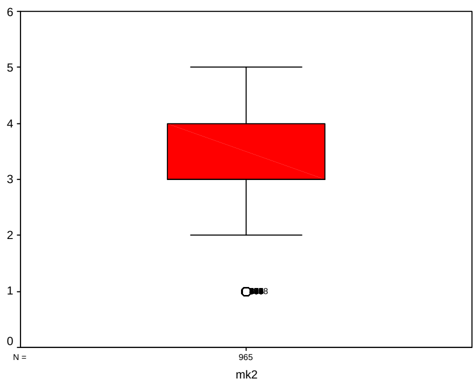
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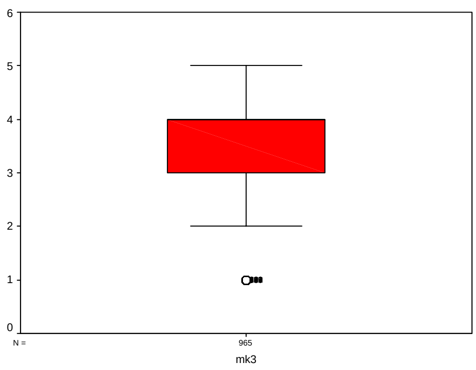
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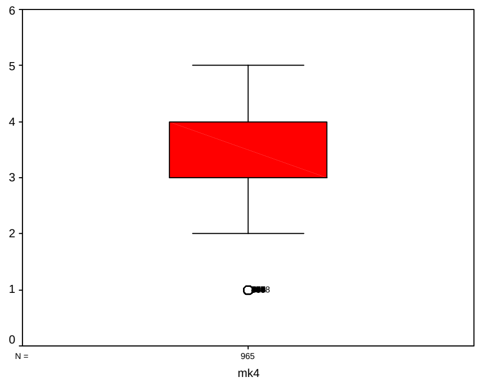

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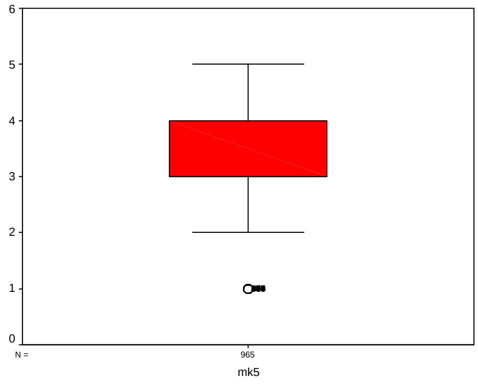

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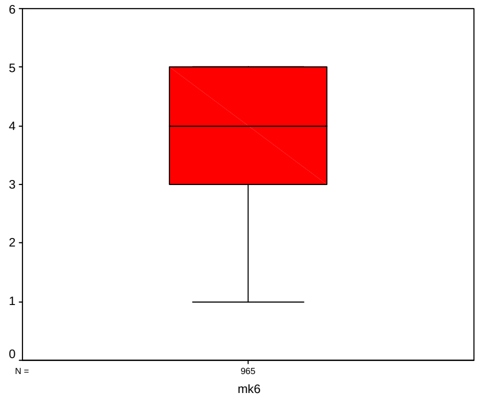

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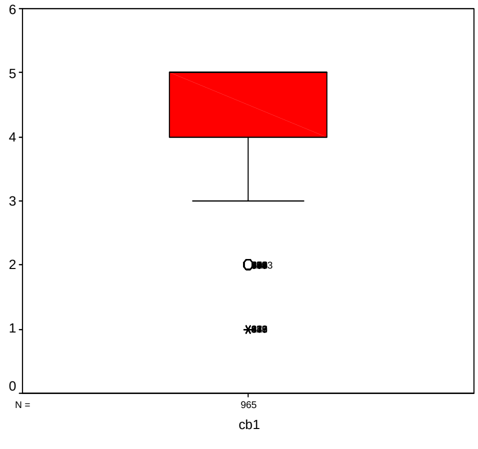

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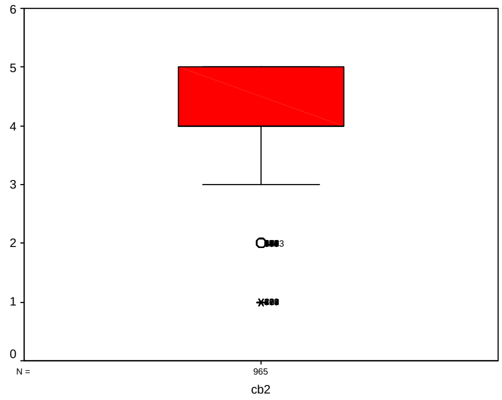

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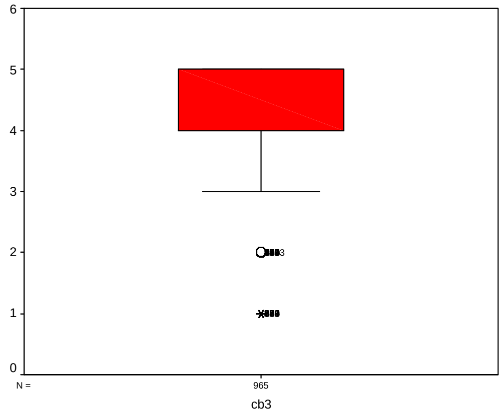

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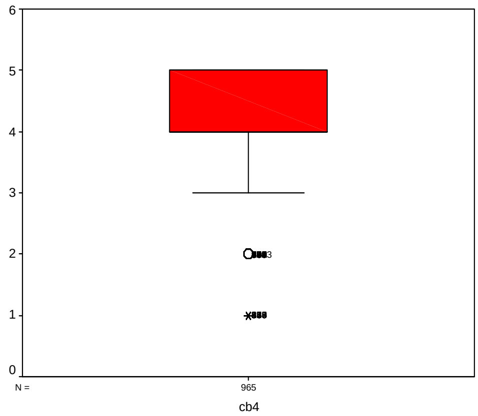

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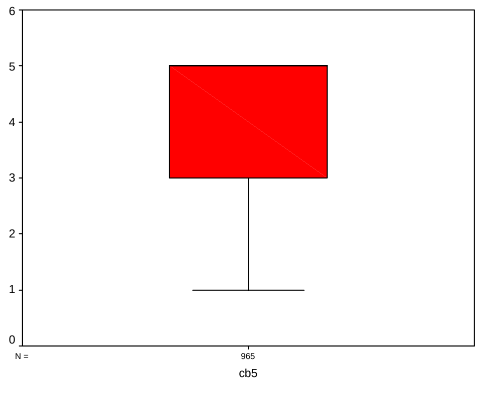

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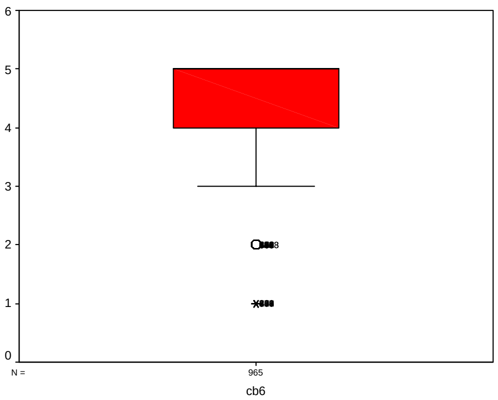
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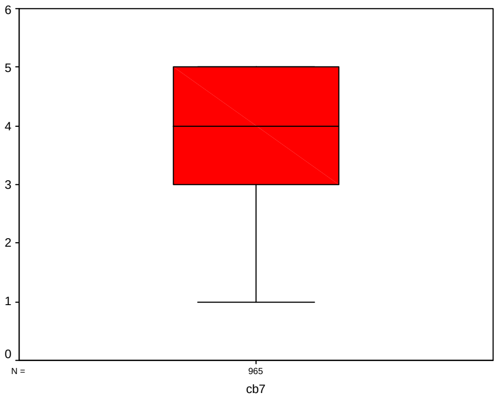
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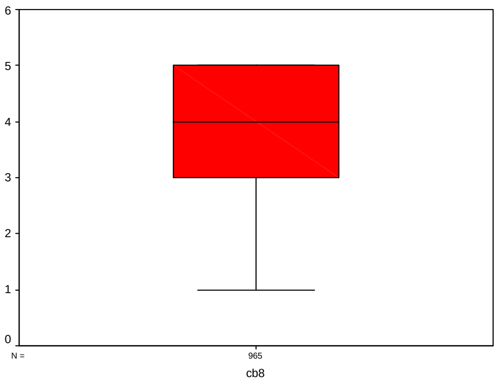
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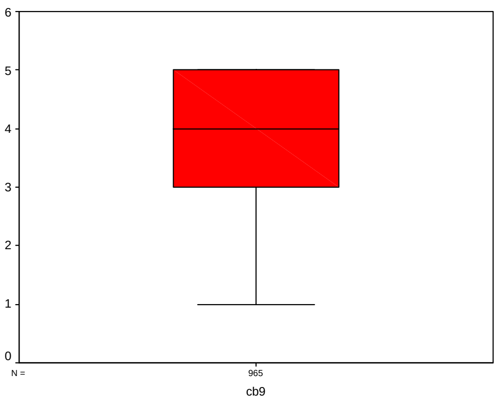
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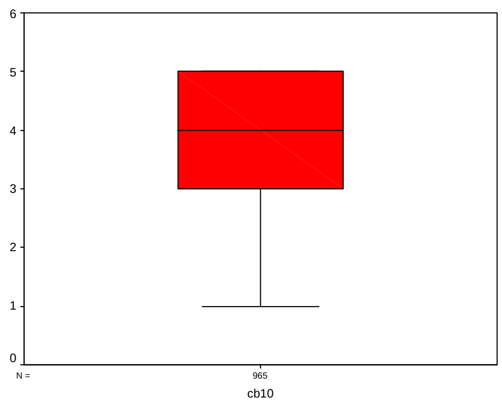
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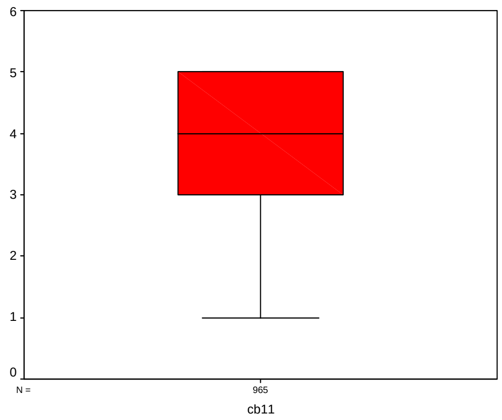
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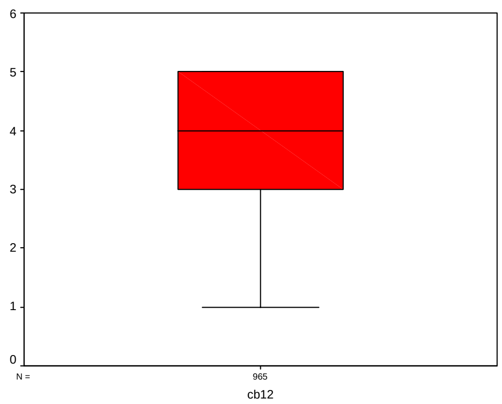
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4
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2
1
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N =
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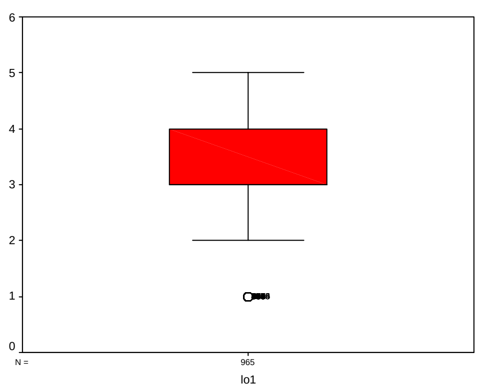
cb12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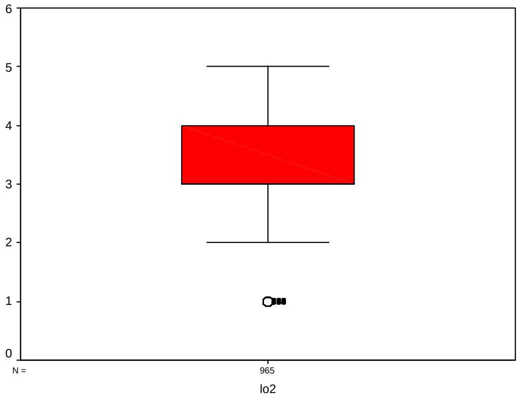
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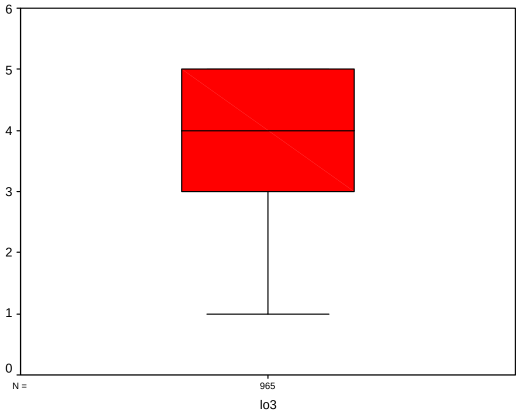
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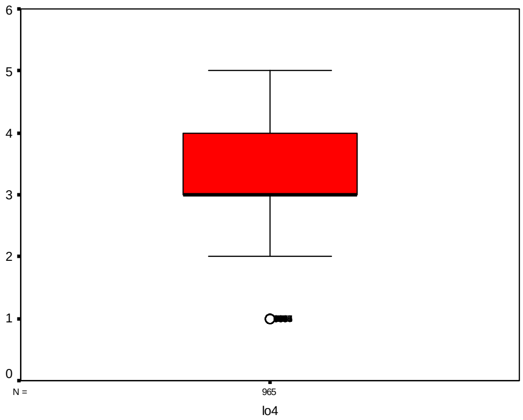
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2
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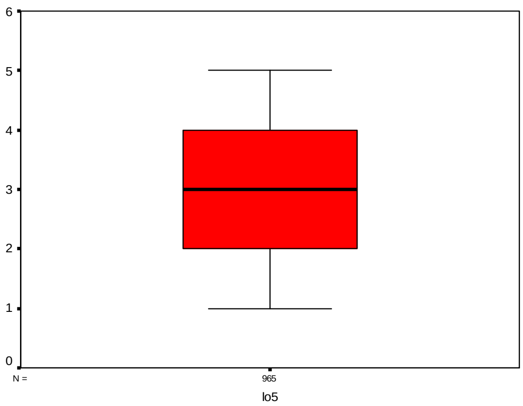
lo4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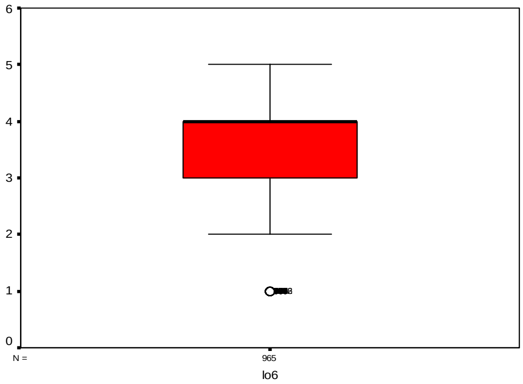
4
3
2
1
0
N =
965
lo5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N =
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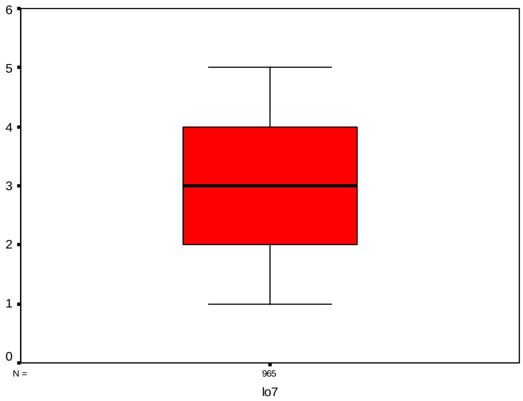
lo6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0
N =
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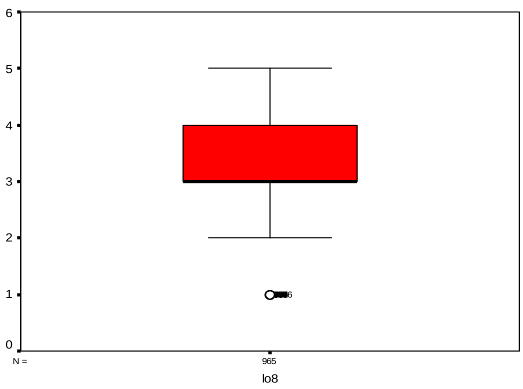
lo7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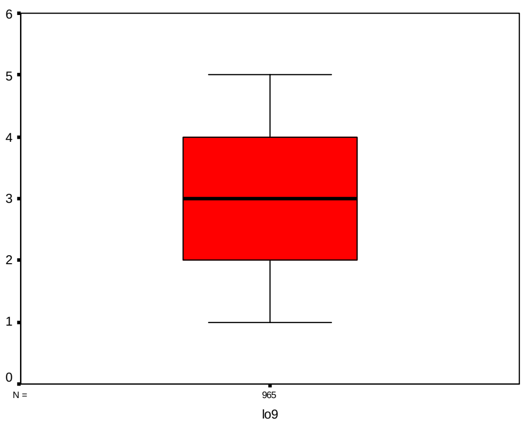
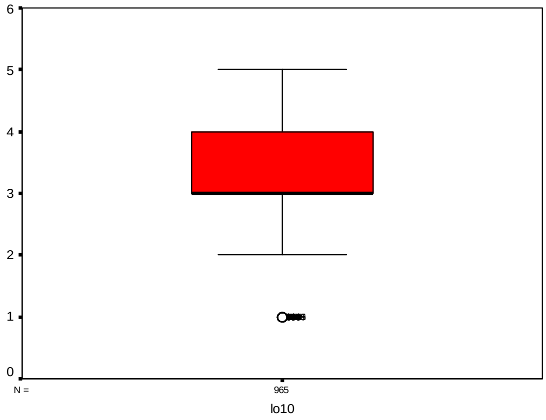
2
1
0
N =
965
lo8


