FUZZY COGNITIVE MAP MODELLING THE ADOPTION OF EDUCATIONAL SOFTWARE IN SCHOOLS

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by

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ABSTRACT

This thesis focuses on modelling factors in the adoption of educational software in schools based on the perceptions of key stakeholders. Findings indicate educational software adoption in UK secondary schools is unsatisfactory. Given the potential of educational software to affect the learning process; the government's emphasis on developing software content for learning purposes and the concern that scarce resources in schools are wasted on software that is inappropriately used or not used at all, there is a need to ensure the successful take-up of educational software. This study aims to provide schools the means to facilitate better management of resources and achieve greater utilisation of educational software. The study in recognising the importance of stakeholders in any technological adoption considers modelling educational software adoption in schools, based on key stakeholders' perceptions. Fuzzy cognitive maps (FCMs), considered extensions of cognitive maps used for modelling complex chains of casual relationships, are used as a modelling approach in this study. A mixed methods research approach is adopted. Participants, include students; a range of teachers; ICT-Coordinators and ICT-Technicians, drawn from three UK secondary schools. The resulting FCM model offers a visual medium providing insight into the factors required in the take-up of educational software. Some factors identified include the availability and accessibility to IT facilities and equipment; the availability of educational software; software ability to satisfy learning requirements and to meet curriculum requirements. The model provides the means to identify factors which have a greater impact on educational software adoption, so scarce resources can be directed accordingly. As a holistic model it provides insight into the context of educational software adoption in schools. As a dynamic model it allows the opportunity to explore 'what-if' possibilities relating to policy and investment options. The model can act as a guide for planners, decision-makers and software developers.

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PUBLICATIONS

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LIST OF ABBREVIATIONS

ACOT	The Apple Classrooms of Tomorrow
BECTA	British Educational and Communications Technology Agency
D&T	Design and Technology
DfE	Department of Education
DfEE	Department of Education and Employment
DfES	Department of Education and Skills
EDI	Electronic Data Interchange
FCM	Fuzzy Cognitive Map
GCSE	General Certificate of Secondary Education
GNVQ	General National Vocational Qualification
ICT	Information Communications Technology
IS	Information Systems
IT	Information Technology
ITCE	Information Technology Communications and Electronics
KS	Key Stage
LEA	Local Education Authority
MFL	Modern Foreign Languages
NC	National Curriculum
NGfL	National Grid for Learning
NOF	New Opportunities Fund
OFSTED	Office for Standards in Education
RBC	Regional Broadband Consortia
SCAA	School Curriculum and Assessment Authority
SLICT	Strategic Leadership in ICT
TTA	Teacher Training Agency

Chapter 1: Issues in the adoption of educational software in UK secondary schools

1.1 Introduction

Governments across Europe have implemented programmes providing specific measures for the introduction of information communications technology (ICT) in education. Schools are under pressure to adopt this technology within their environment, the curriculum and in classroom teaching practices in order to be able to produce a computer literate workforce; prepare citizens for an information-based society and exploit the benefits of educational ICTs (O'Shea and Self, 1988; McKinsey & Co. 1997; Kent and McNergney, 1998). The UK government has invested considerable resources and effort in the introduction and implementation of ICTs (a blanket term which covers educational software resources, adoption, usage in schools, telecommunications, networking etc (OFSTED, 2002)) in secondary school education. There are advances and improvements in the UK, in the ratio of pupils to computer in schools, in the access to the Internet, in the IT skills held by both teachers and pupils and in the confidence of teachers in their use of ICT in teaching (DfES, 2003). Furthermore the importance of developing software content and providing high quality learning services has also been recognised and emphasised by the government (OFSTED, 2002).

Unfortunately however, ICT and educational software have not been as widely adopted across the curriculum, in the teaching and learning practices or been as pedagogically effective in classrooms as envisaged by the advocates of ICT in education. The question therefore arises as to why, against this background of skills-successes, advancement of technology, efforts and recognition of the importance of software content, has the use of educational software been so limited? Current research recognises the importance of ICT and educational software in the teaching and learning practices but research in educational ICTs has usually concentrated on software or hardware related issues; this study recognises that educational software adoption in schools presents a complex social and cultural context. It is against this backdrop that this study, aims to identify factors and the extent to which these factors can influence and ensure the satisfactory take-up of educational software in schools, based on the perceptions of key stakeholder groups.

This chapter provides: the background and current status of ICT and educational software adoption in UK schools; it gives brief details of programmes aimed to improve the use of ICTs, in UK secondary education and presents evidence of unsatisfactory progress. The chapter firstly discusses the drivers for the development and use of educational ICTs, and the benefits that can be achieved as a result of their successful adoption and use in education. The following section expands this discussion by addressing the efforts of political bodies in terms of investment, initiatives and policies to introduce and implement ICT in school education and how this has generally affected schools and relevant stakeholders. The next section presents findings which indicate that the adoption is not fully satisfactory yet, and in doing so sets the scene for this study. Section 1.5 outlines the study aims and objectives. It discusses the boundaries of this study, in terms of accepting the wider picture of ICT adoption in schools and recognising the key stakeholder groups in the domain, which are important to this study. The section also provides brief details of the modelling approach used and the research methods adopted for this study. Section 1.6 provides an outline of the remaining chapters presented within this thesis.

1.2 Drivers for adopting ICTs in education

The pervasive spread of ICT in education can be attributed to many forces: the rapidly changing technology; the growing e-economy and information-based society; political and global influences; the envisaged pedagogical benefits and the benefits to the school organisation. Technological advances in both hardware and software, in addition to the advances and expansion of computerised telecommunications technology such as the Internet has led to a range of educational possibilities (McKinsey & Co, 1997; Selwyn, 1999; Maddux, 1994). Information superhighways offer the potential to deliver widely and cheaply a vast range of educational services; software and other resources can be shared between schools, universities and external bodies; teachers can pool resources and ideas and all can have access to information and resources they could not access before.

The other motivating factor for the adoption of technologies in education is that technology pervades nearly every business and professional sector of the economy. The primary output of organisational workers consists of information and knowledge. In general information processing has become an integral part of people's business and personal lives. Importantly with the sophistication of the global e-economy it has become essential for most employees and employers to have knowledge of computers and information systems (Naqvi, 2000). Within the IT industry alone, the Information Technology Communications and Electronics (ITCE, 1999) report that, after taking account of expansion demand, retirements and net occupational mobility, the IT Services industry will need to recruit over 340,000 people between 1997-2006 and that employment in Computing Services will grow by 421,000 by 2010. Even though there are some variations in the forecast size of workforce in ITCE (Information Technology Communications and Electronics) occupations, they report that demand will continue to grow and that it will be substantial (ITCE, 1999). It is essential therefore to have a computer literate workforce that meets the demands of the economy and society. The preparation of the future workforce can be facilitated through education and therefore presupposes the widespread adoption of ICT within the educational field.

The influence of the international community has also been a primary driving force for the adoption of ICT in UK schools. There has been much educational policy making as a result of technological advances - specifically the internet and superhighways. Many countries have initiated nation wide policies (Selwyn and Brown, 2000) designed to develop "educational superhighways" via the connection of schools, colleges and other educational institutions to the internet, examples include the 'National Information Infrastructure' in the USA, Singapore's "Information Technology 2000" programme and the German "Schulen ans Netz" programme (DfE, 1995; Selwyn, 1999). Similarly the UK Government in 1997 announced their intention to establish a "National Grid for Learning" via a £1 billion of investment which would connect every school, college and university to the internet by 2002 (Selwyn , 1999; Selwyn and Brown, 2000).

Expanding on the political note the UK government not only has encouraged and brought about telecommunications, cable, broadcasting, information technology and multimedia industries to work with the education community but has had a key role in proclaiming and championing the ICT strategy in UK education. Two crucial aspects were: (1) Making it a requirement for the national agencies (e.g. OFSTED (Office for Standards in Education), SCAA (School Curriculum and Assessment Authority), TTA (Teacher Training Agency), British Educational and Communications Technology Agency (BECTA) etc.) in the education service to help the government to achieve its strategy. (2) Encouraging every school to formulate, implement and report back on its own policies on ICT across the whole school. (DfE, 1995; The Independent ICT in School Commission's, 1997).

Evidence suggests that the adoption of ICT has a positive effect on the school organisation. ICT may be used for a wide range of purposes besides training pupils in skills for their future jobs such as in the schools' administration processes; in terms of access to information and communication outside the classroom walls through the use of the Internet; in the support of teacher development, through external networks and in enhancing teachers' professional skills in addition to their subject specialities (The Independent ICT in Schools Commission, 1997). Finally and importantly, one of the key drivers for ICTs in education is the potential of ICTs to support and transform the process of teaching and learning (see section 1.2.1 for further discussion).

1.2.1 Key driver- the potential of ICTs in teaching and learning practices

ICT has many attributes which make it particularly suitable for education. It combines and integrates the full range of media i.e., sound, vision, text and numeric data through which successful learning can take place. Integrated learning systems, have proven to be beneficial in raising basic numeracy and provide an example of ICT bringing considerable benefits to bear on the learning process (McKinsey & Co., 1997; The Independent ICT in Schools Commission, 1997). The ability of ICT to integrate the full range of media provides teachers with new opportunities and options such as computer based teaching. Examples of ICT as a teaching tool include content-rich software used to aid the teaching of subjects such as geography and history and interactive tuition used for example to teach modern languages (McKinsey & Co., 1997). Given the ability of ICT to transform teaching and learning practices, educational ideals which were once desired, are now possible to achieve.

Harris (1979) argues that education should provide the opportunity to cope with the unknown future i.e. changes in jobs, transport and mobility. Therefore whatever the level of education, one of the primary purposes of education should be to enable the learner to learn on his own. Similarly Bates (1991) contends that it is not enough for learners to just observe and read, they need to demonstrate that they have understood, reprocess the knowledge to incorporate with existing knowledge, or apply the new knowledge they have acquired to new situations. Most theories of learning suggest that for learning to be effective, the learner must respond in some way to the learning material i.e. be an active learner. Ultimately these arguments are in line with the ideals aimed for by the constructivist approach, where the learner is considered independent and the constructor of knowledge.

Various forms of ICT can now help to achieve such educational ideals: ICT, provides a number of tools to support learning; facilitates the collaboration with communities outside the school bringing together teachers and students to share ideas otherwise prevented by location and distance or support learning outside school walls; provides the recognition that knowledge is not static as it is continuously created and changing; allows access to up-to-date knowledge; enables students to become stakeholders in their own learning and in the knowledge that they are creating and are engaged in etc (Flecknoe, 2002; Lewin et al., 2003; Leask and Younie, 2001; Dede, 2000; McFarlane and Sakellariou, 2002). The internet has now made it possible to experience virtual discovery-based or experiential-based learning; enabling learners not only create knowledge but also collaboratively create knowledge for the community i.e. achieve communal constructivism (Leask and Younie, 2001). This is one of the pedagogical strategies i.e. desirable learning experiences (Vygotsky, 1986) once unachievable because material tools were unavailable.

Integrated Learning Systems (Rogers and Newton, 2001) i.e. computer-based systems which manage the delivery of curriculum materials to students, proven to enhance students' learning (Underwood and Brown, 1997; Wood, 1998; Rogers and Newton, 2001), now effectively provide individualised learning materials which allow students to develop according to their own needs and learning styles, an educational ideal advocated by Harris (1979). In addition, computers have also shown a significant impact on the social dynamics within the traditional classroom by encouraging, and enforcing, group activities (Davies et al. 1997). Finally, it is worth mentioning that ICT has significant potential in the help it can bring to disabled children (The Independent ICT in Schools Commission, 1997).

The driving force for the adoption of ICTs in education, as discussed, has included a range of factors i.e. the advancing technology, the influence of international communities, the growing e-economy and the changing society. Importantly one of the primary drivers has been the potential of ICTs to impact education; advocates envisage and expect ICTs to not only support but transform teaching and learning practices to be able to achieve many pedagogical benefits. For all these reasons discussed in this section, there is a clear need for the adoption of ICTs in education. Therefore, it isn't surprising that during the last few years a political stance has been taken to invest resources and implement programmes providing specific measures for the introduction of ICTs in school education (McKinsey, 1997, Selwyn, 2000; DfEE and OFSTED, 2000, OFSTED, 2001, 2004, etc).

1.3 Background and current status of ICT adoption in UK schools

The UK government's efforts to support ICT adoption in education originally started in 1982 when the government teamed up with Local Education Authorities (LEAs) to provide funds for at least one computer in every school. It is at this juncture that the installation of hardware gathered momentum, which was stimulated further by the government requirement that ICT be included in the National Curriculum (McKinsey, 1997). Following the rapid and progressive global IT prominence, the UK government introduced initiatives and made substantial investments for ICT adoption in education. The Department for Education and Skills (DfES) has been responsible for the implementation of the government's strategy. The DfES has worked with the ICT supply industry, LEAs (Local Education Authorities), the Teacher Training Agency (TTA), the British Educational and Communications Technology Agency (BECTA) (OFSTED, 2004).