6
5
4
3
2
1
0
N =
965
lo9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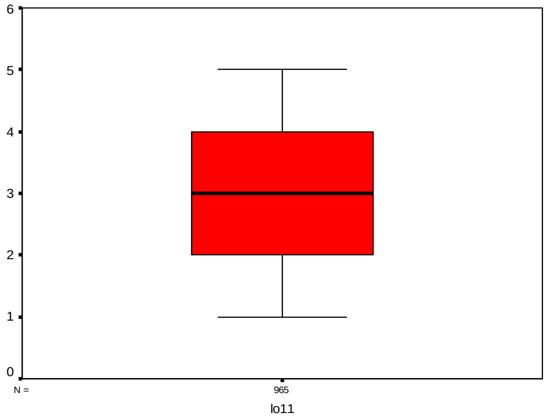
4
3
2
1
0
N =
965
lo10


6
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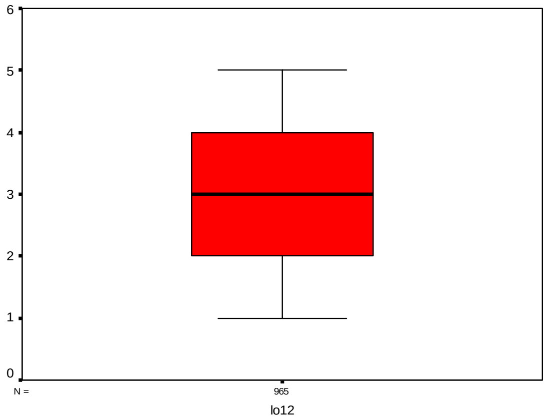
3
2
1
0
N =
965
lo11


6
5
4
3
2
1
0
N =
965
lo12

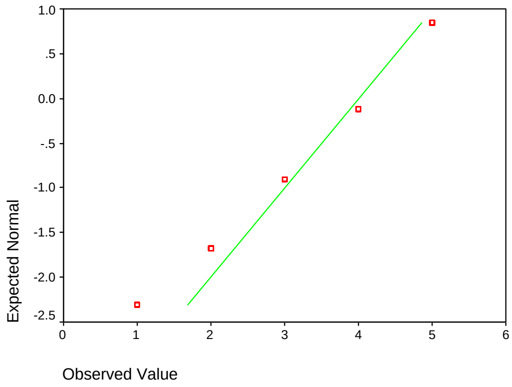
Appendix D Observations farthest from the centroid (Mahalanobis distance)

Observation number	Mahalanobis d-squared	P1	p2
685	244.823	.000	.000
227	209.598	.000	.000
696	207.539	.000	.000
643	206.686	.000	.000
610	198.349	.000	.000
889	185.940	.000	.000
936	182.571	.000	.000
595	174.938	.000	.000
205	172.990	.000	.000
893	172.320	.000	.000
285	172.229	.000	.000
748	159.777	.000	.000
832	158.811	.000	.000
887	147.606	.000	.000
226	147.169	.000	.000
897	145.746	.000	.000
325	144.220	.000	.000
516	143.390	.000	.000
654	140.754	.000	.000
153	140.144	.000	.000
271	134.214	.000	.000
114	133.708	.000	.000
760	132.292	.000	.000
784	132.019	.000	.000
840	131.272	.000	.000
382	130.687	.000	.000
290	126.002	.000	.000
896	125.050	.000	.000
810	124.456	.000	.000
321	122.741	.000	.000
158	121.750	.000	.000
8	121.473	.000	.000
233	121.015	.000	.000
188	119.756	.000	.000
91	119.525	.000	.000
826	118.819	.000	.000
856	118.331	.000	.000
287	117.843	.000	.000
752	116.930	.000	.000
103	116.865	.000	.000
707	115.973	.000	.000
859	114.271	.000	.000
816	113.105	.000	.000
234	112.511	.000	.000
677	109.971	.000	.000
550	109.378	.000	.000
800	109.183	.000	.000
45	109.166	.000	.000
315	108.727	.000	.000
499	108.159	.000	.000
882	107.423	.000	.000

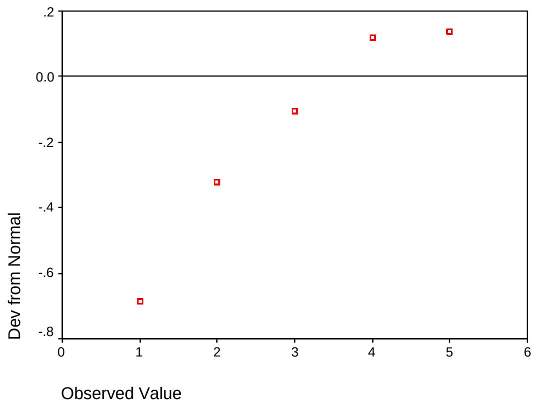
Observation number	Mahalanobis d-squared	P1	p2
521	107.262	.000	.000
301	107.036	.000	.000
483	106.955	.000	.000
413	106.920	.000	.000
101	105.990	.000	.000
343	105.168	.000	.000
911	104.650	.000	.000
180	104.290	.000	.000
695	104.229	.000	.000
83	104.192	.000	.000
530	103.888	.000	.000
30	103.588	.000	.000
507	102.431	.000	.000
327	101.984	.000	.000
65	100.262	.000	.000
265	98.826	.000	.000
364	98.434	.000	.000
781	98.031	.000	.000
171	97.801	.000	.000
176	97.249	.000	.000
86	96.949	.000	.000
801	96.155	.000	.000
766	95.975	.000	.000
796	94.871	.000	.000
184	94.712	.000	.000
782	94.614	.000	.000
230	94.564	.000	.000
150	94.522	.000	.000
259	93.068	.000	.000
340	92.736	.000	.000
39	92.716	.000	.000
941	92.567	.000	.000
295	91.603	.000	.000
456	91.365	.000	.000
386	90.658	.000	.000
899	90.625	.000	.000
170	90.345	.000	.000
724	89.606	.000	.000
629	89.564	.000	.000
783	89.114	.000	.000
794	88.918	.000	.000
13	88.475	.000	.000
29	88.289	.000	.000
726	87.843	.000	.000
131	87.719	.000	.000
416	87.505	.000	.000
209	86.955	.000	.000
845	86.853	.001	.000
374	86.023	.001	.000

Appendix E Normal probability plots and detrended normal probability plots

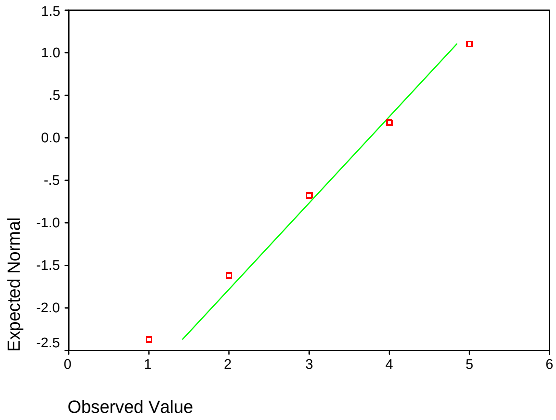
Normal Q-Q Plot of ab1



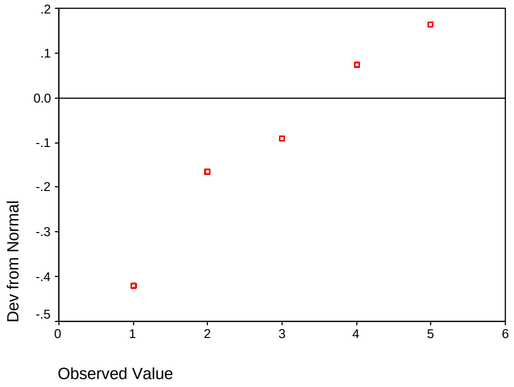
Detrended Normal Q-Q Plot of ab1



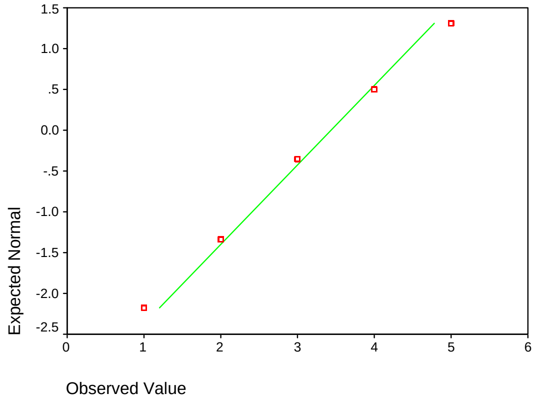
Normal Q-Q Plot of ab2



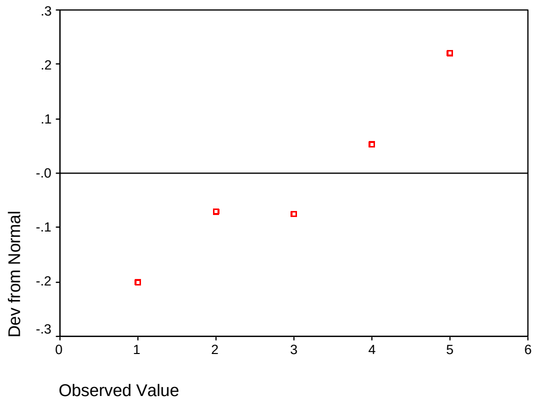
Detrended Normal Q-Q Plot of ab2



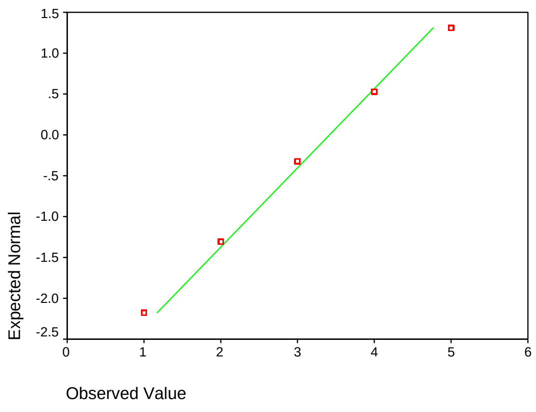
Normal Q-Q Plot of ab3



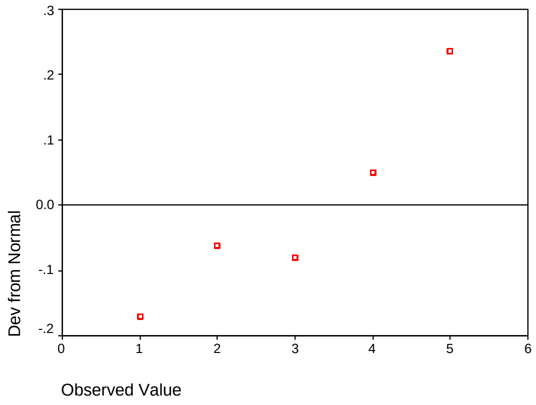
Detrended Normal Q-Q Plot of ab3



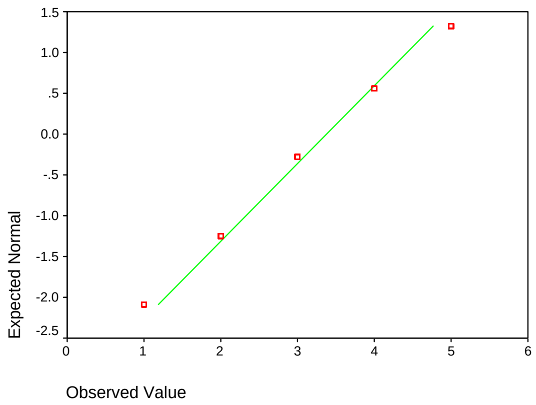
Normal Q-Q Plot of ab4



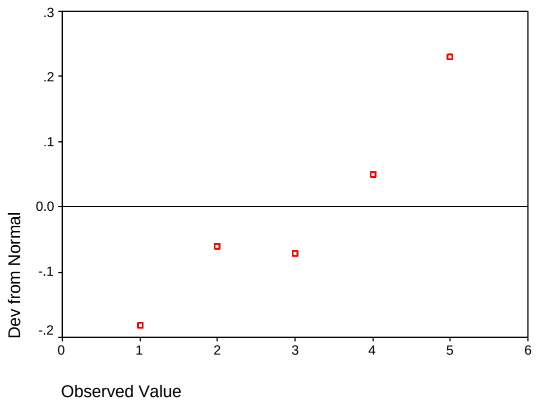
Detrended Normal Q-Q Plot of ab4



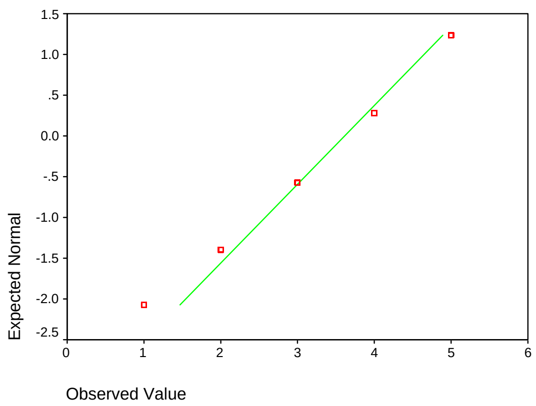
Normal Q-Q Plot of ab5



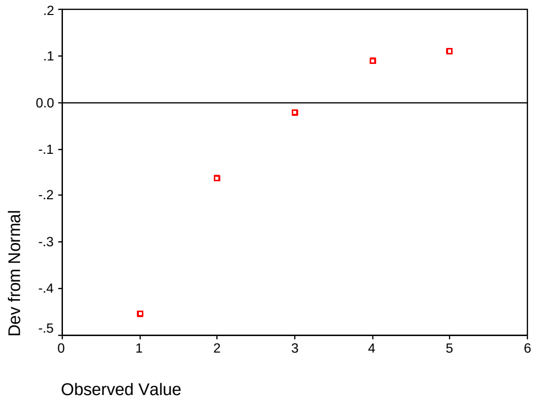
Detrended Normal Q-Q Plot of ab5



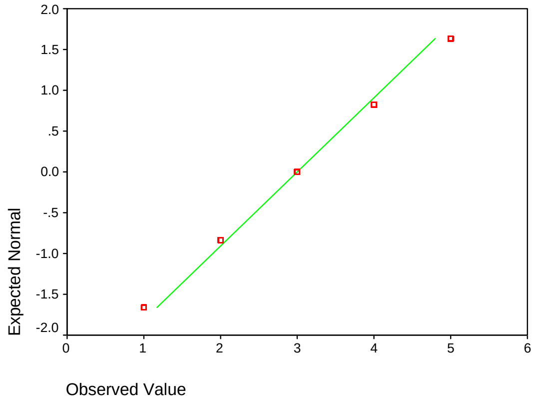
Normal Q-Q Plot of sn1



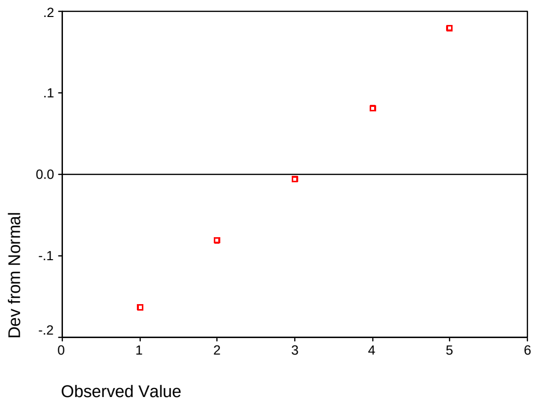
Detrended Normal Q-Q Plot of sn1



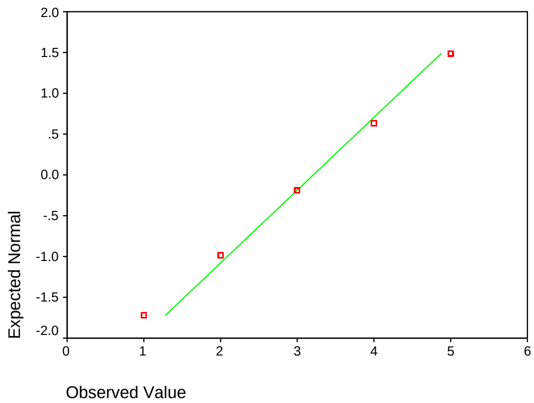
Normal Q-Q Plot of sn2



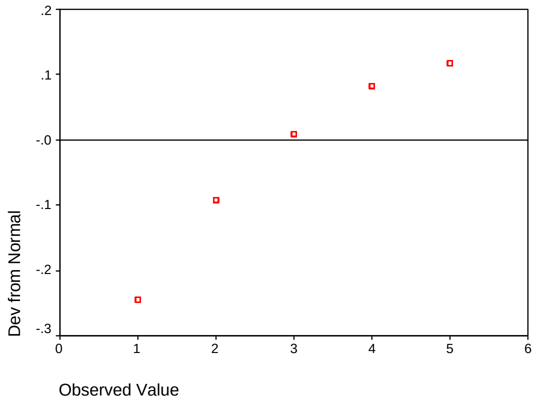
Detrended Normal Q-Q Plot of sn2



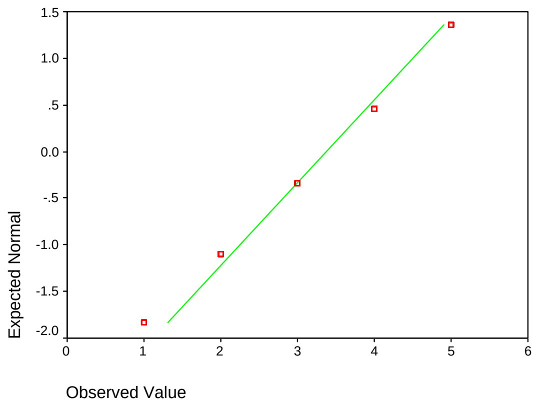
Normal Q-Q Plot of sn3



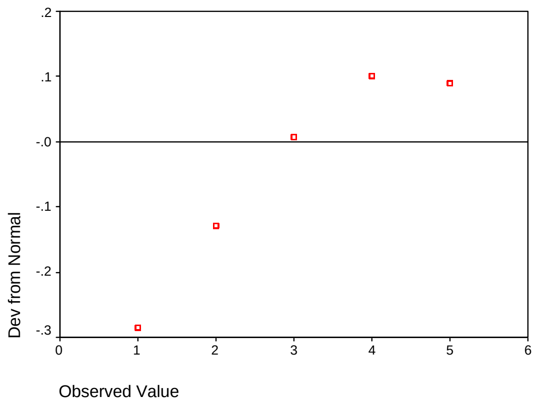
Detrended Normal Q-Q Plot of sn3



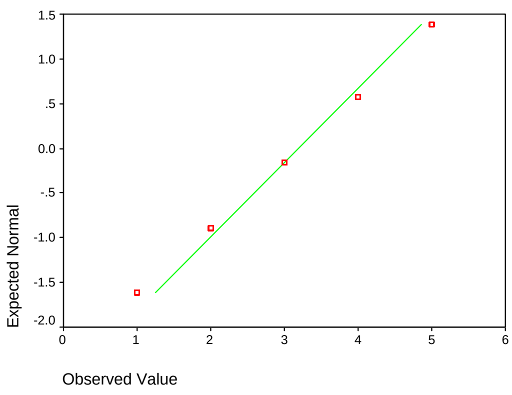
Normal Q-Q Plot of sn4



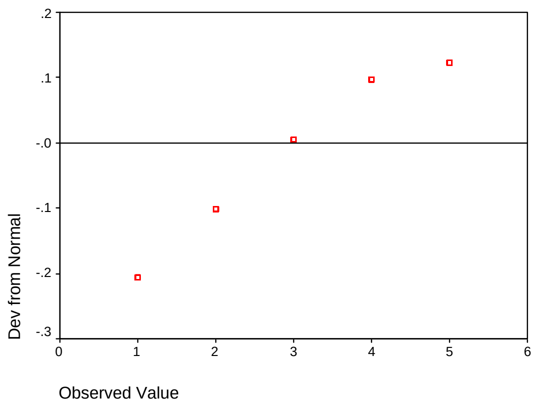
Detrended Normal Q-Q Plot of sn4



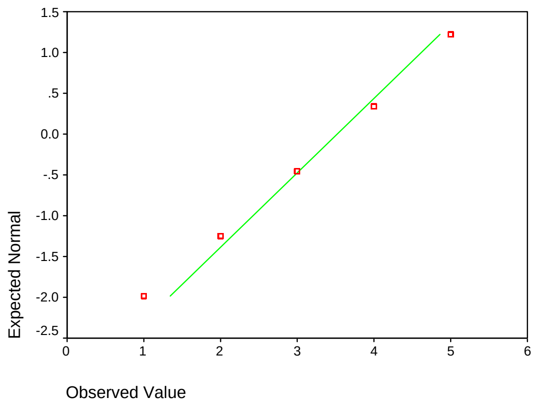
Normal Q-Q Plot of sn5



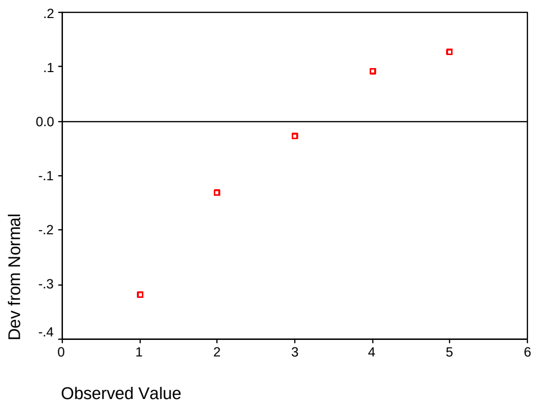
Detrended Normal Q-Q Plot of sn5



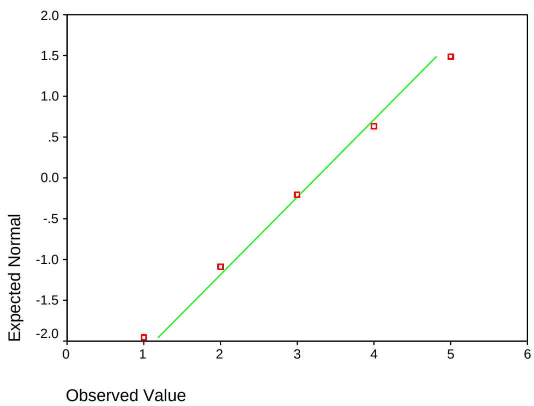
Normal Q-Q Plot of pbc1



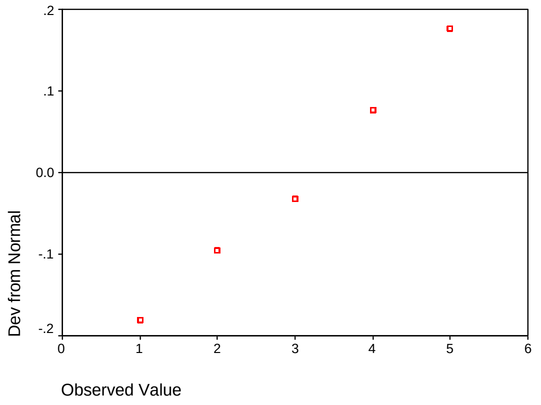
Detrended Normal Q-Q Plot of pbc1



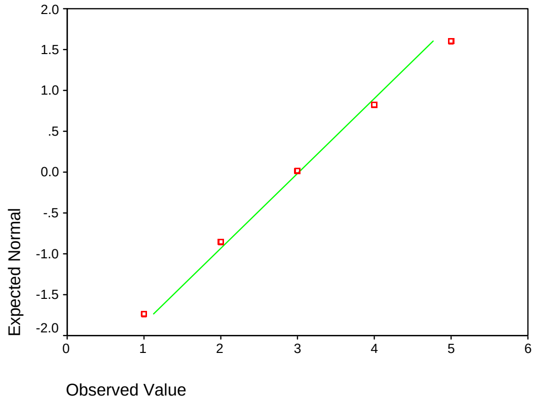
Normal Q-Q Plot of pbc2