In 1998, the "National Grid for Learning" (NGfL) was launched, a £1 billion of investment, to connect every school, college and university to the Internet by 2002 and was considered to be the national focal point for learning on the Internet (Selwyn, 2000; DfEE and OFSTED, 2000). The Regional Broadband Consortia (RBC) was established in 1999, to develop the provision of broadband connections to schools through the purchase of an appropriate infrastructure, with the aim of extending schools' access to broadband, providing faster and more robust connections (OFSTED, 2004). There is software available to support different subjects within the National Curriculum and other aspects of the wider curriculum such as religious studies and special educational needs (Harris and Preston, 1993); these applications include both subject-specific software and programs, which are generic or cross-curricular in application such as word processing. There is also an increasing availability of high quality software free of charge from the internet such as graph plotters and dynamic geometry packages etc (Butler, 2000).

The UK government through the NGfL Standards Fund grant expected all schools to achieve a minimum level of ICT provision in 2002, i.e. the NGfL baseline. The NGfL baseline was defined as: access to ICT for teaching and learning purposes equivalent to a computer to pupil ratio of at least 1:11 in each primary school and 1:7 in each secondary school; secure connection to the Internet in each school with at least 20% of schools connected at the broadband level: at least one networked computer with Internet access in each school for management and administrative purposes. From April 1999, £230 million of Lottery funds, managed by the New Opportunities Fund (NOF), has been made available for teacher training in the use of ICT in teaching and learning (OFSTED, 2001). The DfES funding for ICT in schools has increased substantially since it began in April 1998; it totalled £510 million in 2002–03 compared with £657 million over the years from April 1998. This has been distributed to LEAs via the Standards Fund (OFSTED, 2004).

The combined initiatives were re-launched as 'ICT in Schools' in 2003, with continued earmarked funding for schools to purchase ICT hardware. Other significant schemes include:

Laptops for Teachers – a scheme providing laptops to schools for teachers' professional use via LEAs on a pro rata basis, it is estimated that two thirds of teachers will have participated in this and related schemes by 2006. Strategic Leadership in ICT (SLICT) – a programme of in-service training for senior school staff provided by BECTA and the DfES. Curriculum Online – a learning materials scheme whereby approved software titles are brought together categorised and made accessible to teachers via a single portal, is combined with earmarked funding for schools through the Standards Fund. Enhancing subject teaching using ICT – a scheme to provide online training materials for teachers in a range of subjects in primary and secondary schools (OFSTED, 2004).

Undoubtedly these endeavours have led to positive results which have been reflected in schools across the country. The Department for Education and Skills (DfES) (2001) reports that the average number of computers per school has increased from 27.1 in 1998 to 37.3 in 2001, while the percentage of schools connected to the Internet has risen from 28% in 1998 to 97% in 2001. In 2000-2001 there was a substantial increase in the use of ICT in all subjects across all schools. In 2003, the average number of pupils per computer in secondary schools decreased from 8.7 in 1998 to 5.4 (DfES, 2003). While by 2004 (DfES (2004a) survey of ICT in schools) the mean computer:pupil ratios were 1:7.5 in primary schools and 1:4.9 in secondary schools. These all indicate that the government had met their published targets for 2004 which included achieving a ratio of computers (excluding those used for management/administration) to pupils, averaging 1:5 in secondary schools, and 1:8 in primary schools. Practically all schools are now connected to the Internet.

Furthermore Table 1 shows that the percentage of teachers who have received training in the use of ICT equipment in secondary schools and updated training in the use of ICT in the past two years, has risen. It is also seen that there has been an increase in the percentage of teaching staff that are confident to use ICT in their subject teaching from 65% in 2000 to 82% in 2003, although in 2004 there was a slight decrease to 81% this was not considered to be statistically significant (DfES, 2004a). The OFSTED (2004) report claims that the competence of staff in ICT has increased dramatically since 1997, over 90% of teachers observed were competent users of ICT. Teachers are increasingly using ICT for planning, for the preparation of worksheets, presentations and other learning resources, the recording of assessments and the tracking of pupils' progress. ICTs are also being used by teachers in the curriculum (see Table 2).

Table 1 Statistical figures from the survey of ICT in Schools 2003 (Source: DfES, 2003)

ICT issues related to staff (including school leaders and teachers) in Secondary Schools		
Year	2000	2003
Percentage of staff who have received training in the use of ICT equipment	75%	87%
Percentage of staff who have received updated training in the use of ICT in the past two years	49%	73%

Table 2 indicates the percentage usage of ICT by teachers in areas of the curriculum in secondary schools in 2003 and 2003 (DfES, 2003; DfES, 2004a). The term 'ICT' in Table 2, represents a number of principal approaches to the use of ICT in subject teaching which includes for example, the adoption of computer-linked instrumentation to support pupils' practical work; the use of single computer and data-projectors or interactive whiteboards as teaching tools; lessons in computer suites for the use of interactive software or information retrieval; use of commercial tutorial packages on CD ROM linked to course books etc (OFSTED, 2002). The table indicates that there has been a slight fall in the percentages for 'little/none' and a slight increase in the percentages for 'substantial' ICT use in most of the curriculum subjects in 2004 compared to 2003. This suggests that there has been an increase in the use of ICTs by teachers in the curriculum.

Table 2 Use of ICT by teachers in areas of the secondary curriculum in 2003 and 2004 (Source: DfES, 2003; DfES, 2004a)

	2003			2004		
Subject	Substantial %	Some %	Little/None %	Substantial %	Some %	Little/ None %
Art	17	63	20	26	62	12
Citizenship	4	50	46	8	52	41
Design and Technology	62	35	3	66	30	3
English	19	69	12	24	63	14
Geography	22	66	12	30	61	9
History	15	65	20	21	63	16
Information Technology	99	1	*	99	*	1
Mathematics	31	57	11	41	51	8
MFL.	20	60	20	28	55	17
Music	24	51	25	29	49	22

	2003			2004		
Subject	Substantial %	Some %	Little/None %	Substantial %	Some %	Little/ None %
PHSE (Personal and Social Health Education)	n/a	n/a	n/a	7	50	44
Physical Education	3	38	59	7	45	48
Religious Education	6	55	38	11	53	36
Science	41	54	4	49	46	5

Although the above statistics are in relation to the use of ICTs by teachers in secondary school education, and includes the use of educational software, the amount of educational software used is not specified. Harris and Preston (1993) contend that there is rather less information about the range of software use in schools and its impact on the curriculum. However findings of the OFSTED (2002) report do draw some light on the use of educational software in subjects across the curriculum in terms of software packages used and noticeable benefits:

- It is reported for mathematics that the use of dynamic geometry packages and graph-plotting packages, enhances students' knowledge and understanding of mathematics and the use of practice software to support the learning of key skills and examination revision raises attainment level.
- In English, the use of the internet and selected CD-ROMs helps to add breadth to students' research, for example Shakespeare from key stage 3 onwards, while the adoption of one or two integrated learning systems programmes for Special Educational Needs' students improves their basic skills.
- The use of applications, in History, such as revision guides, available from the internet, some of which are interactive, have beneficial effects on students.
- In Music, good examples of effective use of software in composing music exist such as the use of sequencing software, furthermore there is use of software to support GCSE and post 16 groups.
- In Design and Technology, the use of 3D-CAD (Computer-aided design) software helps students to understand basic drawing systems such as orthographic projection, and it is used by students in an increasing proportion of schools.
- In Science, the use of template software in investigative work and the use of high-quality revision packages raise achievement. Students' are motivated by the

approach and appreciate the immediate feedback and examination focus that high-quality revision packages provide.

From the discussion above it is possible to contend that both teachers and students are now better equipped in terms of ICT facilities, equipment and in the IT skills they possess. They are able to word process, access the Internet, send and receive emails and are familiar with educational software (DfES, 2003; OFSTED, 2002; DfES 2004a). Despite the positive picture that is portrayed i.e. substantial investments, efforts, improved teacher training and increased teacher confidence there are still many issues with the adoption of ICTs in schools. For example the DfES (2003) survey found that the percentage of teaching staff who use a computer on a regular basis for teaching, has increased from 57% to 70% in 2004. Although a positive sign, at the same time this indicates that 30% of teaching staff still do not use ICT on a regular basis (DfES, 2004a). Furthermore in regard to the use of ICTs by teachers as indicated by such figures and as indicated by the figures in Table 2, there is evidence that more than often the use of ICTs is just for word processing or presentation purposes rather than for any pedagogic use (Leach and Moon, 2000; OFSTED, 2002). Unfortunately this is just a minor indication from a list of concerns about how widely ICT is being adopted and how effectively it is being used in classrooms. These concerns, which have been prevalent over the last couple of years irrespective of monies spent and efforts entailed, are discussed in the next section.

1.4 Indications of unsatisfactory adoption of ICTs in school education

UK government spending and efforts in educational ICT adoption have resulted in positive gains but there are concerns as well, which have been persistent and have existed over the last couple of years. The Independent ICT in Schools Commission (1997), McKinsey (1997) and the Office for Standards in Education (OFSTED) reported that: state of ICT in schools was primitive and much of the hardware in schools was technologically behind the times; experience, skills and attitudes of teachers varied widely; little software was directly related to the curriculum and there was considerable variation in the way ICT was used; 53% of schools did not comply with curriculum requirements in IT; standards were too low in more than half of secondary schools and the attainment in the subject did not meet expected levels (based on OFSTED inspections in 1997-98) (TES, 1999).

The April 2001 OFSTED interim report claimed that there were significant improvements in students' IT capability, but the standards of students' achievements in IT were lower than in most other national curriculum subjects. There was an increase in teaching and using ICT in both primary and secondary schools, however good practice remained rare. With reference to the impact of the NOF initiative on teacher training, the report stated that the majority of teachers had not yet completed their NOF training programmes. For those that had completed the training, it had contributed to an increase in their use of computers but it only rarely contributed to the pedagogic expertise necessary to help them make the most effective use of ICT in their lessons. Lastly, it was reported that one in five primary schools and a half of secondary schools and most special schools still did not comply with the National Curriculum requirements for IT (OFSTED, 2001).

The OFSTED (2002) report, claimed: The overall effect of the NOF training has been unsatisfactory- in six out of ten secondary schools the scheme failed to build on teachers' ICT skills or enable them to tackle pedagogical issues of ICT use in the classroom adequately. Many teachers struggle with unfamiliar technology and are sometimes apprehensive about using it. Differences exist among and within schools in the frequency and quality of subject teaching using ICT. Across the range of subjects inspected, ICT has some beneficial effect on teaching in over four in ten departments, about a third of departments have not been affected by the use of ICT. Between these extremes there are departments in which there are some good teachings using ICT, but where ICT has not yet had a significant effect on standards. There are also variations among subjects and many secondary schools face difficulty in enabling all departments to access ICT resources.

Similarly the recent OFSTED (2004) report also states that: The expected outcomes in regard to the NOF training programme were not met in about a third of schools and were met significantly in only another third. The training made a limited contribution to teachers' awareness of subject-specific ICT applications and did not encourage them to consider pedagogical issues of teaching and learning with ICT. Although by July 2003, the RBCs had met their target in ensuring that 50% of all schools and 90% of secondary schools were connected to broadband, few schools have yet to make significant use of applications that specifically require broadband. Standards Fund monies for 'e-learning credits' have generally been well used to purchase software, but teachers have sometimes been frustrated by the quality of the materials. Despite record spending levels and high overall pupil–computer ratios, many schools still struggle to provide adequately for the different ICT requirements. Unfortunately the gap between the best and worst ICT provision is unacceptably wide and increasing. Furthermore the OFSTED (2004) report claims that the impact on standards is more significant where pupils have regular access to ICT resources, but very limited where work using ICT is sporadic or not sustained beyond a single lesson. Disappointingly only a small minority of schools are embedding ICT in work of the school, the typical picture is that pupils' ICT experiences across the curriculum are sporadic and dependent on teachers; in many schools, opportunities to exploit the technology are being lost on a daily basis. Some teachers who are confident users for personal and administrative purposes still shy away from using ICT in the classroom. Although strengths can be found in all subjects of the curriculum, both the take-up and use of ICT across subjects remain inconsistent, with considerable variation from school to school.

With specific regard to using ICT in teaching the following weaknesses have been noted (OFSTED, 2002): a) ICT is used where other modes of learning would be more appropriate or potential of ICT application is not fulfilled. b) Low expectations of written outcomes- teachers tolerate shortcomings in ICT-based products, otherwise not tolerated. c) Acceptance of glossy computer-generated effects without extending pupils' artistic or intellectual capabilities. d). Allowing work that simply reproduces information rather than enabling analysis. e) Failure to use the full potential of particular ICT applications. These points are further illustrated with specific regard to educational software, by OFSTED (2002) in that:

- Only one in three Mathematics departments devise schemes which refer to specific ICT applications, many mathematics teachers remain unaware of the potential of specific software and tools. Lessons incorporating software tend to be isolated. Very little use is made of the powerful dynamic geometry or algebra software available. Mathematics departments use ICT more often for administration purposes than to support teaching and learning.
- ICT initiatives have had a limited effect on History; the word processor is the most predominant form of ICT used in this subject.
- Although a wide range of software is available to all Geography departments which include desk-top publishing packages, spread sheets, data bases, CD-Rom based information, these are not used consistently by all departments, and where the range is limited, insufficient opportunities are identified in the planning.
- Some Religious Education departments make good use of word processing, desk-top publishing or multimedia presentations to create writing frames, however there are only few instances of teachers using ICT to enhance pupils' analytical skills or research.
- Only a third of teachers demonstrate effective use of ICT to promote pupils' learning in Physical Education. The majority of schools teaching PE at GCSE have a small number of software items, and although pupils have access to PE specific hardware and software, they have limited opportunities to use this.

- In Music, at times some aspects of music technology are underused. Several schools have insufficient resources and need sufficient access to music software to offer opportunities to all and not just as isolated experiences.
- The effect of ICT on Modern Foreign Languages has been uneven with activities often limited to consolidation and practice, using CD-ROM packages linked to course books, although many of these have much to offer they are often used uncritically and unselectively. The range of Modern Foreign Languages varies greatly; some departments for example may have no text manipulation software.

Generally it is noted for most subjects that there is frequently, the use of presentational software, however more than often it is used for effect rather than for any substance (OFSTED, 2002). Furthermore in a study by Loveless et al. (2000) teachers were asked to indicate their use of specific software packages ranging from MSOffice to subject specific software. 82% and 77% indicated usage of MSOffice and MSPublisher respectively, none of the other software packages were used by many of the respondents. Teachers are therefore using a very limited range of software and/or using them ineffectively.

Overall the above findings and discussion bring us to the conclusion that ICT adoption in school education over the years has been problematic; the full potential of ICTs, in education remains to be achieved. Intertwined with the general problematic ICT adoption is the unsatisfactory up-take of educational software. Despite facilities, availability of software, IT skills held by teachers and students, the use of subject specific software across the range of subjects in the curriculum is limited and ineffective. Educational software is one of the many applications of ICTs, which has the potential to significantly affect learning in a positive manner. There are a number of pedagogical benefits that can be associated with the use and adoption of educational software in schools. This has been seen when there has been appropriate use of educational software i.e. subject specific software in different areas of the curriculum such as in mathematics, English, science, design and technology, and history (OFSTED, 2002). For example the use of subject specific software has been found to: enhance students' knowledge and understanding; their learning of key skills; cause an increase in their attainment levels and to have beneficial effects on them (OFSTED, 2002). These are undoubtedly some of the pedagogical benefits envisaged by the advocates of ICTs in education and that can be achieved from the appropriate use of educational software. Soloway (1998) contends educational software is a key component if technology is going to have an impact on education. The government too has highlighted the importance of developing software content and providing high quality learning services (OFSTED, 2002). Furthermore scarce resources being wasted on software and hardware that is inappropriately used or not used at all is a main concern with

ICTs in schools (Butler, 2000). It is therefore important to study the reasons for the slow adoption and limited use of educational software in schools and to shed light on the factors which will ensure the satisfactory up-take and use of educational software in the teaching and learning practices.

1.5 Study overview

1.5.1 Study aims and objectives

The aims of this research are to:

- Facilitate better management of resources by schools, in order that they can achieve greater utilisation of educational software within their environment.
- Provide the means by which it is possible to determine where resources, in terms of monies and efforts, should be directed, so that factors which either alone or in combination with other factors are enabled and can influence the up-take of educational software by teachers and students schools.
- Provide a holistic view of the combination of the various factors which are required in the adoption and usage of educational software within a school's teaching and learning practices. This will allow for an insight and a better understanding of the educational software adoption context.

By providing the means to achieve greater utilisation of educational software in schools this can potentially lead to the attainment of many of the pedagogical benefits associated with the use of educational software. This study will be potentially useful to educational software developers, educational planners and decision makers both at local and national levels.

The objectives of this research are to:

- Explore the issues surrounding the unsatisfactory adoption of educational software and general ICTs in schools from past and current findings.
- Model complex chains of causal relationships, which allow for the measure of such relationships to be determined and where many stakeholder perceptions can be incorporated.
- Devise means of targeting and collating relevant stakeholders' perceptions on the adoption of educational software and general ICTs in schools.

- Elicit specific knowledge from relevant stakeholders, needed for modelling the adoption of educational software in schools.
- Construct models of the adoption of educational software in schools, based on relevant stakeholder perceptions, which show the various combinations of factors and the extent to which each factor influences the adoption of educational software by students and teachers
- Employ the developed model to ascertain and examine the outcomes or the overall effects when certain factors within the model are activated. For example, explore scenarios in which an initial policy or investment change means enabling/activating a factor or factors in the model and where the evolved model, as a result of the change in the factors, is seen as the final outcome or the overall effects of such policy/investment change.

In light of the research to be conducted within the context of this thesis to address the above aims and objectives, the section below outlines the scope of this study.

1.5.2 Study Scope

The study acknowledges the bigger picture of ICT adoption in schools i.e. the hardware, the infrastructure etc, since without these elements being in place schools would fail to have the technology rich environment in which educational software can be utilised (Ward, 1999; Weikart and Marrapodi, 1999). This is synonymous with the suggestions advocated by information systems academics that the adoption of any IT/IS in any organization needs to address a broad spectrum of issues for the adoption to successful (Lyytinen and Hirschheim, 1987; Currie, 1994; Waters and Cane, 1993; Beynon-Davies, 1995, Heatly et al. 1995; Pouloudi and Whitely, 1997; Markus, 1983 etc). Therefore in the adoption of educational software in schools it is imperative to consider broader issues that make up the adoption context, such as technological, organizational, social, cultural and economical factors (Schofield 1995; Ward, 1999; Weikart and Marrapodi, 1999; Selwyn, 2000; Mau, 1999; Siemer 1998 etc). Furthermore the study acknowledges, that the term ICT, commonly used within the literature, is often considered a blanket term, which covers educational software resources, adoption, usage in schools, telecommunications, networking etc (OFSTED, 2002). Therefore, although the study is primarily concerned with the adoption of educational software, within the context of this thesis it will examine and draw from past and current issues and perceptions on wider educational ICT adoption matters.

The study recognises the importance of stakeholders in the adoption of technologies i.e. IT/IS within organisations. Lacity and Hirschheim (1995) have argued that a major obstacle for the alignment of information systems and business strategies are the conflicting expectations and perceptions of information systems that different organisational stakeholders have. Failure to recognise the importance of stakeholders and take into account different stakeholder opinions and expectations, in the development and adoption of systems have resulted in projects and systems being considered a failure or being terminated (Beynon-Davies, 1995; Heatly *et al.*, 1995; Currie, 1994; Waters and Cane, 1993; Tolsby, 1998). Information systems' academics strongly advocate that the development and adoption of an information system requires the participation of interested parties i.e. stakeholders; the extent and effectiveness of the participation of stakeholders influences the success of the resulting system (e.g. Mumford and Weir, 1979; Checkland and Scholes, 1990; Cavaye, 1995; Cavaye and Cragg, 1995; Pouloudi and Whitley, 1997). Therefore it is important in any information systems development or adoption to take into account the opinions and views of relevant stakeholder groups. Within the educational context of ICT adoption there are relevant stakeholders who need to be recognised and their perceptions taken into account. Hossain (2000) identified a number of stakeholders within this domain ranging from the government, local education authorities, national agencies, and teacher raining providers to IT- coordinators, teachers and students.

Given the constraints of time and resources this study focuses on the perceptions of key stakeholder groups. These are stakeholders internal to the school environment and play an important role in the up-take of educational software i.e. they are either directly affected or can directly affect the adoption and use of educational software within the school. They include department heads, teachers, IT-coordinators, technical support staff, and students. IT-coordinators are responsible for ICT related policy formulation, policy implementation, overall management of resources (Donnelly, 1995). They are the main sources of recommendations for software purchases (Harris and Preston, 1993). Heads of departments and individual teachers are also indicated as persons influencing the choice of programs/software within the school (Harris and Preston, 1993). Technical support staff are responsible for maintaining the school's ICT infrastructure, managing networked computers, checking the compatibility of software with hardware, installing software onto the system and ensuring trouble free usage. Teachers (which include head of departments and IT-coordinators whose duties include teaching within the school) and students are the users of educational software and considered obvious and important stakeholder groups (Hossain, 2000). Users play an important role in determining the success of a system development or adoption, their involvement, participation and influence are considered to be beneficial to the success of a system (Laudon and Laudon, 1998; Markus, 1983; Hwang and Thorn, 1999; Lin and Shao, 2000 etc). Gibson and Nocente (1999) contend that by listening to the successes and frustrations of teachers and pupils involved in the implementation of computer technology will ICTs be used in a more positive and productive way in schools. In addition teachers have been identified as having a crucial role in the success of ICT in schools; they are responsible for facilitating, organising, structuring activities which incorporate ICTs within the classroom (Scrimshaw, 1997; Kaye, 1995; Gibson, 2001).

Thus these key stakeholders can provide a better understanding of the reasons for the slow up-take of educational software based on their own first hand experiences and knowledge as they are directly involved in the adoption of educational software in the school environment. This study is therefore concerned with the views and opinions of IT-coordinators, IT support staff, department heads, teachers, and students in modelling the factors in the up-take of educational software in schools.

1.5.3 Application of Fuzzy Cognitive Map (FCM) modelling approach

The study explores and justifies the use of fuzzy cognitive mapping as an approach to model the factors in the adoption of educational software in schools, based on the perceptions of the relevant stakeholder groups. This will be discussed in detail in chapter 3. The study develops and presents an FCM model which provides a holistic view of the technological, organisational, pedagogical etc factors influencing the up-take of educational software by teachers and students. The model offers a visual medium providing insight and an understanding of the educational context and of the relevant factors involved; as a dynamic model it offers the opportunity to simulate 'what-if' possibilities and explore the effects and outcomes of policies and investments. It therefore provides a useful guide to educational software developers, educational policy-makers and decision-makers in schools.

1.5.4 Research methodology

A mixed methods research approach is adopted by this study. The mixed methods research approach allows for an understanding of the multiple perspectives, held by key stakeholder groups, from an environment which presents a complex social and cultural context. At the same time it allows for the generation of numeric data vital to the development of the FCM. The combination of both qualitative and quantitative methods enables for the construction of a rich FCM model within the context of this thesis. The research approach and the methods adopted by this study will be discussed in chapter 4.

1.6 Structure of the thesis

Chapter 2 provides an overview of the diverse and extensive research that has taken place with respect to ICTs in schools. It discusses studies concerned with the implementation/integration of ICT in schools. It presents examples of those studies which have focused on examining which factors influence the integration and use of computers and their applications. The chapter provides an overview of the significant factors and issues which have arisen from such studies and from the literature in general. It provides details of two studies which have developed models related to computer use and discusses the methods generally used by such studies and highlights potential areas of concern. The chapter discusses the use of fuzzy logic within educational research. It then concludes by highlighting the need to explore fuzzy cognitive maps as a potential modelling approach given that the modelling techniques described within the literature do not adequately address the modelling requirements of this study.

Chapter 3 introduces the theory of Fuzzy Cognitive Maps. It examines a body of research which has considered a modelling approach based on the theory of fuzzy cognitive maps. The chapter sheds light on the: reasons as to why the FCM modelling approach has been adopted in these studies; the advantages and the disadvantages that have been realised from its use and any potential areas of concern. It provides justification for considering fuzzy cognitive maps as an appropriate modelling approach for use within this study.

Chapter 4 presents and reviews the epistemological and ontological stances of positivist, postpositivist, interpretive and pragmatic research paradigms and highlights the differences between them. It presents the research approaches associated with these paradigms. It lists the strategies of inquiry and methods typically used by qualitative, quantitative and mixed methods approaches. The chapter provides justification for selecting the mixed methods approach for this study. It discusses the methods used to conduct the empirical study which include details of: the selection of the sample; the modes of data collection; design of the instruments for data collection and the methods used to analyse the empirical data. The chapter also provides details of the simulation process chosen to conduct the simulation of the FCM model.

Chapter 5 describes the empirical research conducted. It presents the backgrounds of each the field sites i.e. the three participating schools and provides insight into the current level of their ICT infrastructures and ICT capabilities. The chapter discusses similarities and differences between the schools and establishes that the three schools are typical of schools in their respective boroughs and in England. The chapter describes the ways in which each of the schools were approached and the manner in which the research was conducted with participating staff and students. It presents a statistical summary description of the sample and a detailed description of each of the participants. The contents of this chapter are particularly important, given that the information presented within will be used in the determination of participants' credibility weightings in chapter 6.