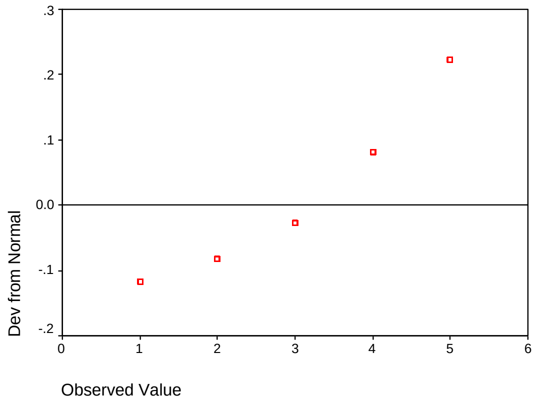
Detrended Normal Q-Q Plot of pbc2



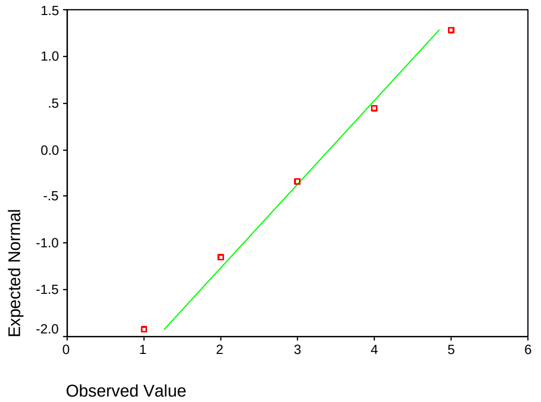
Normal Q-Q Plot of pbc3



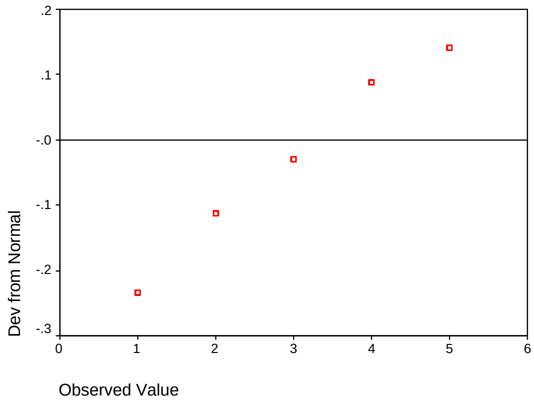
Detrended Normal Q-Q Plot of pbc3



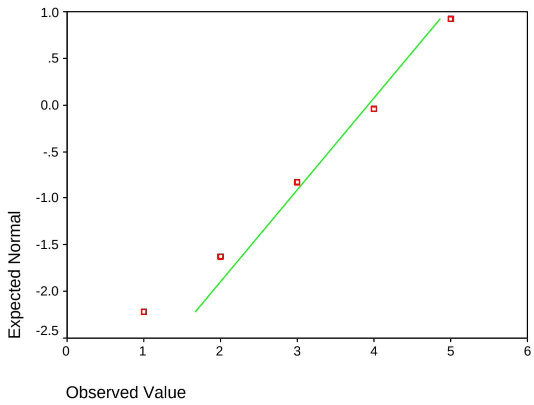
Normal Q-Q Plot of pbc4



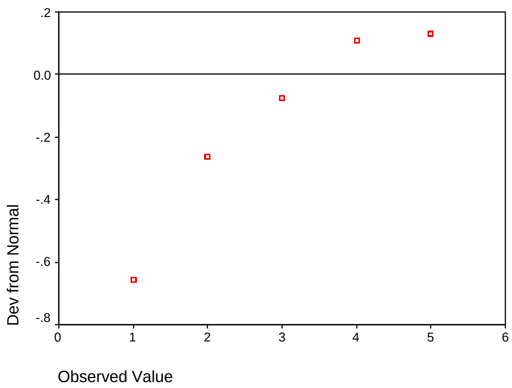
Detrended Normal Q-Q Plot of pbc4



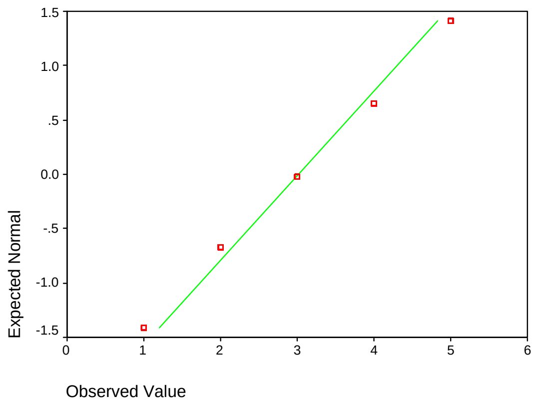
Normal Q-Q Plot of pbc5



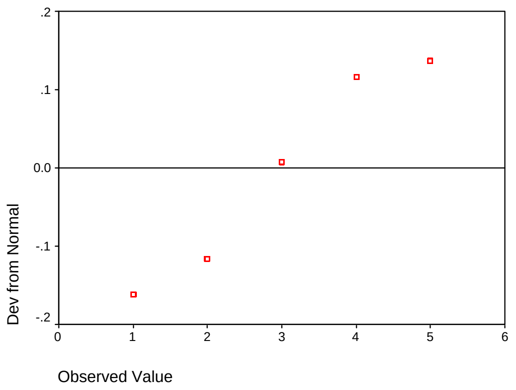
Detrended Normal Q-Q Plot of pbc5



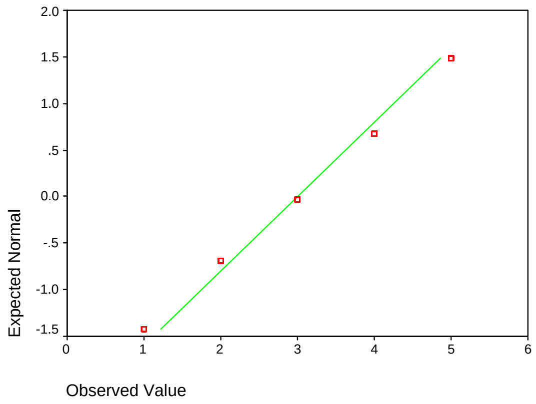
Normal Q-Q Plot of i1



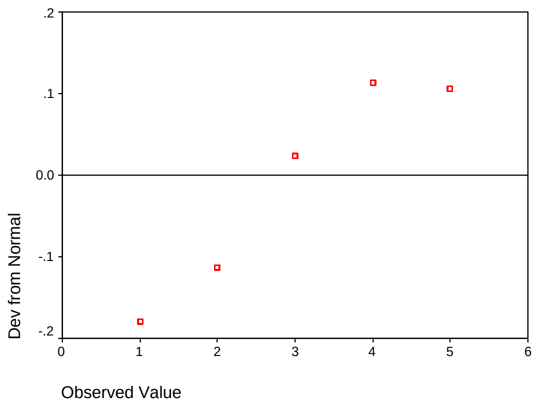
Detrended Normal Q-Q Plot of i1



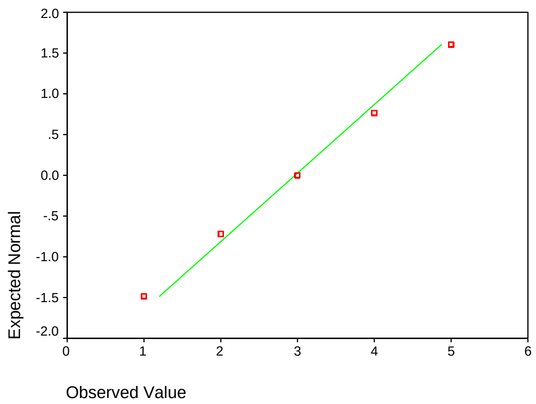
Normal Q-Q Plot of i2



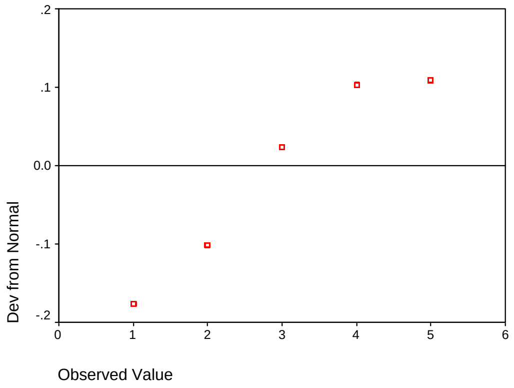
Detrended Normal Q-Q Plot of i2



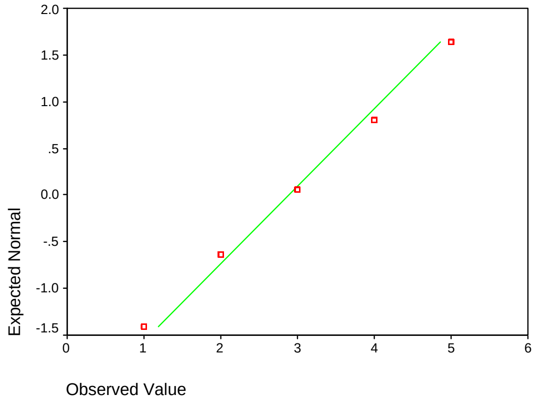
Normal Q-Q Plot of i3



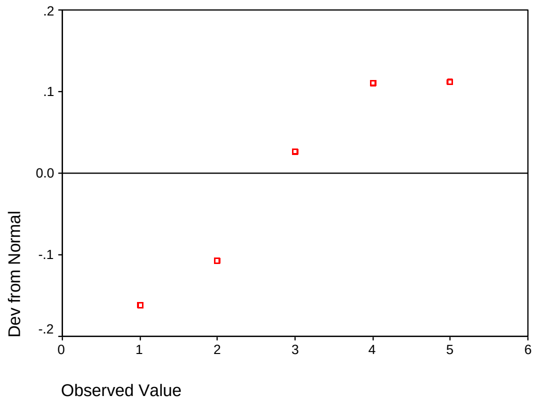
Detrended Normal Q-Q Plot of i3



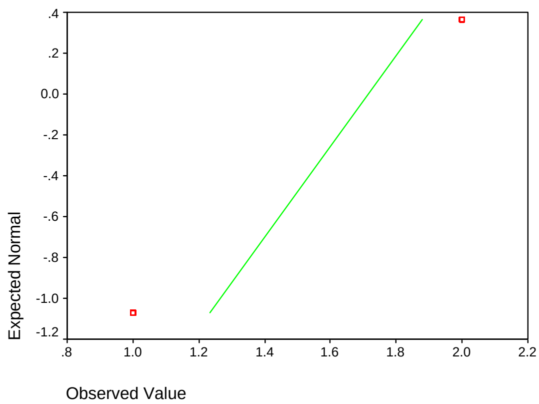
Normal Q-Q Plot of i4

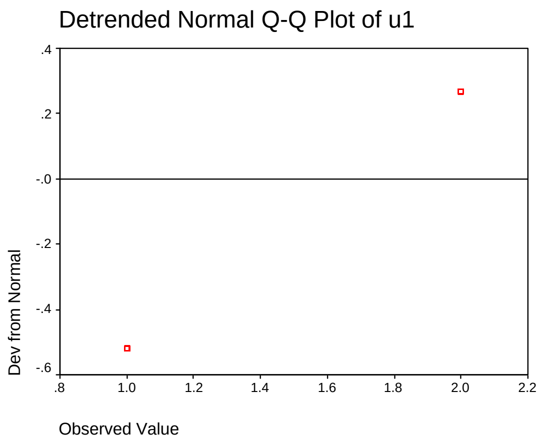


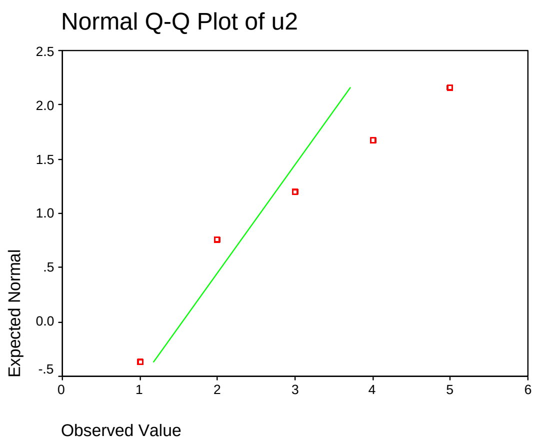
Detrended Normal Q-Q Plot of i4

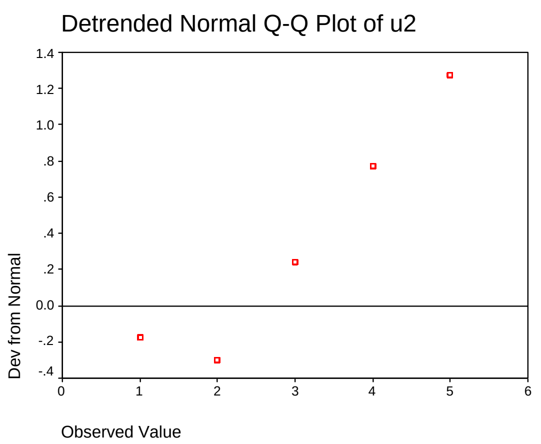


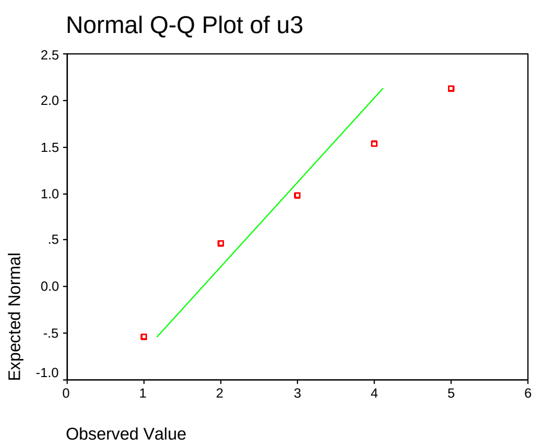
Normal Q-Q Plot of u1



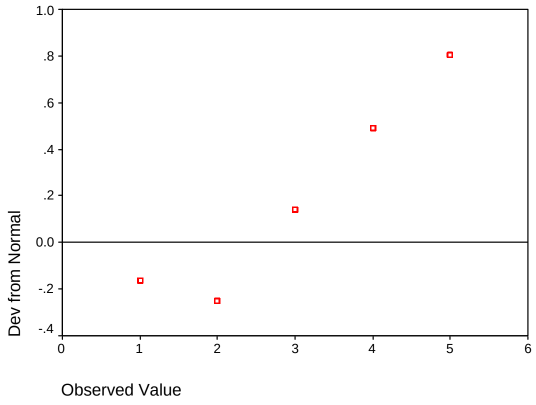

Detrended Normal Q-Q Plot of u1
.4
.2
-.0
-.2
-.4
-.6
Dev from Normal
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
Observed Value


Normal Q-Q Plot of u2
2.5
2.0
1.5
1.0
.5
0.0
-.5
Expected Normal
0
1
2
3
4
5
6
Observed Value

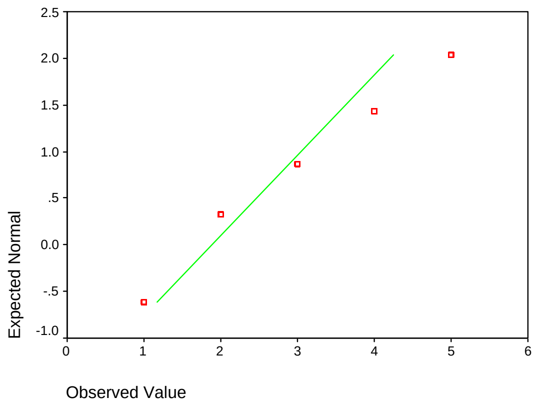

Detrended Normal Q-Q Plot of u2
1.4
1.2
1.0
.8
.6
.4
.2
0.0
-.2
-.4
Dev from Normal
0
1
2
3
4
5
6
Observed Value


Normal Q-Q Plot of u3
2.5
2.0
1.5
1.0
.5
0.0
-.5
-1.0
Expected Normal
0
1
2
3
4
5
6
Observed Value