Chapter 6 describes the construction of the FCM model. The analysis of the empirical data which leads to the construction of the FCM model is described in three phases within this chapter. The first phase of the FCM model development is concerned with the basic FCM construction for each individual participant. The second phase of the FCM development addresses the issue of determining participants' credibility weightings, an area of concern highlighted in chapter 3. The chapter presents the criteria developed for determining credibility weightings of the participants within the context of this study. It draws on the contents from chapter 5 in allocating credibility weightings based on the criteria developed and subsequently shows the aggregation of individual FCMs to form one main model. The third phase of the development involves further additions to and refinement of the model. It discusses the analysis of the empirical data from which further relationships are identified and presents a framework for determining the strength weightings of these relationships. The chapter shows the incorporation of the newly identified and weighted relationships into the model and presents the final FCM model for this study.

Chapter 7 discusses the analysis, simulation, validation and application of the FCM model. It discusses the static analysis of the FCM model. It describes the dynamic process adopted within this study to simulate the FCM model. It highlights the potential of a dynamic FCM analysis in comparison to a static analysis. The chapter discusses the validation of both the static and dynamic FCM model. The dynamic validation is based on a study known as the ACOT (The Apple Classrooms of Tomorrow) project. The chapter next considers the application potential of the FCM model and demonstrates the application of the FCM model based on a practical situation.

Chapter 8 provides an overview of the earlier chapters. It discusses the contributions and the limitations of this study. The chapter concludes with opportunities for future research. Figure 1 provides a summary of the structure of this thesis. It acts as a quick guide and highlights some of the main areas covered in each chapter of this thesis.

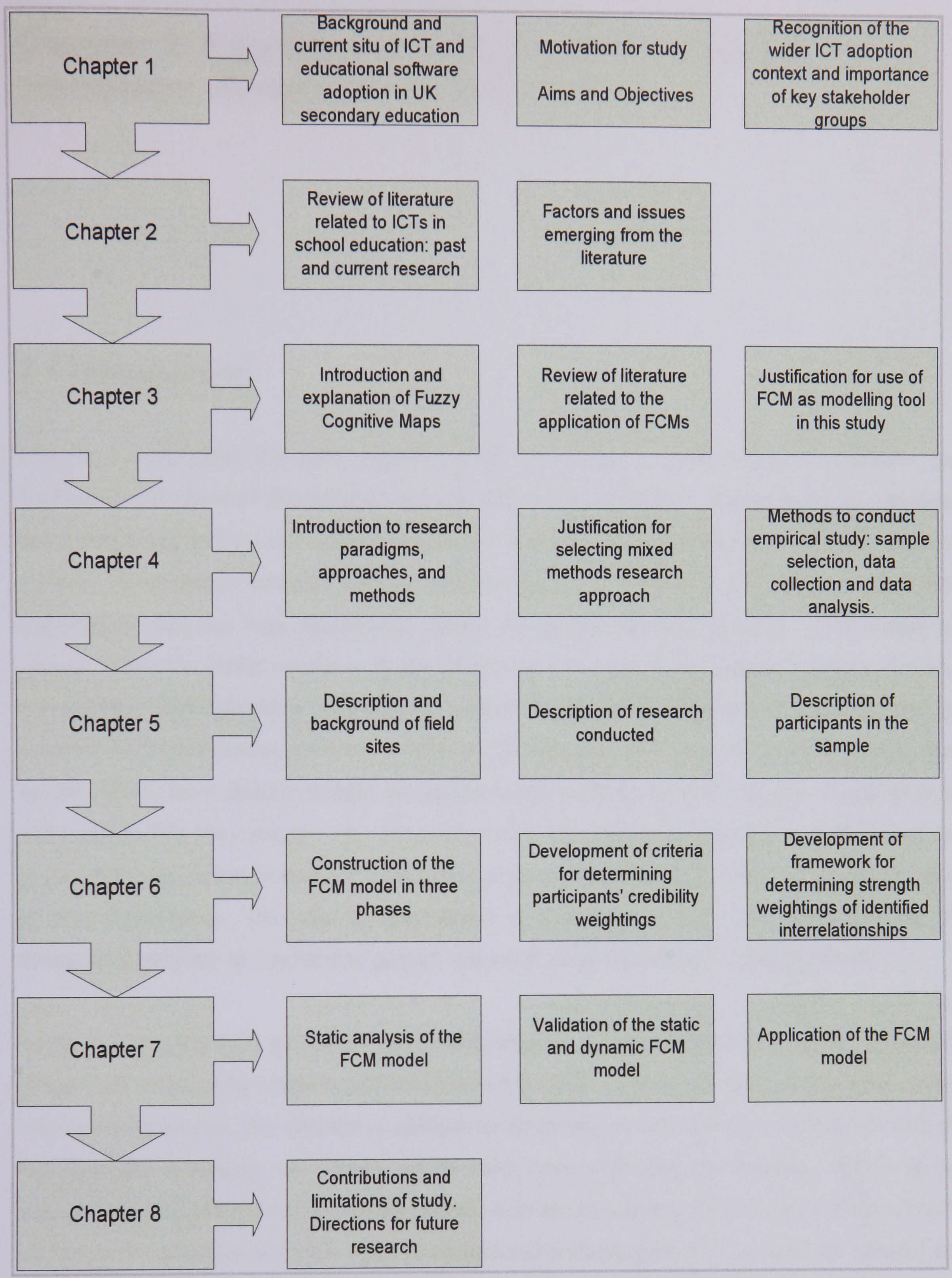


Figure 1 Summary of the thesis structure.

Chapter 2: Educational technologies in school education: Review of the literature

2.1 Introduction

Chapter 1 highlighted the slow adoption of ICT in school education and in particular the ineffective utilisation of educational software across the curriculum. Although the government has directed much effort and investment towards the integration and adoption of technologies in schools, the evidence indicates that the overall impact on teachers and students to adopt the technologies has not been satisfactory. Given the drivers for this adoption, as discussed in chapter 1, and the recent emphasis by the government to develop appropriate software content, it is essential that software is adopted and utilised in schools. It is valuable to not only identify and address the barriers or inhibitors affecting this adoption but devise the means to identify the factors which have greater impact on teachers and students in their up-take of educational software. In this way schools can direct resources and efforts to addressing, developing, or improving these factors instead of wasting resources and/or allocating limited resources to areas of less significance. This can be considered a vital step towards increasing the use of educational software and achieving greater utilisation of educational software in schools.

Given that this thesis is concerned with modelling the factors which influence the uptake of educational software by teachers and students and the extent of such influences, as perceived by relevant stakeholders, this chapter in addition to reviewing current and past studies will aim to highlight the following: a) Factors which have been identified by existing studies to be important in the adoption of ICTs/educational software in schools; b) Existing models of such factors in the adoption and utilisation of educational technologies; c) The methods adopted by these studies in order to identify, determine and model these factors and their interrelationships; d) The measures, if any, which have been used to determine the extent of the influence causal factors, may have on other factors i.e. the strength of relationships between factors. Finally e) any modelling approaches which have been used, to represent interrelationships and exhibit the strength of these relationships based on the perceptions/knowledge of relevant stakeholders groups.

Firstly the chapter provides an overview of research that has taken place with respect to ICTs in schools. It provides examples of studies which have drawn upon theories from organisational IT/IS implementation research. The chapter then looks at studies concerned with the implementation/integration of ICTs in schools. It presents examples of studies which have focused on examining which factors influence the integration and use of computers and their applications. The chapter then provides an overview of the significant factors and issues which have arisen from such studies and from the literature in general. It next looks at two studies which have developed models related to computer use. The chapter provides a discussion of the methods generally used by such studies and highlights potential areas of concern. The chapter then considers the use of fuzzy logic within educational research. It concludes by indicating the interest of this study to consider a branch of fuzzy logic i.e. fuzzy cognitive maps, which is to be discussed in the following chapter.

2.2 Overview of research related to ICTs in schools

Research and studies related to ICTs in school education, have been both extensive and diverse. A large body of research has predominantly concentrated on the effects of educational technologies on the teaching and learning practices; exploring and examining the pedagogical benefits that can be achieved from its adoption (Niederhauser and Stoddart, 2001; Davis, 1993;; Flecknoe, 2002; Lewin et al., 2003; Leask and Younie, 2001; Goodison, 2002; McFarlane and Sakellariou, 2002; Underwood and Brown, 1997; Dede, 2000; Wood, 1998; Leach and Moon, 2000; Zhong ad Shen, 2002 etc). Others have considered the potential of technology to affect the school's administration and management processes (Wolf et al, 1993; McKinsey and Co, 1997). Some have developed the means and ways in which to evaluate the effects of these technologies within the school environment (Means, Haertel, Moses, 2003; Lesgold, 2003).

There have been many studies, especially government led ones, which have concentrated on providing statistical and general information on: ICT related expenditure; the number of computers in schools; number of schools connected to the internet; the amount of ICT use; types of software used, percentage of teachers trained; the general adoption of ICTs in schools and so on (DfEE and OFSTED, 2000; OFSTED 2002; DfES, 2001, 2003, 2004a; Davis 1993; Harris and Preston, 1993, TES, 1999 etc). A number of projects have also been commissioned by the DfES to evaluate the progress of the government's 'ICT in Schools' programme. For example the ImpaCT2 project investigated the impact of networked technologies on the school and out of school environment and the degree to which these technologies affected the educational attainments of pupils at key stages 2, 3 and 4 (BECTA, 2002). Other studies have looked at: Social and economical issues such as gender in relation to ICT adoption (Mayer-Smith et al, 2000; Ordidge, 1997; Sutton, 1991; Furger 1998; Schofield 1995; Reinen and Plomp, 1993; Durndell et al., 1995 etc); the rich and poor divide i.e. those who have and those who do not have computers (Selwyn, 2000; Solomon, 1999; Cuthell, 1999; Durndell and Thompson, 1997; Hickling-Hudson, 1992; Shashaani, 1993) and the widening IT skills disparity between teachers and students (Cuthell, 1999).

2.3 Studies drawing from organisational IT/IS implementation research

Furthermore parallels have been drawn to show that a school body can be considered to be similar to that of any other organisation (Telem, 1996; Kast and Rosenzweig, 1985; Telem, 1987). Like any other organisation, it too is considered to be composed of technical, structural, psychosocial, goals, values and managerial subsystems. However at the same time it is recognised that schools as institutions have objectives which are fundamentally different from those of business organisations and that teachers differ from the end-users found in business settings. In comparison to business related end-users, teachers are relatively independent and have considerable autonomy over their teaching activities, including the choice of technology and its use (Hu, Clark and Ma, 2003).

Based on the premise, that schools are similar to any other organisation, some researches of ICTs in schools have drawn on theories and models from organisational IT/IS implementation research. For example, Cox, Preston and Cox (1999) related their findings of the factors motivating teachers' computer use to 'perceived usefulness' and 'perceived ease of use', two important features of the Technology Acceptance Model (TAM), one perspective on computer acceptance behaviour (Davis, Bagozzi and Warshaw's, 1989). Hu et al. (2003) developed a research model, which used TAM as a theoretical basis, to examine technology acceptance decision making by teachers. Telem (1996) used a socio-technical approach to develop a school management information system (SMIS) implementation framework, suitable to the characteristics of a school. Lim, (2002), Lim and Hang (2003) argued for the adoption of a socio-cultural perspective in the study of ICT in schools, and developed a framework based on activity theory to study the integration of ICT in Singaporean schools. Yuen, Law and Wong (2003) compared the change models of ICT, identified in their study, to models in business organisations (Laudon and Laudon, 1998).

2.4 ICT implementation/integration in schools

The implementation/integration of technologies into the school system has been the focus of a large body of research (Davis, 1993; Pelgrum, 1993; McKinsey & Co., 1997). Frameworks and models have been developed to help generate questions and guide studies related to the implementation of ICTs in schools and/or provide descriptions or an understanding of the process itself. For example Plomp and Pelgrum, (1993) developed a framework which consisted of concepts derived from systems theory, curriculum theory and theories on educational change, to guide research questions and instrumentation for an international comparative study, looking at technology innovation in more than 20 educational systems. Lim (2002) and Lim and Hang (2003) proposed a framework based on activity theory to study ICT integration in schools in Singapore. The framework allowed for the generation of a research agenda to study and document the totality of successful and unsuccessful ICT integration into Singaporean schools. Mooij and Smeets' (2001), study led them to propose five successive phases of ICT implementation in schools, where each phase constituted a model representing gradual ICT transformation of everyday educational and learning processes. The phases included: a) Incidental and isolated use of ICT by one or more teachers; b) Increase of school awareness of ICT relevance for the school at all levels; c) Emphasis on ICT co-ordination and hardware within school; d) Emphasis on didactics innovation and ICT support. Finally given there was no empirical evidence in practice, Mooj and Smeets' (2001) model of the fifth phase i.e. e) the use of ICT-integrated teaching and learning, independent of time and place, was based on theoretical elaboration.

Such studies, in envisaging an optimum ICT adoption situation which can be achieved in schools, have suggested strategies and actions for the implementation/integration process and for the study of such processes so that appropriate information can be elicited on how to successfully integrate ICT into schools. Mooij and Smeets (2001) provide multiple suggestions and various actions to support the steps in their models of ICT transformation, from model one i.e. incidental and isolated use of ICT by one or more teachers to model five i.e. the use of ICT-integrated teaching and learning, independent of time and place. They emphasise the need for both schools and national policies to focus on pedagogical and ICT conditions that must be met in order to achieve the ICT implementation model described in this final phase. However Yuen, Law and Wong (2003) contend the models proposed by Mooij and Smeets (2001) are based more on the technical history of ICT use and they argue for the importance of examining implementation history and school development, in ICT implementation. Lim and Hang (2003) suggest that the effective integration of ICT in a learning environment depends on the way ICT is situated within the larger social and cultural setting. These are just a few examples of the types of recommendations that have arisen from studies concerned with ICT implementation/integration processes in schools.

2.4.1 The unsatisfactory integration of ICTs in schools

Another major faction of studies related to the integration/implementation of ICTs in schools has been concerned with the investigation of past and current ICT integrations in schools, examining whether the implementation and/or adoption have been satisfactory and whether or not the full potential of adopting such technologies has been realised. Many such studies and reports have clearly indicated the failures and/or signs of a slow adoption of educational technologies, including the unsatisfactory uptake of educational software by relevant stakeholder groups in the school environment (McKinsey & Co., 1997; OFSTED , 2001 and 2002) and have been discussed in some detail in chapter 1. For example, claims have been made that little progress has been made in integrating computers into existing lesson practices; few teachers actually use the technology; software use is constrained to drill and practice activities and integration into the curriculum is poor (Becker, 1986). Draper (1998) claims that most ICT packages failed to have a significant effect on learning and teaching practices in schools because only a small proportion of their potential is used. Siemer, (1998) contends that computers in school failed to be successful, because the evolution of computer use in the classroom had been very much technology driven, with little attention given to factors that are encountered within the context of the 'real' classroom. Such findings have led many studies to highlight the barriers which hinder this adoption, and/or draw attention to factors which need to be addressed in the implementation and adoption of educational ICTs (McKinsey & Co., 1997; OFSTED, 1996; Siemer, 1998; Stammers, 1997; Gulliver, 1999; Guest and Alimi, 2000; Ward, 1999; Weikart and Marrapodi, 1999; Hossain et al,. 2000; Hossain et al. 2003).

2.5 Studies concerned with factors in the adoption and use of educational ICTs

A number of studies have specifically concentrated on the identification of factors which affect the adoption and use of computers or computer related applications and/or the examination of the effects of these factors on the use of ICTs. For example Cox, Preston and Cox (1999) investigated which factors motivate teachers to use and to sustain their use of ICT in teaching. Niederhauser and Stoddart (2001) examined the relationship between teachers' epistemological and pedagogical perspectives and their use of educational software. Hadley and Sheingold's

(1993) conducted a survey of teachers in schools known for their efforts to integrate technology into their teaching, as to the motivating factors considered important in such integration. While Baylor and Ritchie (2002) investigated the effect of seven factors related to school technology (i.e. planning, leadership, curriculum alignment, professional development, technology use, teacher openness to change and teacher non-school computer use) on the following five dependent measures: teacher skill (technology competency and technology integration), teacher morale and perceived student learning (impact on student content acquisition and higher order thinking skills acquisition). Baylor and Ritchie's (2002) primary research question was "which combination of factors best predicted the five desired outcomes?"

The Compters in Education (Comped) study (Plomp and Pelgrum, 1993) focused on how computers were being used, the effects on students, schools, and looked at factors influencing the use of computers in school (i.e. more specifically, the analysis of relationships among factors concerning the use and application of computers). The Comped study also examined the changes over time and the effects of school variables, teacher and teaching variables on student outcomes in the domain of computer usage within schools. For example one stream of this study presented principals, subject teachers, computer teachers and coordinators with a list of problems that might occur in the implementation of computer use and asked them to indicate and rank the most serious ones (Davis,1993). This list included problems related to:

- Hardware- insufficient number of computers available, difficulty in keeping computers in order, limitations of computers i.e. out-of-date, too slow, incompatible with software.
- Software- not enough instructional software available, software too difficult to use, software not adaptable for schools course, manuals and supporting materials poorly designed or inappropriate, lack of information about software and its quality.
- Instruction- difficult to integrate computers into classroom teaching practices, lack of teachers' knowledge and skills about using computers for instructional practices, inefficient guidelines for helping teachers use computers instructionally.
- Organisation- not enough space to locate computers appropriately, not enough technical assistance for operating and maintaining computers, problems in scheduling enough computer time for different classes, insufficient training opportunities for teachers, lack of administrative support or initiatives from a higher level of the school administration i.e. IT culture.
- Miscellaneous- not enough time to develop lessons in which computers are used.

Another stream of the Comped study looked at the relationship between teacher training and computer use (Reinen an Plomp, 1993). While another stream looked at whether more sophisticated hardware increased the integrated use of computers in the school curriculum (Pelgrum, 1993).

However there are issues for consideration and/or limitations associated with some of these studies, as gathered from the literature. In studies, where the sample has been narrowly defined, the outcomes are found to be limited in their applicability i.e. not applicable in the wider environment. For example one such limitation which has been realised is in regard to the choice of schools which have been included in a study research sample. Baylor and Ritchie (2002) acknowledged that the schools they selected for their study were highly technology-integrative, and therefore their results regarding factors such as teacher morale maybe limited to similar schools that are highly supportive of technology, in this regard they recommended a more diverse sample of schools in terms of technology support for future research.

Another limitation that has been realised is in regard to the range of the subjects participating within a study. For example Hu et al. (2003), in examining technology acceptance by teachers, focused on teachers specifically attending a training program as part of their technology competency certification. Hu et al. (2003) recognised this as a limitation in that their subjects who were late recipients of the training may have differed from their peers who had completed their training earlier on. Therefore this thesis, in having highlighted the limitations, with regards to the diversity of the research sample and range of the participants found in some studies, will address such issues in the selection of the research sample for this study in section 4.4.1.

The other main issue for consideration is that although the adoption of ICTs involve a number of key stakeholder groups, a number of studies in determining/establishing their findings about the context of ICT adoption in schools, focus on one particular stakeholder group. In some instances, such studies, in terms of eliciting information, disregard or do not take into account the opinions of some of the other main stakeholder groups. For example many studies in recognising the fundamental role teachers play in the adoption of ICTs (as will be discussed in section 2.5.2) have concentrated predominantly on studying, exploring factors which influence teachers in relation to computer use etc i.e. Cox, Preston and Cox (1999), Niederhauser and Stoddart (2001), Hadley and Sheingold's (1993), Hu et al. (2003) etc. Furthermore some studies in their determination/identification of factors or problems in the use and adoption of ICTs whether by teachers and/or students, or the effects these factors have on both teachers and students, have focused mainly on gathering the perceptions and opinions of teachers. For example Baylor and Ritchie's (2002) study, which explores the effects certain factors have on the integration of technology and affects both students and teachers, has focused on eliciting data only from teachers. While there are some other studies related to computer use, which have included, head teachers, ICT coordinators in addition to teachers in their research sample, but unfortunately have not included students i.e. Davis, (1993), Tuijnman and Brummelhuis, (1993). Hence there seems to be less emphasis on gathering the perceptions and opinions of students in a number of studies, although they are one of the key stakeholder groups of this adoption.

In this regard, section 1.5.2 has explicitly explained the stance taken by this study, in that it has highlighted the importance of the opinions of all key stakeholders in the domain of ICT adoption and identified students as one of the key stakeholder groups. Gibson and Nocente, (1999) contend that, ICTs can be used in a more positive and productive way in schools, by listening to the opinions of both teachers and pupils involved in the implementation of computer technology. Therefore studies, related to the adoption of technologies in schools, need to consider the opinions of key stakeholder groups such as students, in order to provide a fuller understanding of the context in which the adoption is taking place and provide appropriate measures and guides for the better use of ICTs.

Overall the above discussion has provided some examples of studies which have: focused on identifying factors which affect the adoption and use of computers or computer related applications and/or focused on examining the effects these factors have on the use of ICTs. The section has also highlighted limitations associated with a number of these studies. The next section presents and discusses findings i.e. the main factors and barriers in the adoption of ICTs, which have emerged from studies related to ICT adoption in schools.

2.5.1 Significant issues related to: Infrastructure, Hardware and Software

The literature indicates that there is a general consensus about the barriers which hinder the adoption and use of educational ICTs in schools and about the issues which are of particular significance and need to be addressed. Infrastructure is one such example; the lack of structural arrangements within schools has been considered a serious problem (Schofield, 1995). Ward (1999) argues that the main challenge for schools is to create an infrastructure from which an ICT learning environment can be launched and developed, once this is achieved only then can a great many benefits be enjoyed. Weikart and Marrapodi, (1999) state several critical elements are necessary to create and sustain an effective technology infrastructure. These include all the elements that support the integrated use of technology i.e. the computers themselves, the wires that connect them, the administrative rules and regulations that apply to the acquisition and use of computers, the fiscal resources, and the professional development that is needed to use computers. Organisational and financial constraints have been given as significant reasons by schools for not using computers (Pelgrum and Plomp, 1991; Davis, 1993).

Hardware, one of the critical factors listed by Weikart and Marrapodi (1999), is an area of concern which has featured frequently in many studies. Shortage of computers and technically outdated equipment, have been given as important reasons for the unsatisfactory use of computers in schools (Hadley and Sheingold's, 1993; Pelgrum, 1993; Davis, 1993; The Independent ICT in Schools Commission, 1997; McKinsey and Co., 1997; OFSTED, 1998 etc). The OFSTED (2004) report finds that where ICT hardware has been made available to teachers, this has been a catalyst for professional development. For example the 'Laptops for Teachers' initiative has had a very significant impact in this regard. Laptops allow teachers to use ICT at home, so providing for much more flexible use. But the availability of hardware is not enough on its own as many teachers indicated that until they have their own laptop with all the school software they do not start using ICT properly.

Software is the other area of concern that emerges in many studies. The lack of software available and shortage of high quality educational/instructional software has been considered a major barrier in the use of computers in schools (Hadley and Sheingold's, 1993; McKinsey & Co., 1997; Davis, 1993). Pelgrum (1993) argues that the availability of instructional tool software is a necessary condition for using computers in schools, and therefore a key issue to consider.

Harris and Preston (1993) found that software developers consider interface, hardware capabilities and projected cost, as most important factors when developing software. They argue that software developers need to address factors which are considered to be important for schools. For example teachers indicate that one of their main priorities when selecting software for the school is that the software meets National Curriculum requirements, teachers also emphasise the need for subject specific software. In addition cost, technical considerations i.e. compatibility with equipment, ease of use, user friendliness, frequency of use/relevance to a wide age range, quality of software in terms of open-endedness, flexibility and ability to show progression and cross curricular use, are some of the other factors considered by schools in their selection and purchase of software (Harris and Preston, 1993). Ease of use of software is not only one of the factors which influence software purchasing decisions, Halls and Rhodes (1986) identify ease of use of software as being a factor influencing the up-take of computers. Davis (1993) found that lack of software for instructional purposes was considered one of the serious problems in computer use by principals, IT co-ordinators and teachers. Other problems they indicated included: software too difficult to use, software not adaptable for the schools courses, lack of information about software and poor supporting manuals.

2.5.2 Teacher related issues: IT Training, Skills

Another aspect that emerges from the literature are the issues related specifically to teachers given their principal role in the adoption of ICTs in education. Gibson (2001) argues teachers have a central role and responsibility for the successful adoption of ICT in schools by helping in the restructuring of classroom practices and integrating technology into effective learning environments. Rogers and Newton (2001) contend that the teachers' role is vital in ensuring the benefits from the usage of educational ICTs. Unfortunately there has been a general failure to recognise the importance of what teachers believe and how they think, plan and respond to their classroom experiences (Leat and Higgins, 2002). Czerniak and Lumpe (1996) contend that until we understand how teachers' beliefs influence the implementation of an innovation such as technology, curriculum reform in technology or any other field, it is unlikely to be successful. Yeun, Law and Wong (2003) suggest that it is necessary to influence and empower teachers and support them in the ongoing engagement with students in their learning, in order for the successful implementation of ICT. Hence teachers play a fundamental role in the successful adoption of ICT in education (Scrimshaw, 1997; Kaye, 1995).