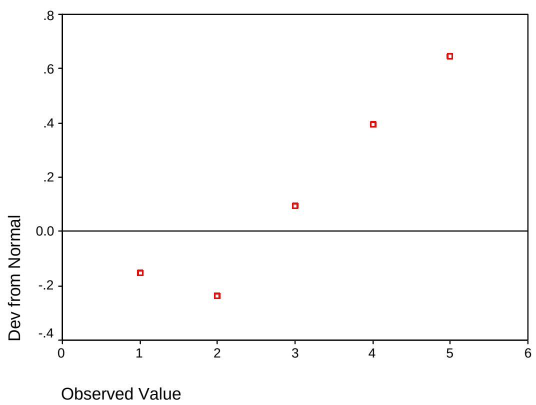
Detrended Normal Q-Q Plot of u3



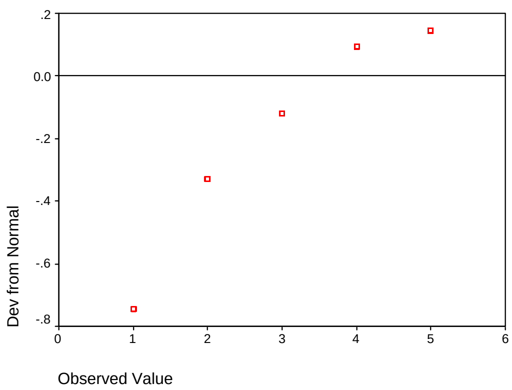
Normal Q-Q Plot of u4



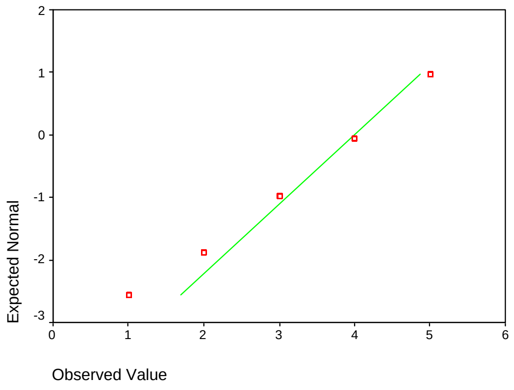
Detrended Normal Q-Q Plot of u4



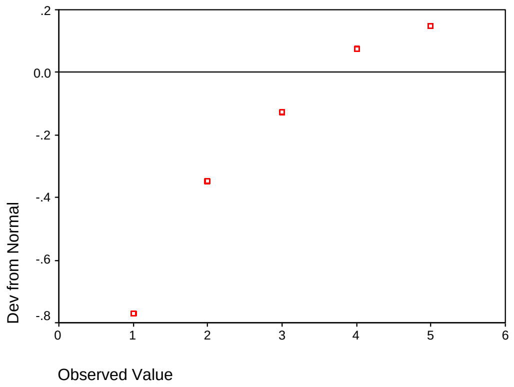
Detrended Normal Q-Q Plot of bi1



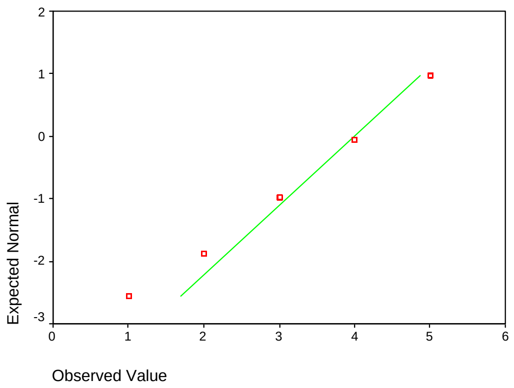
Normal Q-Q Plot of bi2



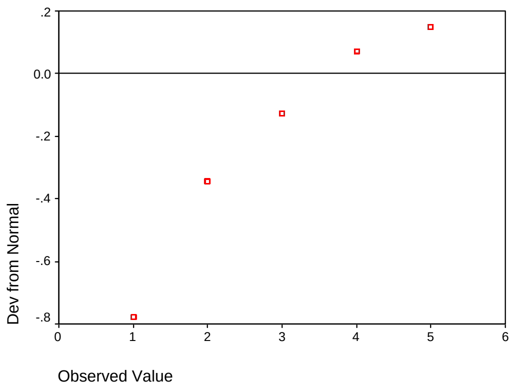
Detrended Normal Q-Q Plot of bi2



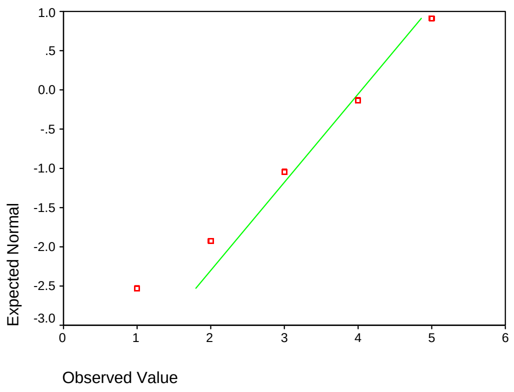
Normal Q-Q Plot of bi3



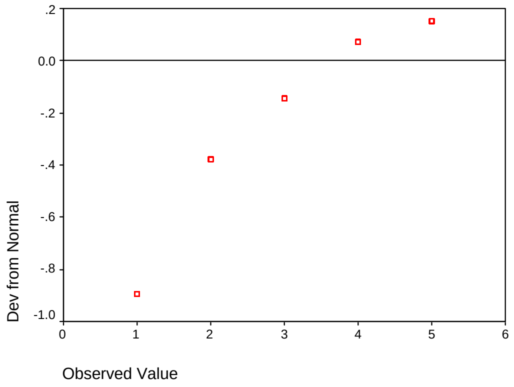
Detrended Normal Q-Q Plot of bi3



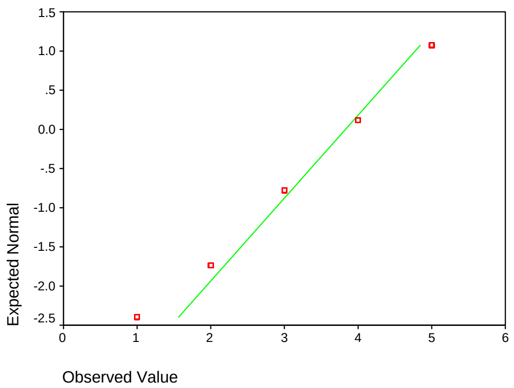
Normal Q-Q Plot of bi4



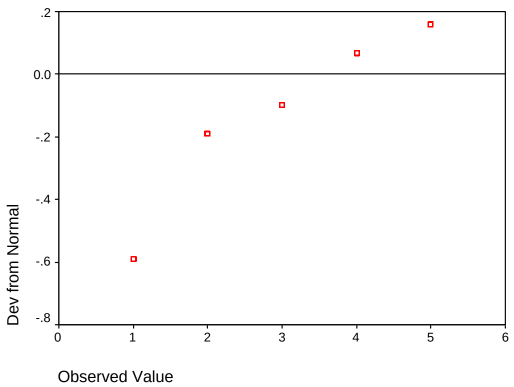
Detrended Normal Q-Q Plot of bi4



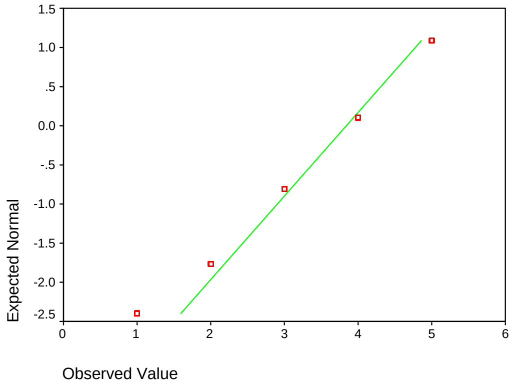
Normal Q-Q Plot of bi5



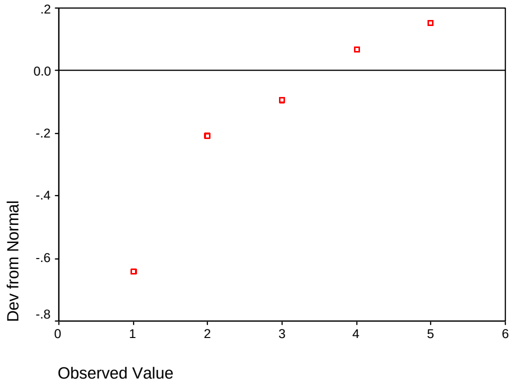
Detrended Normal Q-Q Plot of bi5



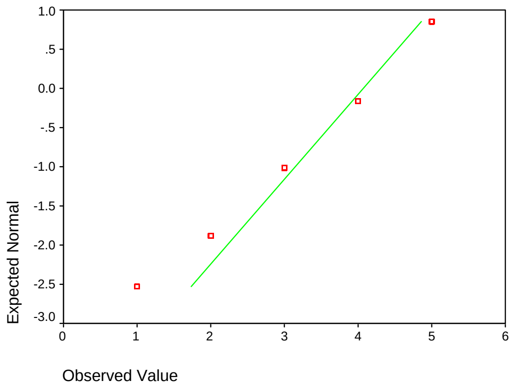
Normal Q-Q Plot of bi6



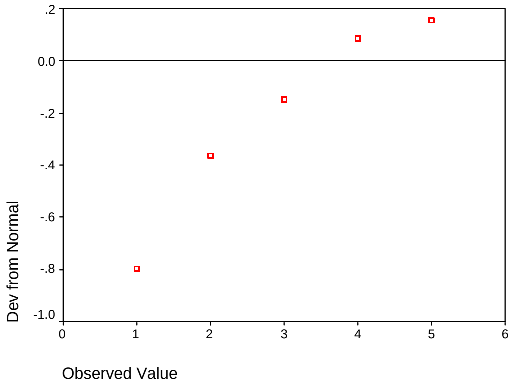
Detrended Normal Q-Q Plot of bi6



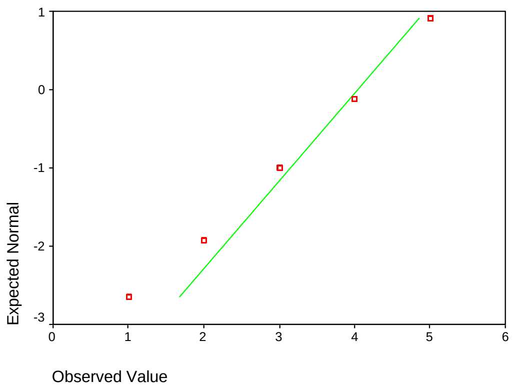
Normal Q-Q Plot of ei1



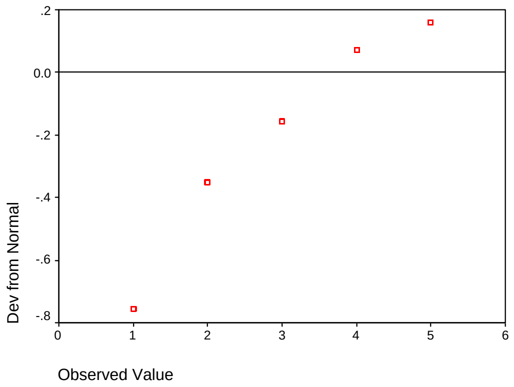
Detrended Normal Q-Q Plot of ei1



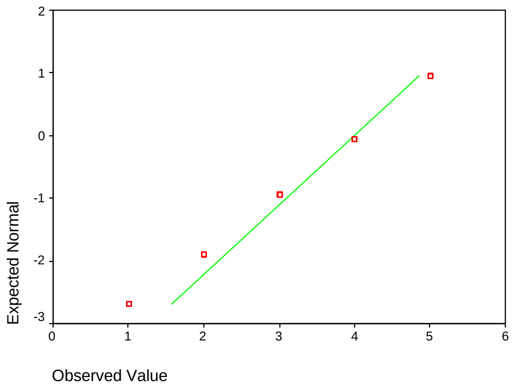
Normal Q-Q Plot of ei2



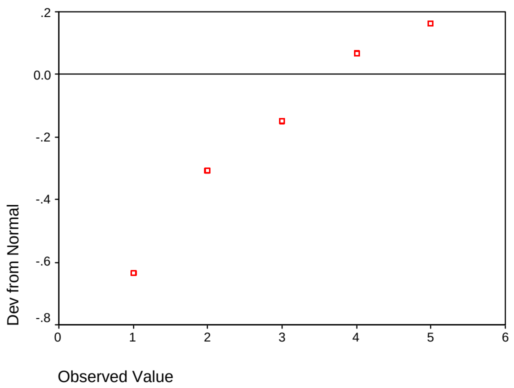
Detrended Normal Q-Q Plot of ei2



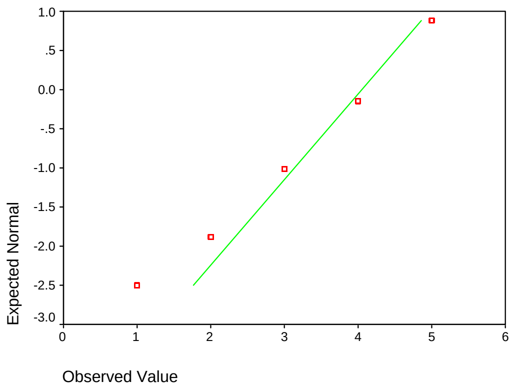
Normal Q-Q Plot of ei3



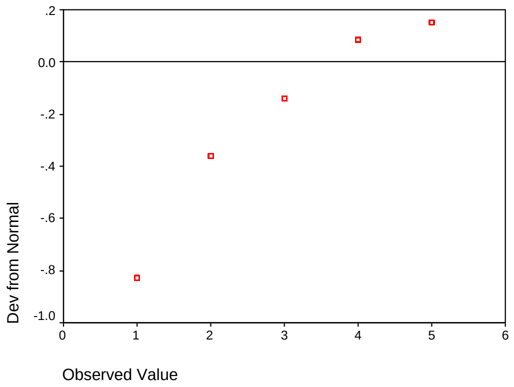
Detrended Normal Q-Q Plot of ei3



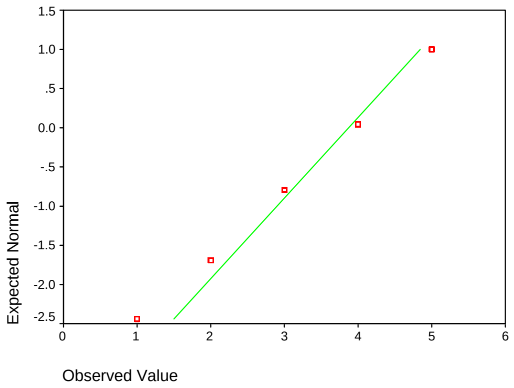
Normal Q-Q Plot of ei4



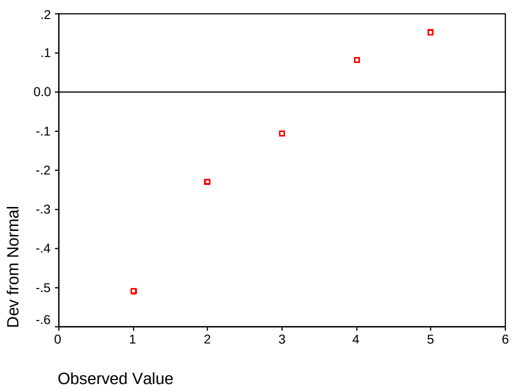
Detrended Normal Q-Q Plot of ei4



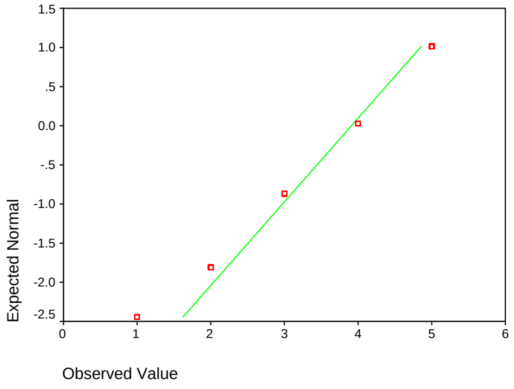
Normal Q-Q Plot of ei5



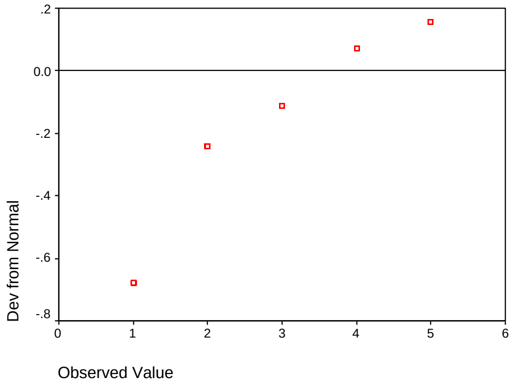
Detrended Normal Q-Q Plot of ei5



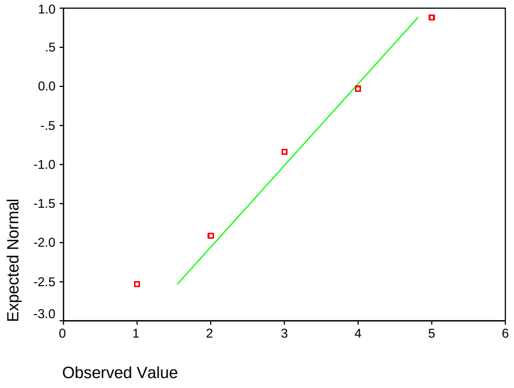
Normal Q-Q Plot of ei6



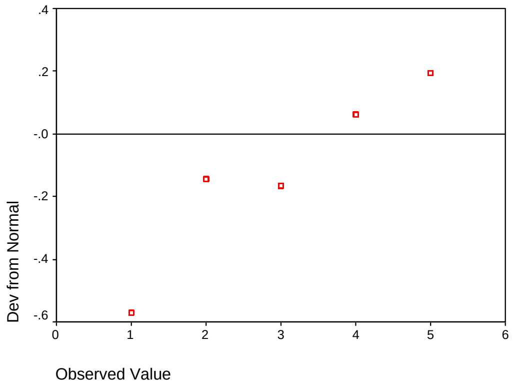
Detrended Normal Q-Q Plot of ei6



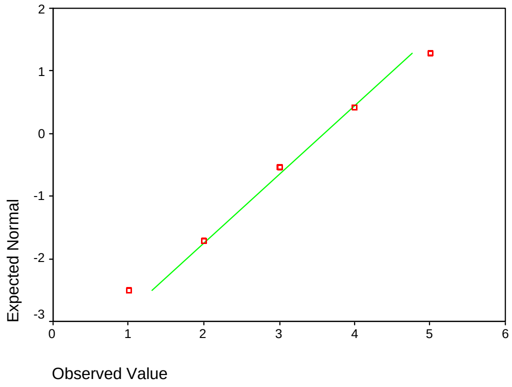
Normal Q-Q Plot of nk1



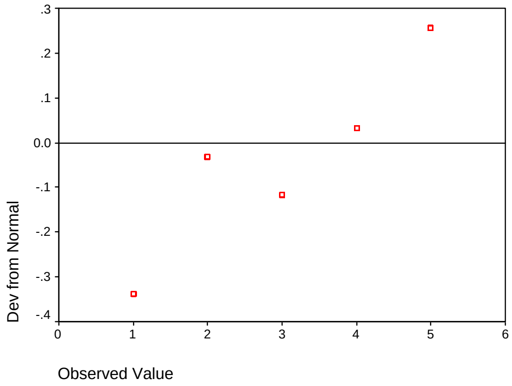
Detrended Normal Q-Q Plot of nk1



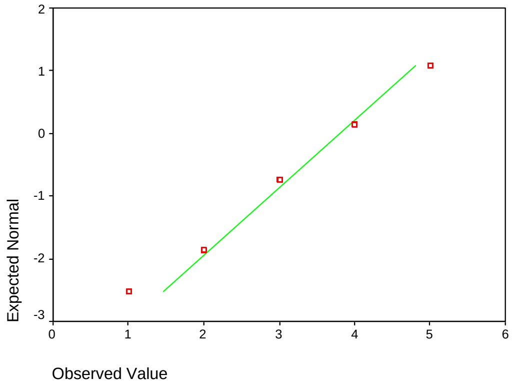
Normal Q-Q Plot of nk2