There are a number of issues which commonly arise in the literature associated with teachers such as: Teachers' resistance to change or to accept or use the technology. Baylor and Ritchie (2002) found that 'teacher openness to change' is a critical variable in influencing how well technology is adopted in classrooms. Schofield (1995) suggests that much of the teachers' trepidation about using computers in their classrooms appears to stem from concern about their relative lack of expertise and how this is likely to influence their position in the classroom and their ability to effectively teach pupils. The lack of teachers' knowledge and teachers' ICT skills have been given as important reasons for the lack of computer use in schools (Pelgrum and Plomp, 1991; Davis, 1993). Siemer (1998) contends teachers need to be confident with the technology in order for them to stand in front of individual pupils and the class. For this, teachers need to acquire the skills needed to handle the software and hardware. Siemer (1998) also states that many in-service teachers are known for their reluctance to make use of this new technology, not only because they feel unconfident but also because their lack of confidence is often revealed by their own pupils who are often more computer literate i.e. the IT skills disparity between teacher and students (Cuthell, 1999). Therefore appropriate and adequate training of teachers is the fundamental basis for ensuring that fears are alleviated and confidence in technology is cultivated (Schofield, 1995; Siemer, 1998). Fullan (1991) contends that training contributes to the successful implementation of an innovation within the educational practice. Therefore teachers' IT related training is an important factor in the adoption of ICTs in schools.

Cox, Preston and Cox's (1999) findings indicate that teachers, who are regular users of ICT have confidence in using it, perceive it useful for personal work and teaching, consider it for future use. Hu, Clark and Ma (2003) also identify teachers' perceived usefulness as a key user acceptance driver, in addition to subjective norm (i.e. where teachers align their initial acceptance decisions with colleagues' opinions) and the ability to use a computer. Perceived usefulness i.e. relevance of an innovation as perceived by educational practitioners is one of the fundamental criteria Fullan (1991) contends, influences the decision to initiate an innovation; the other main criteria include readiness (i.e. the school's capacity to initiate and develop the innovation) and resources (i.e. the availability of computer equipment, software etc). Cox, Preston and Cox's (1999) argue that teachers need to be shown the potential of using ICT in teaching, such that they do perceive it as being useful and relevant and suggest that the training of teachers needs to focus on pedagogical issues.

Teacher training, in acquiring ICT skills and using ICT pedagogically, is a very important factor in the adoption of use of ICTs and has been an issue which has arisen overwhelmingly in a number of studies (McKinsey, 1997; The Independent Schools Commission, 1997; OFSTED, 1998; OFSTED, 2001; OFSTED 2002 etc). For example Cox et al, (1988), Cox, (1994), Cox, Preston and Cox, (1999) argue that the majority of courses in the UK for teacher training in the use of ICT focus on technical aspects of IT with little training about the pedagogical practices required and how to incorporate ICT in the curriculum and the teaching process. The OFSTED, (2002) report claims that the overall effect of the NOF (the New Opportunities Fund made available in 1999 for teacher training in the use of ICT in teaching and learning) remained unsatisfactory and that the scheme so far failed to build on teachers' ICT skills or enabled them to tackle pedagogical issues adequately. Collins, Hammond and Wellington, (1997) contend that teachers are anxious to receive training and guidance about how to integrate ICT into the teaching process. The lack of appropriate training has been given as a vital reason for the limited use of educational technologies within the teaching practices (Davis, 1993). Reinen and Plomp, (1993) findings indicate that training in the pedagogical/instructional aspects of computer use can be considered as an indicator for the amount of computer use for instructional practices.

A study, by Niederhauser and Stoddart (2001), suggests that teachers select software to fit with their existing pedagogical perspectives and these perspectives have a strong influence on how computers get integrated into the teaching practice. Niederhauser and Stoddart (2001) therefore argue that these perspectives need to be addressed if computers are to reach their full educational potential. They add that the likelihood that computers will be used consistent with instructional reforms can be increased by coupling teachers' conceptions of the teaching and learning processes with the availability of appropriate software and the training in how to use it with their students.

2.5.3 Other significant issues: ICT Culture, Technical Support

ICT culture is another prominent issue which emerges from the literature in regard to the implementation, adoption and use of educational ICTs in schools: Latzer (1995) states that cultural variations in individualism and collectivism, norms of power distribution and short-term orientation can both affect and be affected by the implementation of educational ICT. For example the ambitious goals of recent education technology policies in countries such as Japan, Malaysia and Singapore can be traced to a strong cultural faith in technology. Mau's (1999) study recognised that a culture is required among learners and educators in order to promote IT as a tool for learning, and in which a principle plays a major role in developing such an IT culture. Baylor and Ritchie (2002) found 'technology leadership' i.e. in the way that the promotion of IT use by leaders gives credence to an IT culture, to be a highly predictive influential variable in how well technology is adopted in the classroom.

Technical support staff issues also feature in the literature. Technical support is a highly influential contributory factor in determining how well schools progress (OFTSTED, 2004). Unfortunately there is a lack of well trained technical support staff (OFSTED, 2002, 2004; Guest and Alimi, 2000). Where technical support is in place it improves the reliability of ICT resources. This in turn raises teachers' confidence to use ICT in lessons and that of head teachers to invest further in additional resources (OFSTED, 2004). The OFSTED (2004) report finds that the level of technical support for ICT varies widely between schools. Many schools still do not enjoy or cannot afford such support or have to make ad hoc arrangements as best they can in order to meet their needs.

Other issues such as: insufficient time to develop computer based lessons; problems in scheduling enough computer time for different teachers' classes; difficulty in integrating computers into classroom practices; the random implementation of ICT rather than its systematic integration into and across the revised curriculum and its accompanying schemes of work (Hadley and Sheingold, 1993; Davis, 1993; Leach and Moon, 2000; Leask and Younie,

2001) are just some of the other barriers identified in the adoption and use of ICTs in schools. They too are considered factors which need to be addressed for the successful up-take of educational ICTs.

These past sections have endeavoured to give an insight into the wide field of research that has taken place and continues to take place in relation to ICTs in school education. Section 2.5 in particular highlighted studies which were concerned with the identification of factors which affect and/or the examination of the effects these factors have on the adoption and use of computers or computer related applications. This section also presented a number of factors which have emerged in the literature, as significant ones in the adoption and use of ICTs. These factors will be drawn upon later in the thesis. Given that this study is ultimately concerned with modelling factors in the use of educational software by teachers and students, the next section looks at two studies which have developed models related to computer use and discusses the approaches used.

2.6 Selected models related to ICT adoption

This section provides examples of models developed by two other studies. The two particular examples have been chosen because the models developed within these studies are: related to computer use in the educational field; concerned with identifying factors and causal relationships and importantly have used statistical modelling techniques and approaches which are typically used in social and behavioural sciences. Therefore by discussing these two particular examples it is possible to highlight some of the areas of concern in using such typical modelling methods. The section firstly presents the approaches and methods used in developing these models. It then draws on these particular studies and from the literature to discuss the common traits and areas of concern in regard to the modelling approaches used.

The technology acceptance model developed by Hu, Clark and Ma (2003) is presented as the first example. Hu, Clark and Ma (2003) conducted a longitudinal study examining technology acceptance decisions by public school teachers, before and after an intensive training program. Their research model for explaining teacher's technology acceptance decision-making took into account relevant previous research and characteristics of the relevant education context and was based on the Technology Acceptance Model (Davis et al, 1989). The model was tested over a 4-week period using a questionnaire survey methodology conducted with more than 130 teachers. The model was analysed using LISREL 8, and its overall fit with the data was evaluated using common model goodness-of-fit measures. The model exhibited a reasonable fit with the longitudinal responses collected. The causal paths in the model were also examined, each causal path was evaluated in terms of statistical significance and strength using standardized path coefficient ranging between -1 and 1. The strength of each causal path was determined by examining its direct and total effect (Bollen, 1989).

The second example is the structural models developed as part of the 'Comped' study, to predict computer use in six educational systems (Tuijnman and Brummelhuis, 1993). A theoretical model, hypothesising relationships between several implementation indicators based on literature, was first established. The model displayed the sequential order of the implementation indicators, based on four frame factors: exogenous and endogenous preconditions; implementation conditions and implementation outcomes (seen in Figure 2).

The fourth frame factor i.e. implementation outcomes, focused on one particular outcome for the study i.e. the use of computers for educational purposes in central school subjects by grade 8 students. The sample for the study included more that 200 schools (a number considered an absolute minimum for the multivariate data analysis). Head teachers, different groups of teachers and IT coordinators, from the schools responded to questionnaires. Rigorous statistical testing and analysis of the empirical data led to the development of correlation matrices, which then led to the development of linear structural equation models for the six educational systems in France, Germany, Japan, Netherlands, Switzerland and USA.

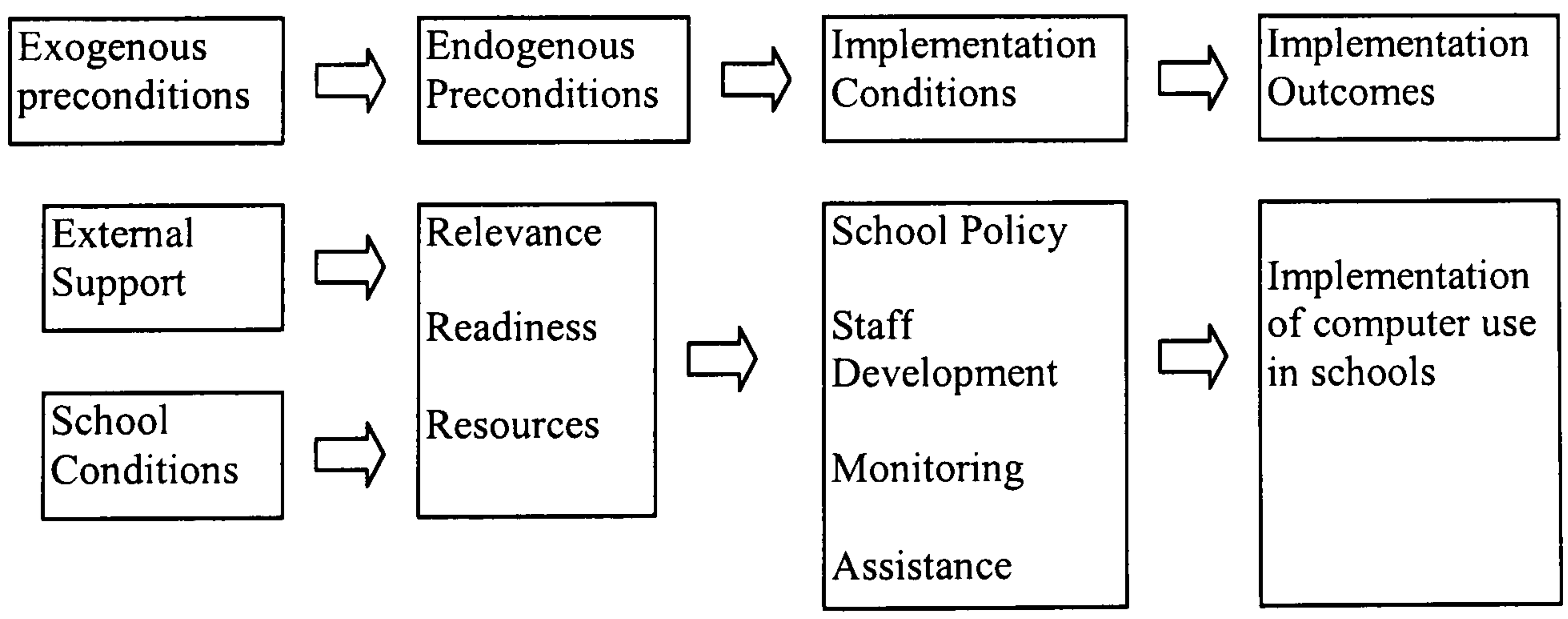


Figure 2 Indicators influencing the implementation of computer use in schools (source: Tuijnman and Brummelhuis, 1993, p. 191)

It is common within the literature, and as seen from the examples above, that a statistical approach is taken in identifying factors, determining causal/influential relationships between constructs and in developing models, related to computer use (Baylor and Ritchie, 2002; Hadley and Sheingold's, 1993; Niederhauser and Stoddart, 2001). In both of the examples, the samples participating in the studies have been large, as dictated by statistical methods. Within such studies, causal paths/ relationships in the model are evaluated in terms of statistical significance and are removed if statistically not significant (Tuijnman and Brummelhuis, 1993; Hu, Clark and Ma, 2003). The other interesting point to note is the difficulty of establishing causal links in relation to computer use, which has been evident within the literature. Although some of the studies mentioned above have identified factors related to computer use in terms of predictors and indicators, it has been made clear that the predictions do not establish cause and effect relationships (Tuijnman and Brummelhuis, 1993; Baylor and Ritchie, 2002).

With regards to establishing a measure for the strength of causal paths, Hu et al. (2003) determined the strength of each causal path by examining its direct and total effect. Whereas in the Tuijnman and Brummelhuis (1993) study, the strength of the relationship, in the sense, to what extent one factor causes a change in another, was not measured, instead it was the extent of the interrelatedness between factors/indicators in their model which was considered. LISREL was used to estimate the true correlations among the indicators and the models presented showed the significant effect relationships between the interrelated indicators/factors. The relationships were denoted by unidirectional arrows, assigned with two values: a standardized regression coefficient and a standard error value.

Furthermore Tuijnman and Brummelhuis, (1993) indicate that computer use, which varied across the six systems could not be systematically and consistently predicted by the indicators/factors in the path model i.e. school size, external financial support, external training support, previous innovation experience, availability and resource needs, perceived innovation relevance, school policy for computer use, internal staff development and internal innovation assistance. Another point worth noting within Tuijnman and Brummelhuis' (1993) study is that because the models were subjected to rigorous empirical testing, it was impractical to hypothesize relationships involving those indicators/factors that couldn't be made operational because the data needed for their measurement was unavailable. This is an example of the limitations posed by statistical modelling techniques (Craiger and Coovert, 1994), and will be further discussed in section 3.3.2. Hence Tuijnman and Brummelhuis' (1993) contend the effects of such additional indicators/factors would pose challenges for future research.

This section provided some insight into the methods adopted by studies which have identified factors, examined their effects and/or modelled such factors and their interrelationships. The section highlighted areas of concern, when statistical modelling methods have been used. The section has drawn attention to ways in which strengths of relationships between factors have been determined by such studies. The next section, (in considering the main aim and objectives of this study which includes the modelling of chains of causal relationships, where the strength of relationships can be determined and where stakeholder perceptions can be incorporated) discusses the emergence and use of fuzzy logic within educational research and its relevance to this thesis.

2.7 Fuzzy logic in educational research

The aim of this research is to facilitate better management of resources by schools, in order that they can achieve greater utilisation of educational software within their environment. It aims to provide the means by which it is possible to determine where resources, should be directed, so as to enable areas/factors, which either alone or in combination with other factors, will have an impact on the up-take of educational software by teachers and students schools. In this regard the objectives of this study include the modelling of causal relationships between factors in the up-take of educational software by teachers and students. Synonymous to this research is a study by Twining (2002a), which is also concerned, with the ways of enhancing the impact of future investments in ICT in education. Twining's (2002a) research initially focused on developing causal models underpinning the level of computer use in schools. However the study moved away from developing causal models, instead to examining ways of describing computer use in education. A conceptual Computer Practice Framework (CPF) was developed to describe computer use, based on three case studies and fieldwork in schools and higher education. It was proposed that the framework could be used as a tool to enhance the planning process prior to investing in ICT use and be used to explore the impact of ICT investment on computer practice (Twining, 2002a, 2002b). Hence the framework ultimately focused on 'classroom practice' and not on the factors that impact on this practice and causal relationships, as is intended within this study.

However the interesting point that is noted from Twining's (2002a) study is that, one of the most useful indicators given for the quantity of 'computer use' was in the form of verbal reports by teachers. Fuzzy terms such as 'not much' was used instead of exact terminology. Twining (1997) claims that fuzzy terms such as 'some' 'little' 'substantial' have been used in various studies in relation to computer use, by the DfES/DfEE (Department of Education and Skills/Department of Education and Employment). He therefore argues for the use of fuzzy descriptors in identifying changes in computer use in schools. However Twining (2002a) contends, because fuzzy terms are not well defined and are relative, they are therefore open to different interpretations and this posed a weakness with regard to the CPF. However at the same time he acknowledges that this characteristic would be considered strength by advocates of fuzzy logic. This is because it allows for the representation of the ambiguous nature of the real world (Kosko, 1994; McNeil and Thro, 1994).

Bassey (2001) also discusses the use of fuzzy logic in educational research. He argues that the use of fuzzy logic is appropriate in educational research and claims that there has been limited use of 'fuzzy generalisations' in research findings. He contends that it is possible to formulate outcomes of empirical research as fuzzy generalisations, which can be useful to educational practitioners and policy makers. Furthermore in the absence of empirical evidence the likelihood of an outcome occurring can be indicated by a best-estimate-of trustworthiness, which is based on the researchers' professional judgement stemming from both literature and experience. The fuzzy prediction would need to be supported by a research account which clarifies the context of the statement and the evidence justifying it (Bassey, 2001). Hammersley (2001) concurs adding that fuzzy generalisations are of considerable value and that it is useful in providing the theoretical knowledge of causal relationships prior to the development of precise and fully formulated scientific laws, especially when such precision and completeness are unachievable. It is therefore evident that the use of fuzzy logic can be relevant within the educational context of ICT adoption (Bassey, 2001; Twining 1997 and 2002).

Ultimately this thesis is concerned with modelling, the factors which influence the uptake of educational software by teachers and students and the extent of such influences, as perceived by relevant stakeholders. Although the review of literature within this chapter has shed light on: The factors which have been so far identified by studies to be important in the adoption of ICTs/educational software in schools; existing models modelling such factors in the adoption and utilisation of educational technologies; the methods adopted by such studies in order to identify, determine and model these factors and their interrelationships, there are issues which still need to be addressed and explored further, given the main goal of this thesis. There is importantly the need for an appropriate modelling approach which can model factors, their inter-relationships and exhibit the strength of these relationships, based on the perceptions/knowledge of relevant stakeholders groups. The methods which have been used to model and examine factors and their effects, discussed in section 2.6 have been shown to have limitations such as the inability to hypothesize relationships involving those indicators/factors that cannot be made operational because the data needed for their measurement is unavailable. Furthermore the measures which have been used to determine the strengths of causal relationships are also not adequate for the purpose of this study, which is concerned with the extent of the influence one factor has on another. In this regard and given the evidence and relevance of using fuzzy logic in the educational context, the next chapter discusses fuzzy cognitive maps, a branch of fuzzy logic. Chapter 3 examines a body of research, which has considered and used fuzzy cognitive maps (FCMs) and examines the potential of FCMs as a modelling approach within the context of this study.

2.8 Summary

This chapter has endeavoured to give an insight into the diverse field of research that has taken place and continues to take place in relation to ICTs in school education. It has provided an overview of research that has taken place with respect to ICTs in schools; provided examples of studies which have drawn upon theories from organisational IT/IS implementation research; looked at studies concerned with the implementation/integration of ICT in schools. Given that this thesis is interested in the effects of factors influencing the up-take of educational software, this chapter in particular has highlighted studies concerned with the identification of factors which affect and/or the examination of the effects these factors have on, the adoption and use of computers or computer related applications. The chapter also provided an overview of the significant factors and issues which have arisen from such studies and the literature in general and which will be drawn upon later in chapter 4. Furthermore given that this study is ultimately concerned with modelling factors in the use of educational software by teachers and students this chapter looked at two studies which have developed models. It discussed the methods used by these studies; highlighted potential areas of concern and drew attention to ways in which the strengths of relationships between factors had been determined in these studies. The chapter then discussed the use of fuzzy logic within educational research. It finally discussed and concluded that statistical modelling techniques commonly used would be unsuitable to address the aims and objectives of this study, furthermore given evidence of the use of fuzzy logic in education the study considers exploring Fuzzy Cognitive Maps as a potential modelling approach next, in chapter 3.

Chapter 3: Fuzzy Cognitive Maps: Review of the literature

3.1 Introduction

The previous chapter reviewed literature, concerned with the adoption and use of educational technologies within school education. It presented a number of factors which have emerged from various studies in the literature as significant in the use of educational ICTs. Furthermore it showed how statistical modelling techniques are generally used by such studies to determine and model the factors related to computer use. Chapter 2 concluded that there are limitations associated with such techniques, which will be further discussed in this chapter. In addition this study, is interested in the extent of the influence that one factor has on another factor i.e. strength of the relationship between factors. The techniques, discussed in chapter 2, used to ascertain strengths of relationships do not address the needs of this study. A suitable approach is required which will help to achieve the main goal of this thesis which is to model the factors and the extent of their influence in the up-take of educational software in schools, based on the perceptions of a number of stakeholders. This chapter considers the potential of Fuzzy Cognitive Maps (FCMs), as a modelling approach for understanding and providing insight into the adoption of educational software within the school environment.

This chapter examines a body of research which has considered a modelling approach based on the theory of fuzzy cognitive maps (FCMs). FCMs (Kosko, 1986; Caudill, 1990; Brubaker, 1996a; Brubaker 1996b) are extensions of cognitive maps (Axelrod, 1976; Tolman, 1948; Eden, 1988, 1989; 1990; Marchant, 1999) used for modelling complex chains of casual relationships (Kosko, 1992, 1994, 1997). In recent years FCMs have been used as a tool for modelling, analysing and simulating complex systems of interacting concepts or system variables which evolve with time (Lee, Kim, Sakawa, 1996; Lee, Lee, Han, Yu, 1998; Taber, 1991) and have been successfully used in decision making (Khan, Quaddus, and Intrapairot, 2001).

In order to provide a basic understanding of FCMs, the next section describes a fuzzy cognitive map, explains the mathematical representation of an FCM and the processes involved which enable the FCM to be used as a dynamic model. The following section presents an overview of the diverse use of FCMs within many different fields of study. The chapter draws on some of these studies and sheds light on the reasons why the FCM modelling approach had been adopted in these studies as well as the advantages and/or disadvantages realised from its use. The chapter concludes by providing justification for the use of FCM as an appropriate modelling approach within the context of this study.

3.2 Fuzzy Cognitive Maps

A fuzzy cognitive map is described to be a collection of nodes linked by edges. The nodes represent concepts (or variables) relevant to a given domain and the edges represent relationships i.e. causal links between the nodes. The edges are directed to show the direction of the causal relationships. In addition assigned to each edge is either a positive or negative value which represents the nature and strength of the relationship. This feature marks one of the primary differences between a fuzzy cognitive map and a cognitive map.

In comparison to the traditional cognitive maps, fuzzy cognitive maps display two distinct characteristics (Kosko, 1986; Khan, Quaddus, and Intrapairot, 2001): Firstly the causal relationships between nodes are fuzzified. Therefore, instead of only using signs to indicate positive or negative causality, a number is assigned to the causal link to express the degree of relationship between two concepts. The directed edge e_{ij} from the causal concept A_i to concept A_j measures how much A_i causes A_j. The edges e_{ij} take values from the fuzzy causal interval [-1, 1], where $e_{ij} = 0$ indicates no causality; $e_{ij} > 0$ indicates a causal increase (i.e. A_j increases as A_i increases, and A_j decreases as A_i decreases); $e_{ij} < 0$ indicates causal decrease or negative causality (i.e. A_j decreases as A_i increases, and A_j increases as A_i decreases). Simple FCMs have edge values in {-1, 0, 1}, so if causality occurs, it occurs to either a maximal positive or negative degree. Alternatively, Kosko (1994) contends that instead of weighting these rules or edges with any number between 0 and 1 (or between –1 and 1) one can use word weights like 'a little' or 'somewhat' or 'more or less'. Secondly, an FCM is able to model a dynamic system i.e. it can evolve with time. In addition it allows for feedback, where the effect of change in a node, may affect other concept nodes, which subsequently in turn can affect the node which was originally changed/initiated. Kosko (1994) contends that experts are able to draw causal pictures of their problems more easily, due to FCM feedback.

In addition, to the characteristics mentioned, nodes or concepts are also considered to be fuzzy i.e. each node is a fuzzy set, where nodes can have an activity level to some degree from 0% to 100%. Fractions or fit values measure the degree nodes are on. In the simplest case the nodes are on or off. For example assuming {0, 1} as the range of the activation/activity level for an FCM: a node showing a value of 0 would mean that the node (concept) is inactive in terms of concept activation, while a node showing a value of 1 would mean that the node (concept) is active in terms of concept activation. In general, fuzzy cognitive maps (FCMs) are fuzzy signed directed graphs which allow feedback. They model the world as a collection of classes (i.e. group of people or things sharing a common characteristic) and the causal relations, which exist between the classes (Kosko, 1992; 1994).

Another aspect of FCMs that needs to be considered as a prequel to understanding its dynamic ability is that in addition to being presented as a map modelling concepts and relationships, an FCM can be represented in the mathematical form of a matrix.

3.2.1 FCM mathematical representation and dynamic process

An FCM can be described by a connection matrix; for example F, whose elements e_{ij}, are the connection strengths (i.e. weighting values) associated with each causal relationship. Therefore the element in the *ith* row and *jth* column of matrix F would represent the strength (weighting) of the link directed out of node A_i and into A_j. The matrix is augmented, so if there are a total of n nodes i.e. concepts considered, the FCM matrix is written as a square matrix consisting of (n × n) numbers/values. Furthermore if there is a node which has feedback i.e. where there is a link directed out of node A_1 and back into A_1 then the weight e_{ij} referred to as e_{ii} exists where $i = j$ and $j = 1, 2....$ n. In the case where there are no feedbacks then it is assumed that $i \neq j$ where $j = 1, 2....i -1, i +1,$ n (Kosko, 1992; 1994).