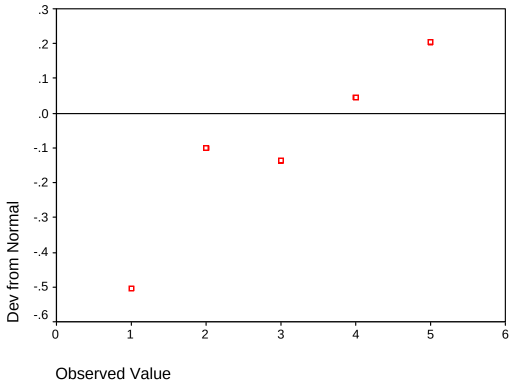
Detrended Normal Q-Q Plot of nk2



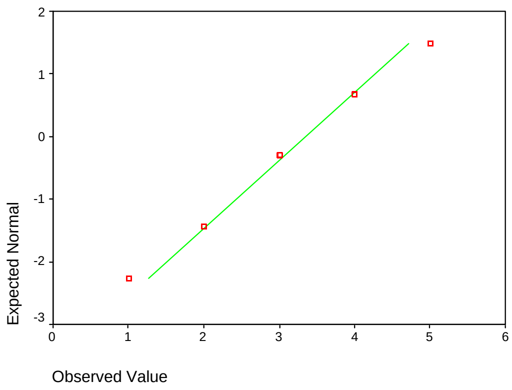
Normal Q-Q Plot of nk3



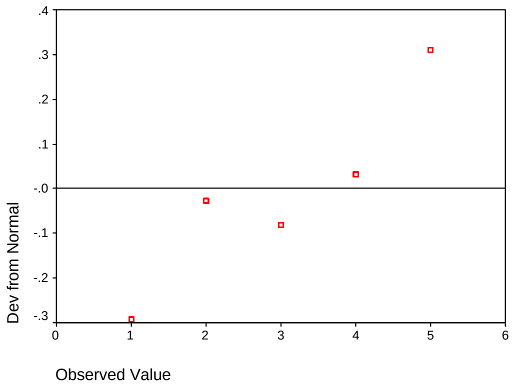
Detrended Normal Q-Q Plot of nk3



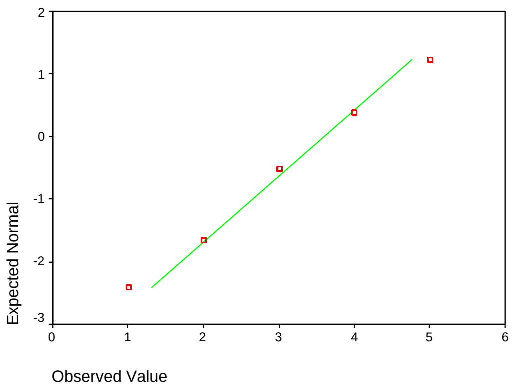
Normal Q-Q Plot of nk4



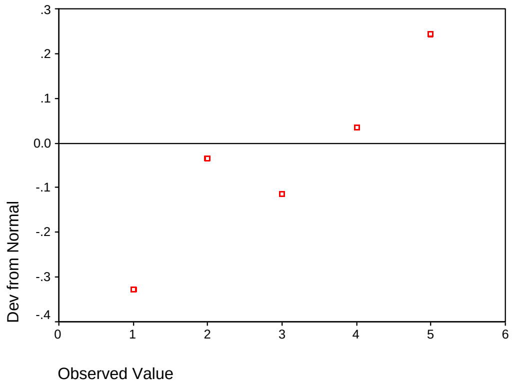
Detrended Normal Q-Q Plot of nk4

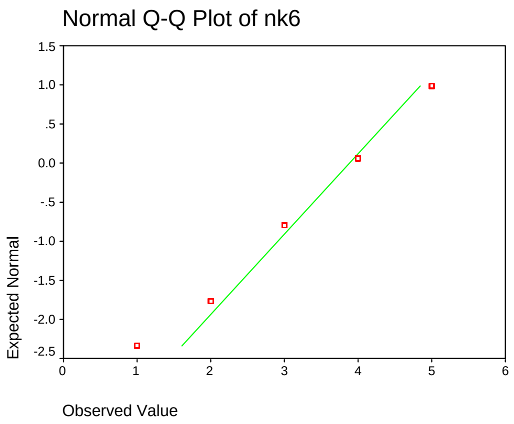


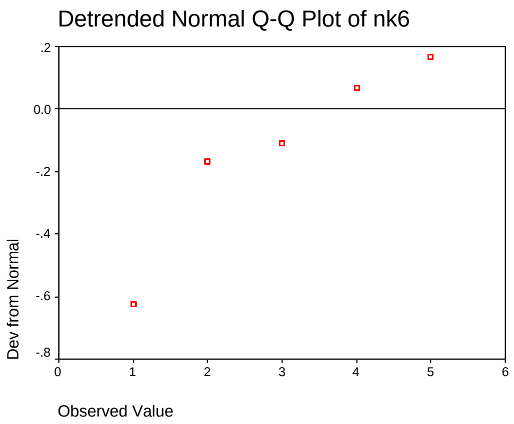
Normal Q-Q Plot of nk5

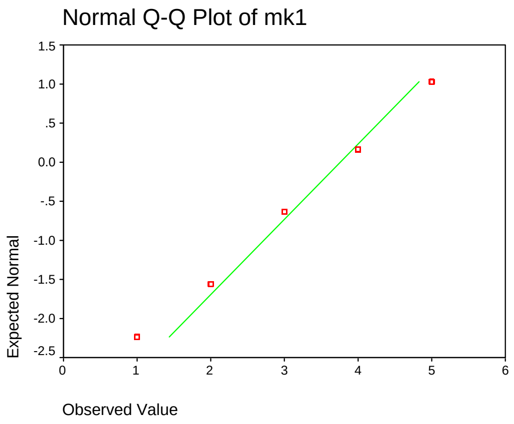


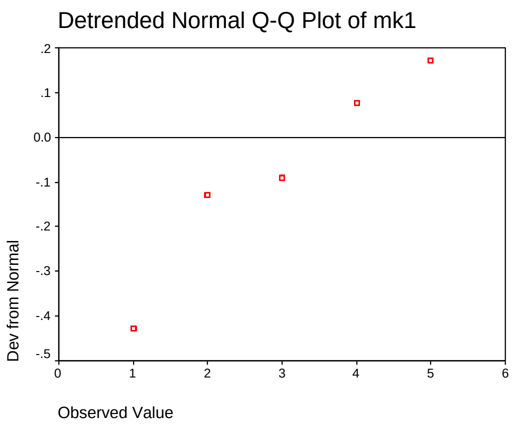
Detrended Normal Q-Q Plot of nk5



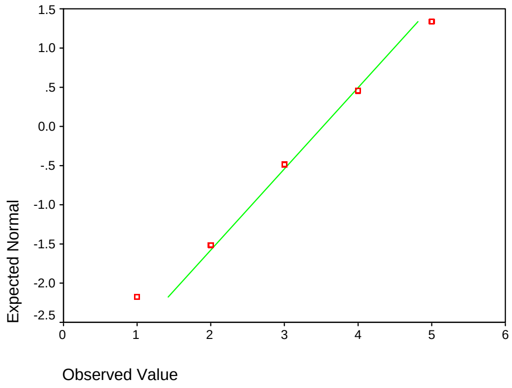

Normal Q-Q Plot of nk6
Expected Normal
Observed Value


Detrended Normal Q-Q Plot of nk6
Dev from Normal
Observed Value

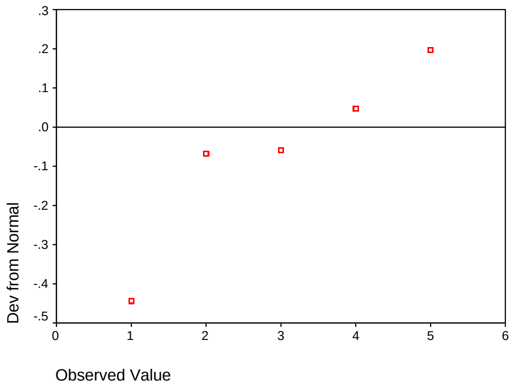

Normal Q-Q Plot of mk1
Expected Normal
Observed Value


Detrended Normal Q-Q Plot of mk1
Dev from Normal
Observed Value

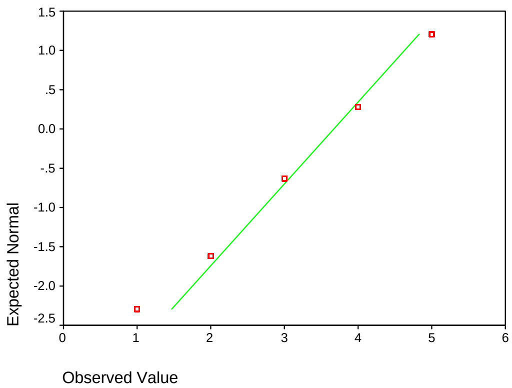
Normal Q-Q Plot of mk2



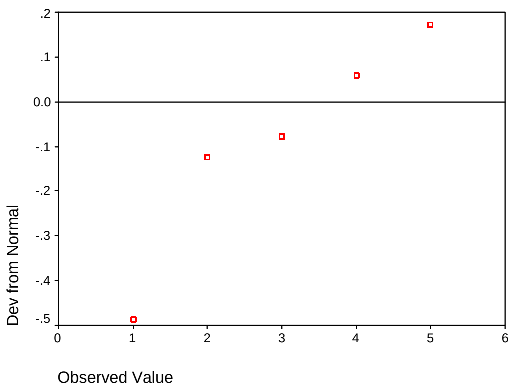
Detrended Normal Q-Q Plot of mk2



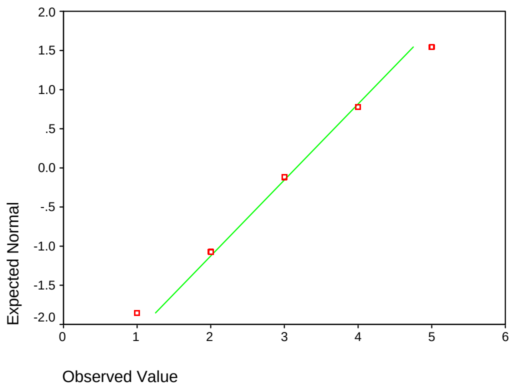
Normal Q-Q Plot of mk3



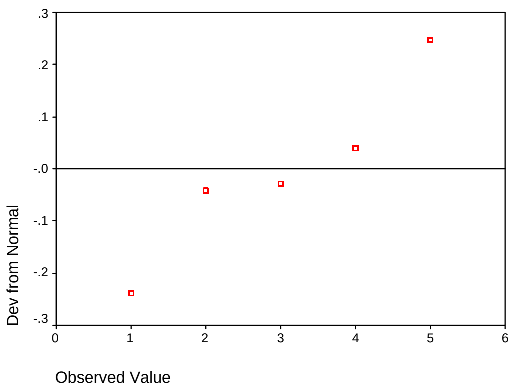
Detrended Normal Q-Q Plot of mk3



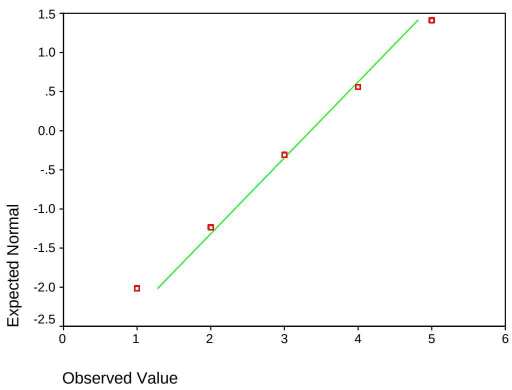
Normal Q-Q Plot of mk4



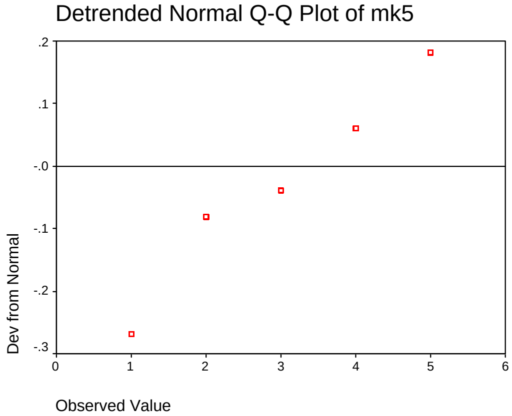
Detrended Normal Q-Q Plot of mk4

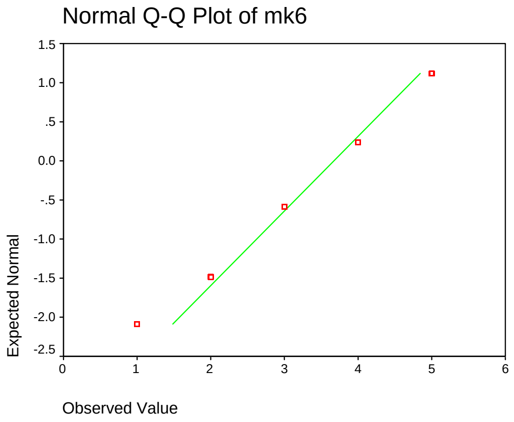


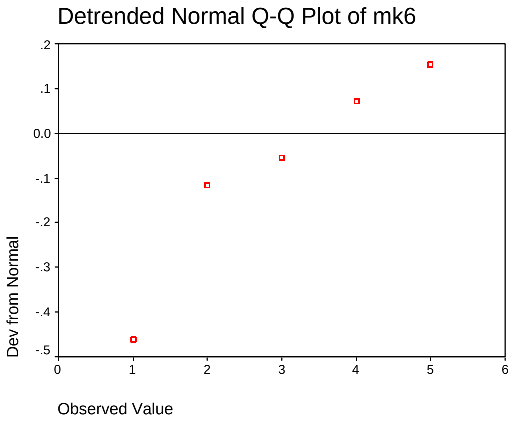
Normal Q-Q Plot of mk5

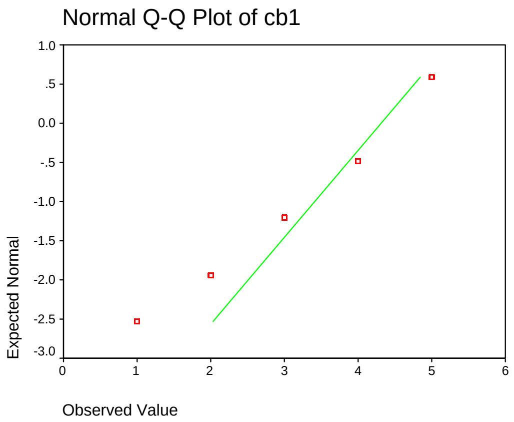


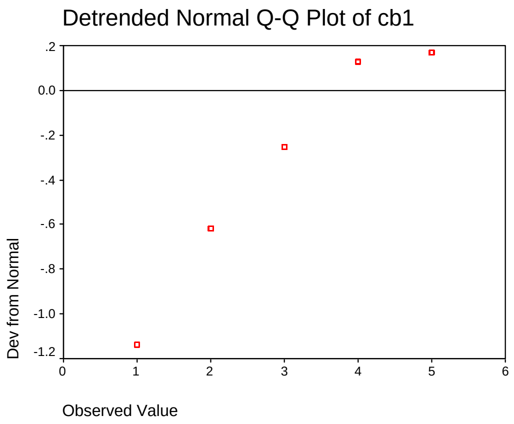
Detrended Normal Q-Q Plot of mk5



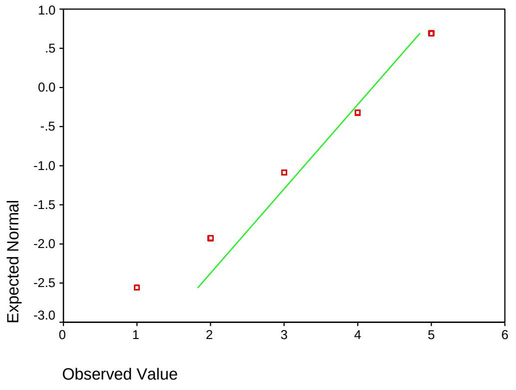

Normal Q-Q Plot of mk6
Expected Normal
1.5
1.0
.5
0.0
-.5
-1.0
-1.5
-2.0
-2.5
0
1
2
3
4
5
6
Observed Value


Detrended Normal Q-Q Plot of mk6
Dev from Normal
.2
.1
0.0
-.1
-.2
-.3
-.4
-.5
0
1
2
3
4
5
6
Observed Value

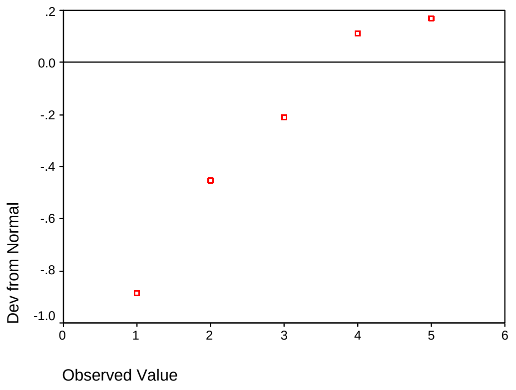

Normal Q-Q Plot of cb1
Expected Normal
1.0
.5
0.0
-.5
-1.0
-1.5
-2.0
-2.5
-3.0
0
1
2
3
4
5
6
Observed Value


Detrended Normal Q-Q Plot of cb1
Dev from Normal
.2
0.0
-.2
-.4
-.6
-.8
-1.0
-1.2
0
1
2
3
4
5
6
Observed Value

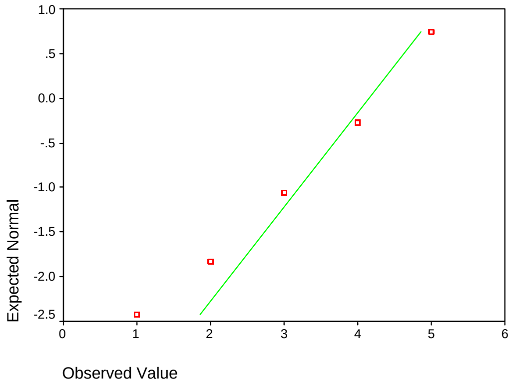
Normal Q-Q Plot of cb2



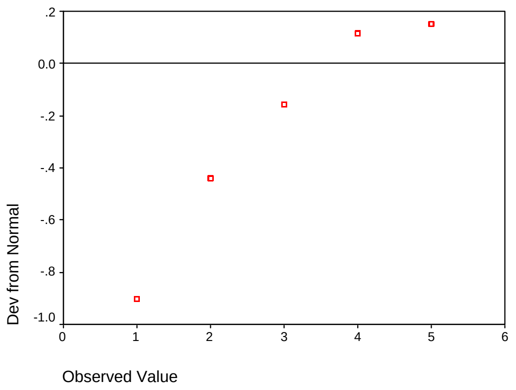
Detrended Normal Q-Q Plot of cb2



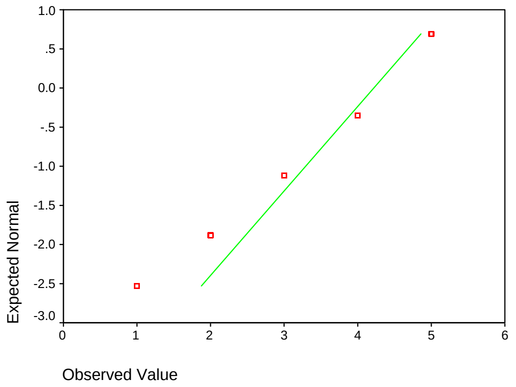
Normal Q-Q Plot of cb3



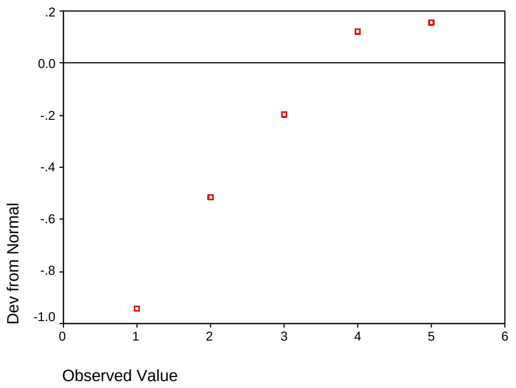
Detrended Normal Q-Q Plot of cb3



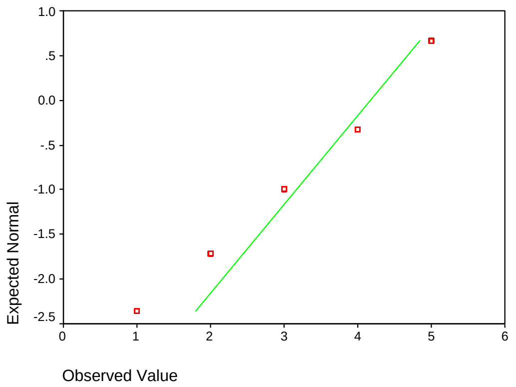
Normal Q-Q Plot of cb4



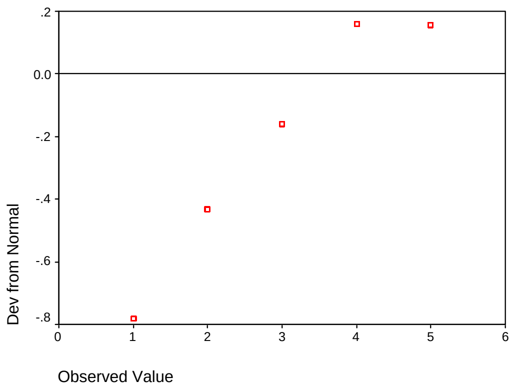
Detrended Normal Q-Q Plot of cb4



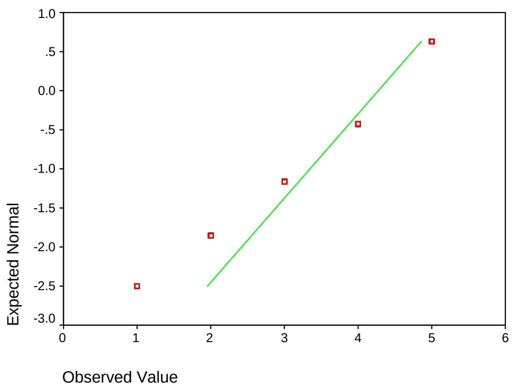
Normal Q-Q Plot of cb5



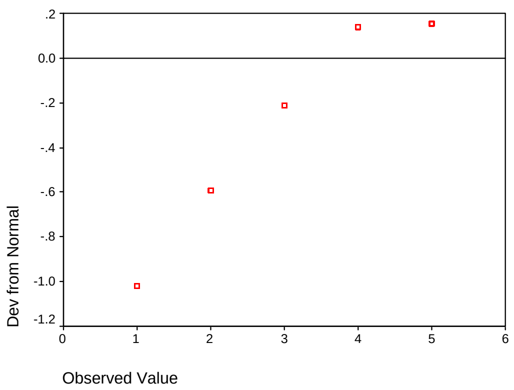
Detrended Normal Q-Q Plot of cb5



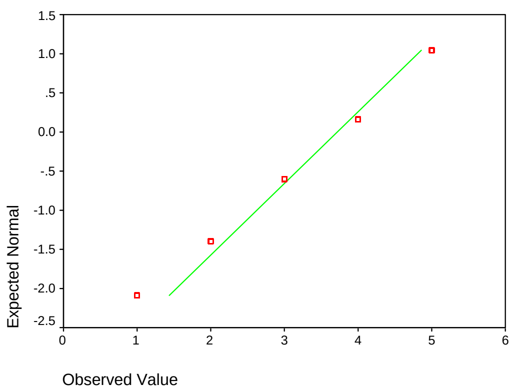
Normal Q-Q Plot of cb6

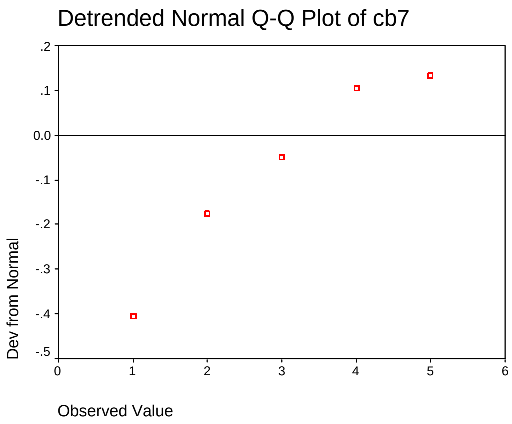


Detrended Normal Q-Q Plot of cb6

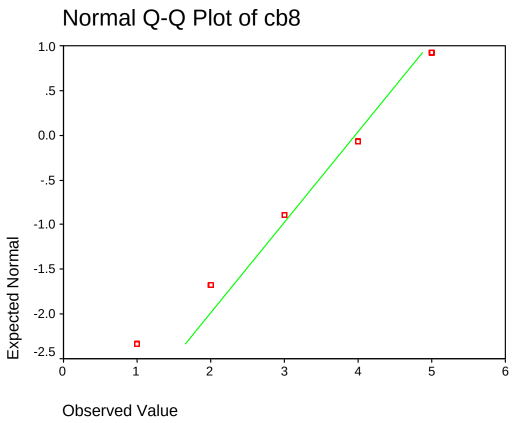


Normal Q-Q Plot of cb7

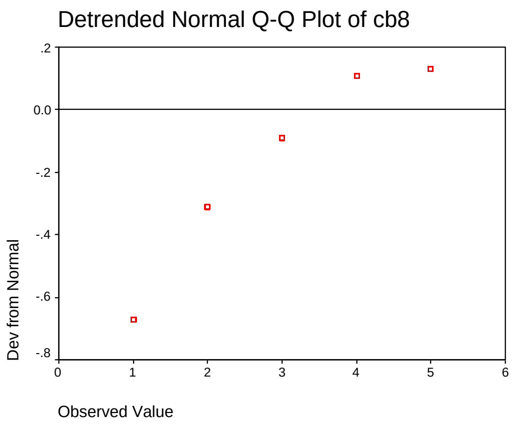




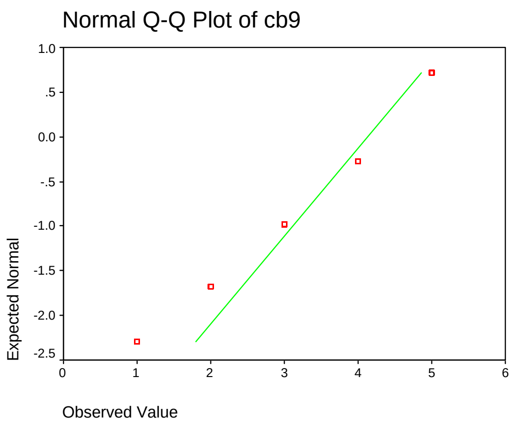
Detrended Normal Q-Q Plot of cb7
Dev from Normal
Observed Value



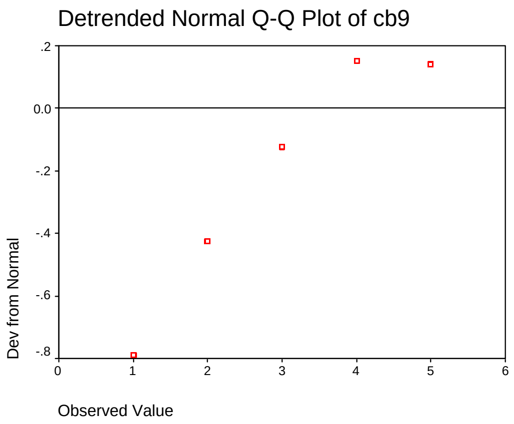
Normal Q-Q Plot of cb8
Expected Normal
Observed Value

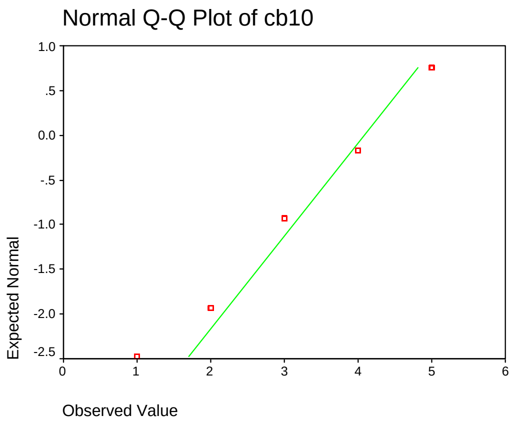


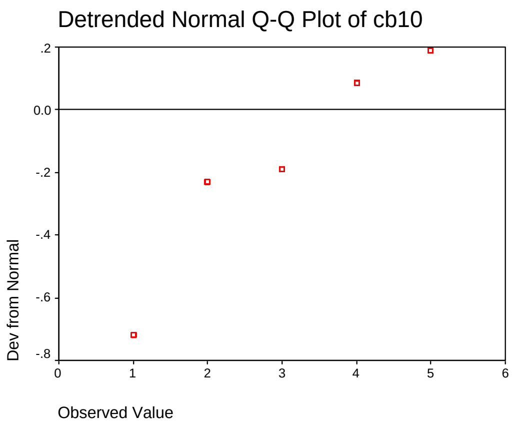
Detrended Normal Q-Q Plot of cb8
Dev from Normal
Observed Value

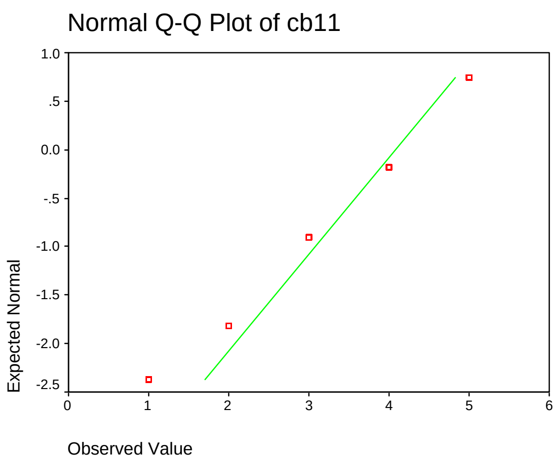


Normal Q-Q Plot of cb9
Expected Normal
Observed Value

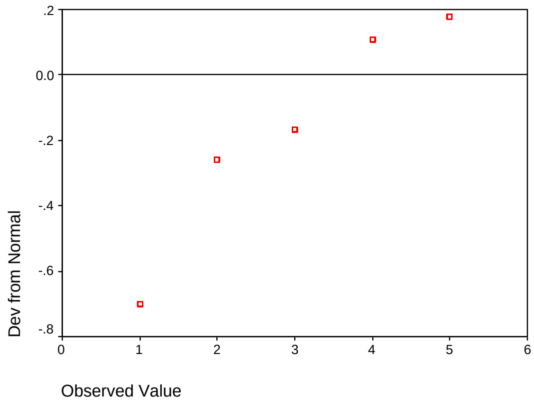

Detrended Normal Q-Q Plot of cb9
Dev from Normal
Observed Value
.2
0.0
-.2
-.4
-.6
-.8
0
1
2
3
4
5
6


Normal Q-Q Plot of cb10
Expected Normal
Observed Value
1.0
.5
0.0
-.5
-1.0
-1.5
-2.0
-2.5
0
1
2
3
4
5
6

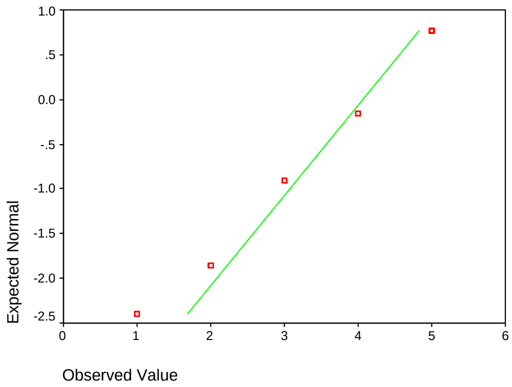

Detrended Normal Q-Q Plot of cb10
Dev from Normal
Observed Value
.2
0.0
-.2
-.4
-.6
-.8
0
1
2
3
4
5
6


Normal Q-Q Plot of cb11
Expected Normal
Observed Value
1.0
.5
0.0
-.5
-1.0
-1.5
-2.0
-2.5
0
1
2
3
4
5
6

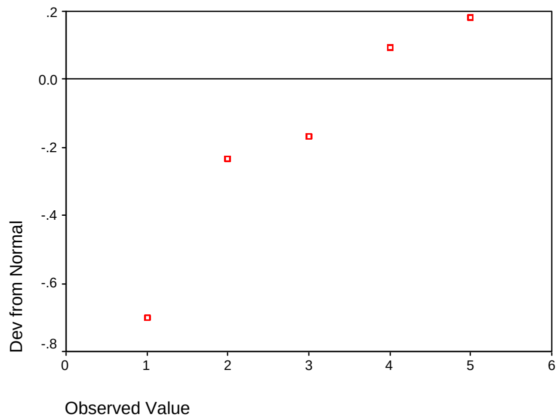
Detrended Normal Q-Q Plot of cb11



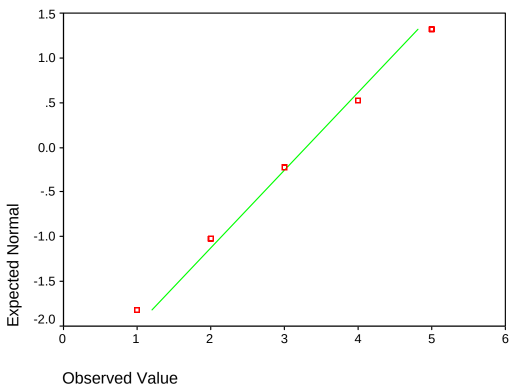
Normal Q-Q Plot of cb12

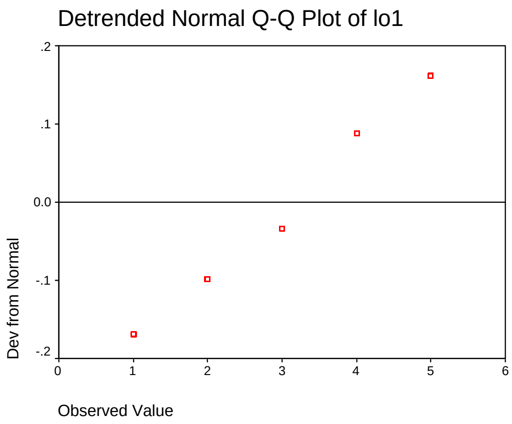


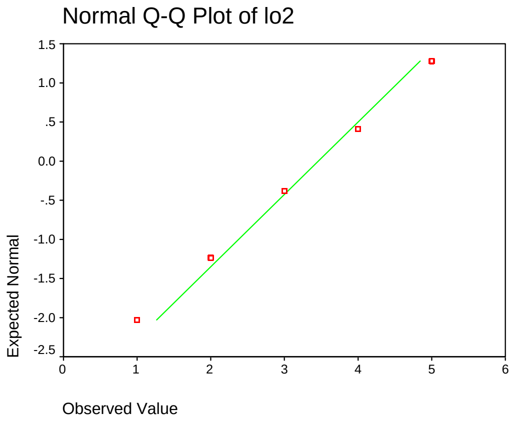
Detrended Normal Q-Q Plot of cb12

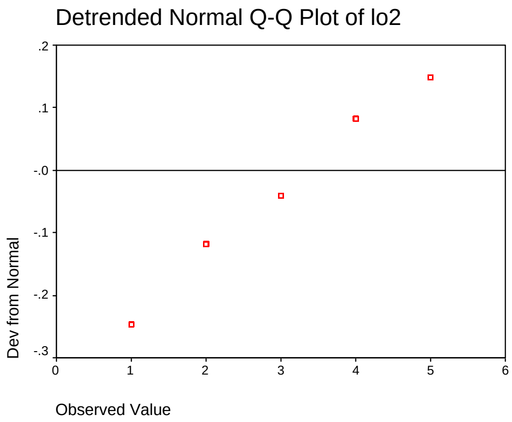


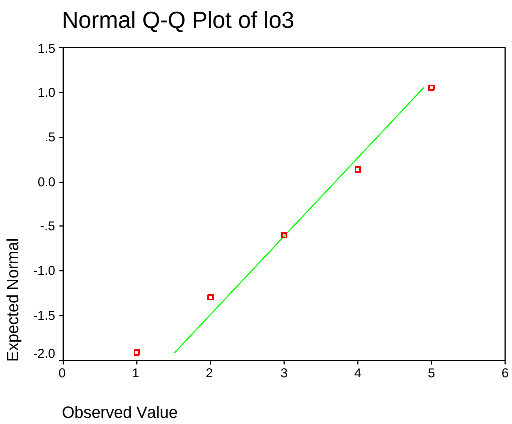
Normal Q-Q Plot of lo1

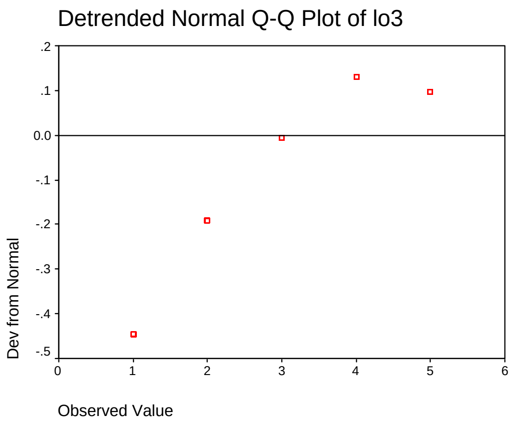


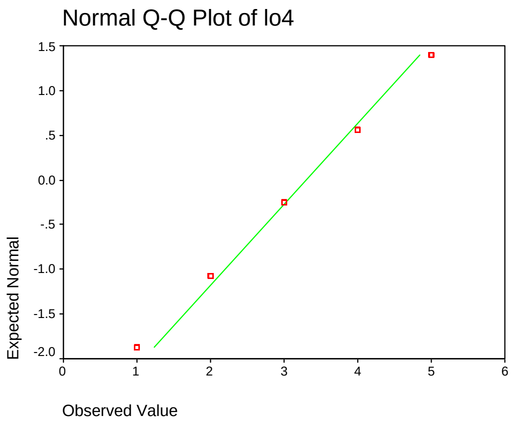

Detrended Normal Q-Q Plot of lo1
Dev from Normal
Observed Value
.2
.1
0.0
-.1
-.2
0
1
2
3
4
5
6

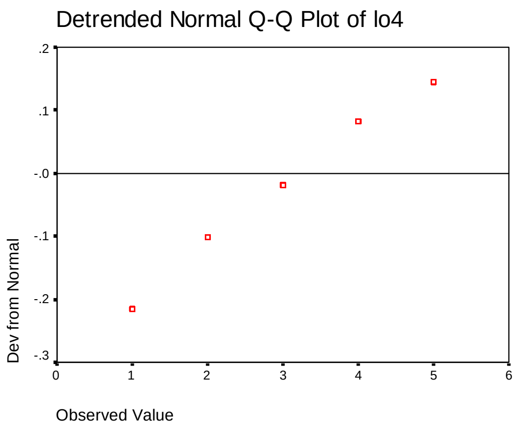

Normal Q-Q Plot of lo2
Expected Normal
Observed Value
1.5
1.0
.5
0.0
-.5
-1.0
-1.5
-2.0
-2.5
0
1
2
3
4
5
6

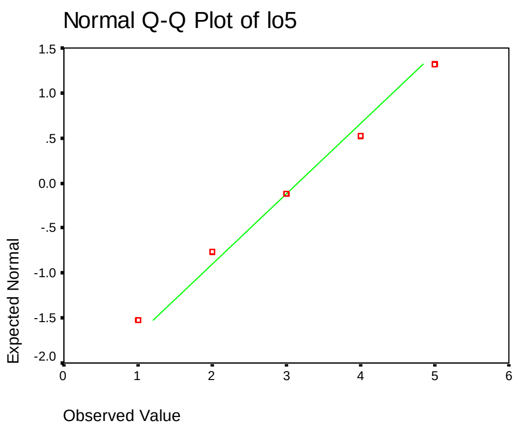

Detrended Normal Q-Q Plot of lo2
Dev from Normal
Observed Value
.2
.1
-.0
-.1
-.2
-.3
0
1
2
3
4
5
6


Normal Q-Q Plot of lo3
Expected Normal
Observed Value
1.5
1.0
.5
0.0
-.5
-1.0
-1.5
-2.0
0
1
2
3
4
5
6

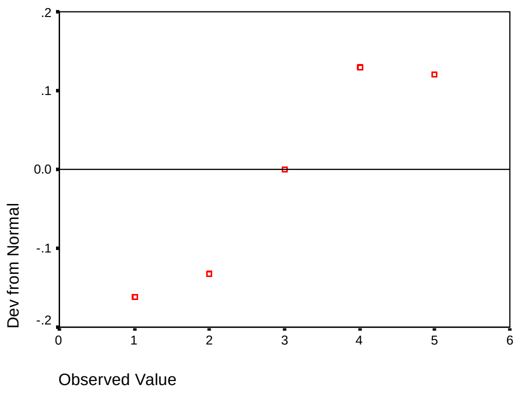

Detrended Normal Q-Q Plot of lo3
Dev from Normal
Observed Value


Normal Q-Q Plot of lo4
Expected Normal
Observed Value

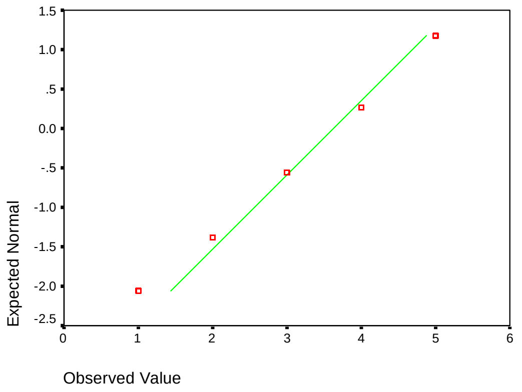

Detrended Normal Q-Q Plot of lo4
Dev from Normal
Observed Value


Normal Q-Q Plot of lo5
Expected Normal
Observed Value

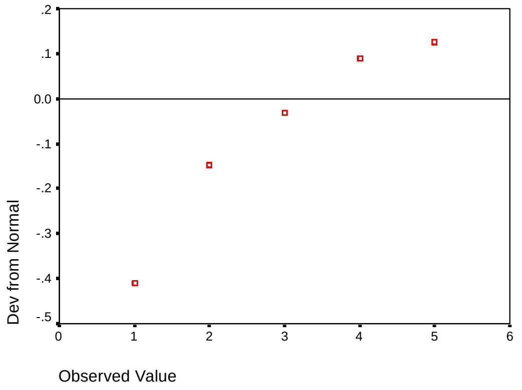
Detrended Normal Q-Q Plot of lo5



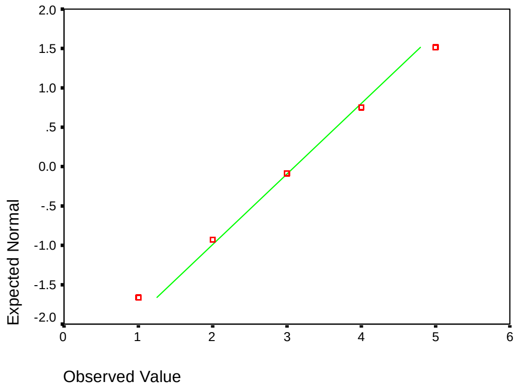
Normal Q-Q Plot of lo6



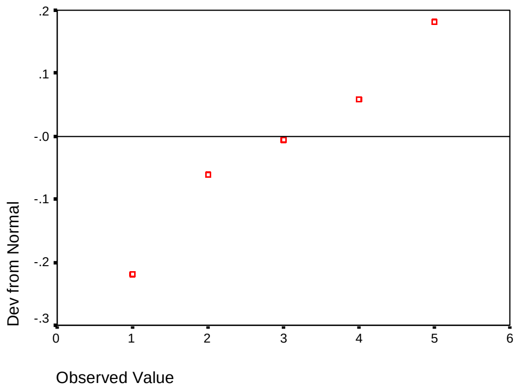
Detrended Normal Q-Q Plot of lo6



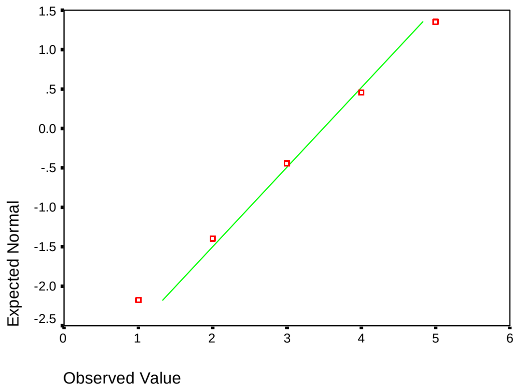
Normal Q-Q Plot of lo7



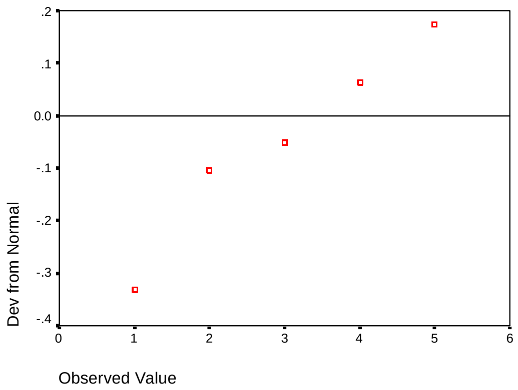
Detrended Normal Q-Q Plot of lo7



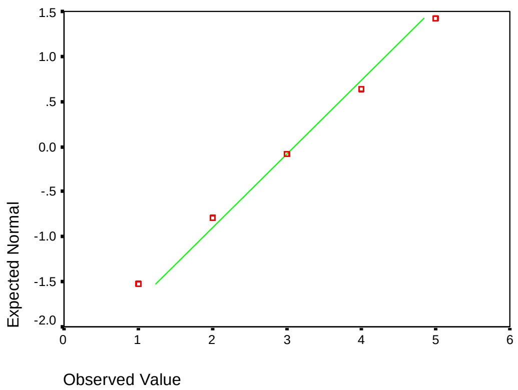
Normal Q-Q Plot of lo8



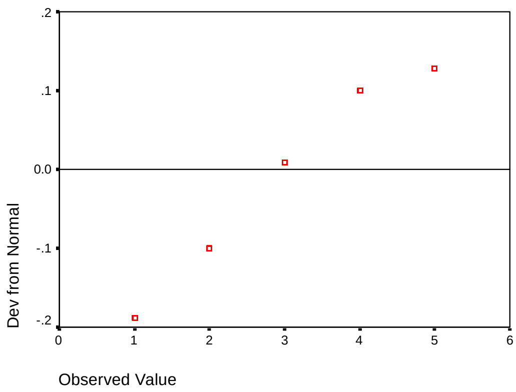
Detrended Normal Q-Q Plot of lo8



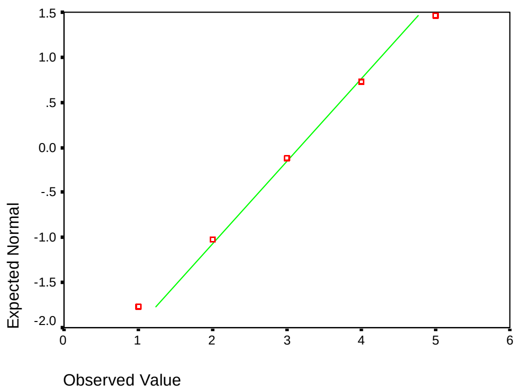
Normal Q-Q Plot of lo9



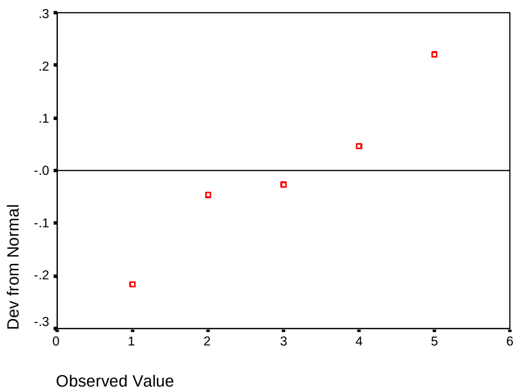
Detrended Normal Q-Q Plot of lo9



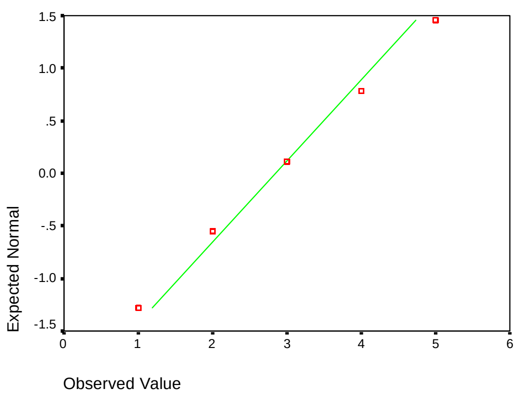
Normal Q-Q Plot of lo10

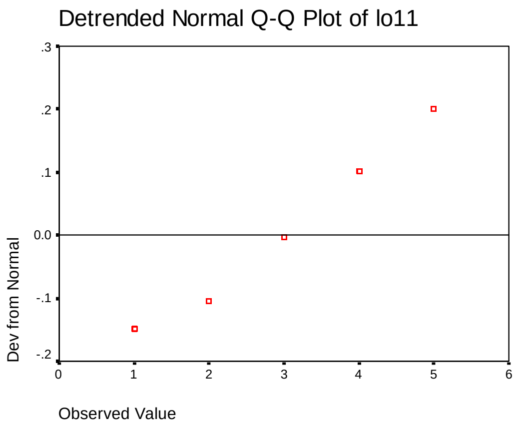


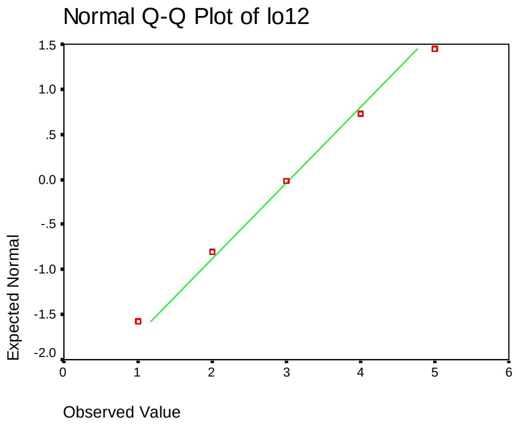
Detrended Normal Q-Q Plot of lo10

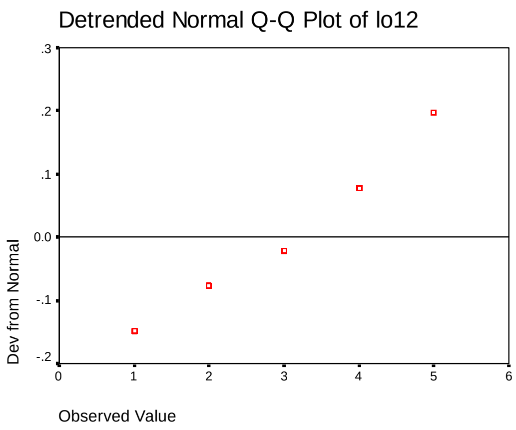


Normal Q-Q Plot of lo11




Detrended Normal Q-Q Plot of lo11
Dev from Normal
Observed Value


Normal Q-Q Plot of lo12
Expected Normal
Observed Value


Detrended Normal Q-Q Plot of lo12
Dev from Normal
Observed Value