The values i.e. activation levels of nodes, A_1, A_2 ....A_n (where n is the number of concepts in the problem domain) together represent the state vector A. An FCM state vector A gives a snapshot of events (or concepts), in the scenario being modelled, at any point in time (t). For example the binary vector (0 1 1 0 1) means that of the five nodes which form the FCM, the 2nd, 3rd and 5th nodes are fully activated, while the 1st and 4th nodes are inactive at that particular time.

It is possible to compute an FCM state vector A at time step (t+1) by multiplying the state vector A(t) (i.e. the state vector A at time step t) by connection matrix F, and then by applying a threshold function to normalise the state value, as is seen next:

$\mathbf{A}(t+1) = \mathbf{S}\ [\mathbf{A}(t).\ F]$ **Equation 1**

Where $A(t)$ = the state vector $(1 \times n)$ of concepts at some time step t

F= the FCM connection matrix $(n \times n)$.

S= the threshold or non-linear transformation function

3.2.1.1 Threshold functions

Mohr (1997b) states that the threshold function serves to reduce unbounded inputs to a strict range. In a way this maintains the stability of the qualitative model, and although diminishes the opportunity of obtaining quantitative results, it does provide a basis for comparing nodes i.e. on or off, active or inactive. Although there are many threshold functions available for this normalisation (Mohr, 1997a, b), the following are considered to be significant ones:

1. The bivalent threshold function is the simplest and most commonly used threshold function in FCM models, seen below as S_i where x_i is the summation of the inputs prior to normalisation i.e. x_i=[A(k). F] :

$S_i\,(x_i) = 0, \quad x_i \leq 0$ **Equation 2**

$S_i\,(x_i) = 1, \quad x_i > 0$ **Equation 3**

Equations 2 and 3 are represented in Figure 3.

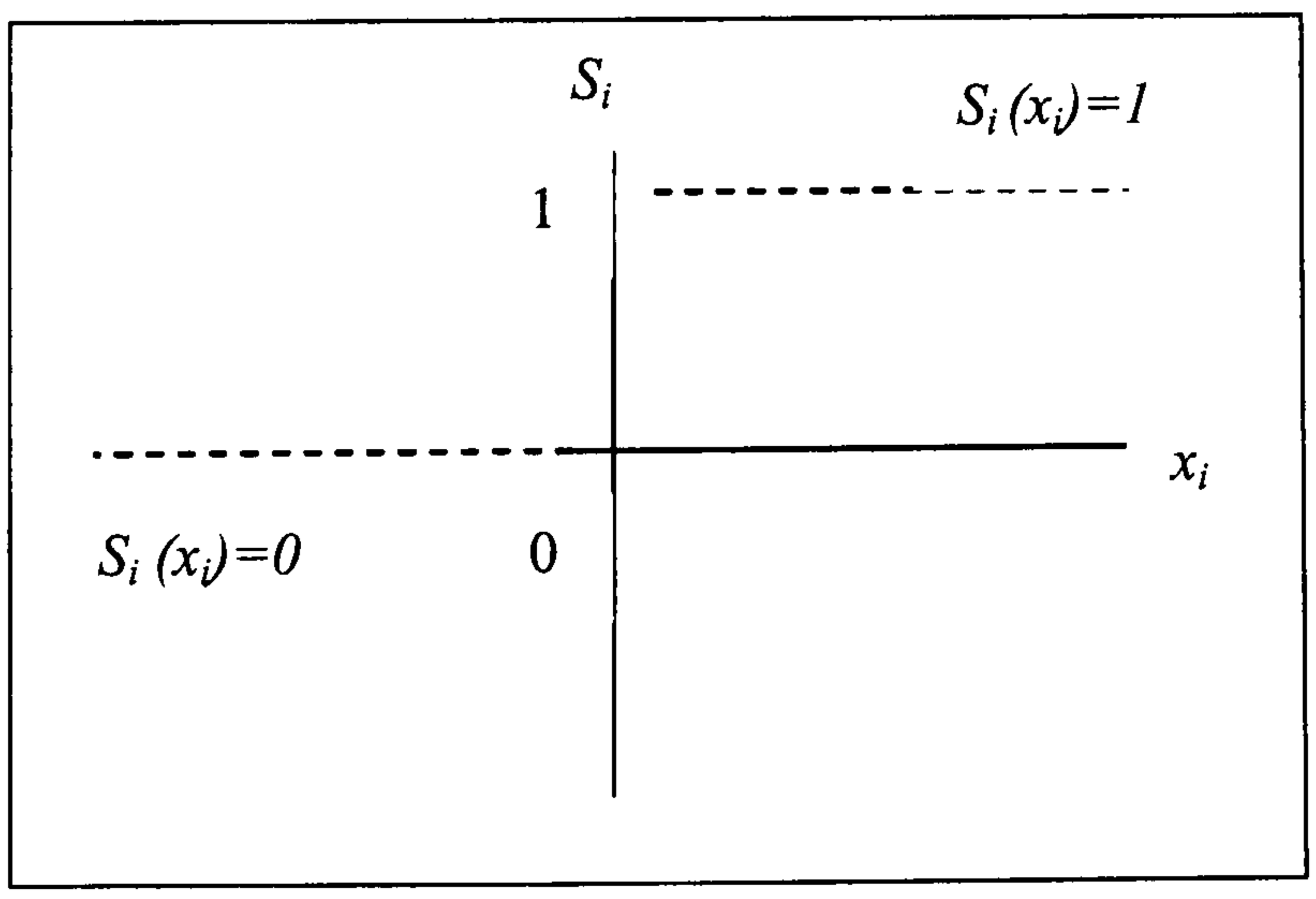


Figure 3 Bivalent Threshold Function Graph

2. The trivalent threshold function extends the range of concept state values to include negative activation, seen below as S_i where x_i is the summation of the inputs prior to normalisation i.e. x_i = [A(*k*). F]:

$S_i(x_i) = -1,$	$x_i \leq -0.5$	**Equation 4**
$S_i(x_i) = 0,$	$-0.5 < x_i < 0.5$	**Equation 5**
$S_i(x_i) = 1,$	$x_i \geq 0.5$	**Equation 6**

Equations 4, 5 and 6 are represented in Figure 4.

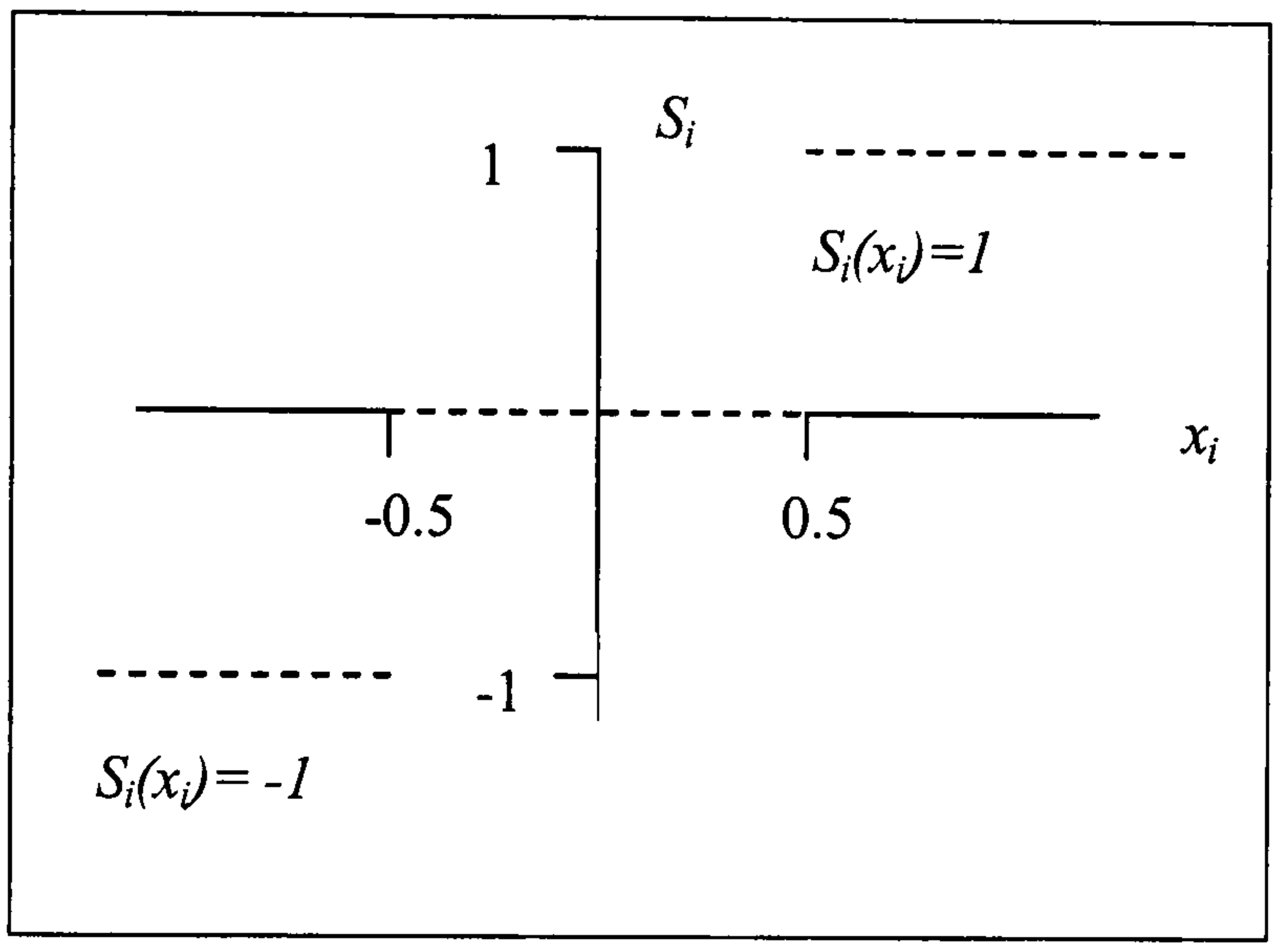


Figure 4 Trivalent Threshold Function Graph

3. The logistic signal function is a continuous function which provides true fuzzy conceptual node states, seen below as S_i ,where x_i is the summation of the inputs prior to normalisation i.e. x_i = [A (*k*). *F*]:

$$S_i(x_i) = \frac{1}{1+e^{-cxi}} \qquad \textbf{Equation 7}$$

Where c is the constant critical in determining the degree of fuzzification of the function (see Mohr, 1997a).[1]

This overall mathematical process, which includes the simple multiplication of the FCM state vector by its connection matrix, followed by the application of a threshold function, as described above, is fundamental to the operation of the dynamic FCM model.

[1] Plots of this threshold function for various values of the constant c are shown in fig.2, pg. 2. Mohr (1997). It was found that at large values of c, the logistic signal function approached discrete threshold functions.

3.2.2 The Dynamic FCM model

An FCM can be allowed to evolve, making it into a dynamic system, when the process, of passing the state vector through the FCM connection matrix i.e. the multiplication of the state vector with the FCM matrix and normalisation, is continuously repeated. Hence A (t +1) = S [A (t). F] is calculated for t = 0, 1, 2, and so on until the FCM reaches either one of the following states:

1. The FCM stabilises. It settles down by producing a fixed pattern of node values called the hidden pattern or fixed-point attractor. This is when equilibrium is reached. This state can be detected during FCM simulation by comparing two successive state vectors. If the two successive state vectors are identical then the FCM is considered to have reached equilibrium (Mohr, 1997a).
2. The FCM produces state vector values and it keeps cycling between a number of these fixed states. This is known as the 'limit cycle'. Kosko (1994) gives an example of an FCM limit cycle in terms of blinking light bulbs where one light snapshot might blink N, the next E, the next T and then go back to blink N and repeat the process. Therefore in the limit cycle which spells NETNETNETNETNETNETNETNETN.... the hidden pattern is NET.
3. A third possibility exists when a continuous transformation function is used. The FCM does not stabilise, instead it continues to produce different state vector values for each cycle. This is known as 'chaos' and can occur in complex cases (Kosko, 1994; Khan, Quaddus, and Intrapairot, 2001).

Given that an FCM can be subjected to an initial stimulus in the form of a state vector A(t) representing the states of the system's variables, FCMs can be viewed as a variant of recurrent neural networks (Khan, Quaddus, and Intrapairot, 2001). Once an FCM has been subjected to an initial stimulus, it is possible to gain insight into a system's behaviour by studying the resulting stable state or cycle of states.

This section has briefly described the features of a fuzzy cognitive map and the mathematical processes which are important to the dynamic aspect of the FCM model. The FCM methodology, which Taber (1991) contends consists of five stages (source selection, map acquisition, conversion to matrix form, inference and global knowledge base construction) will be reflected upon and discussed in section 3.3.4.2. The next section examines a body of research which has adopted the theory of FCMs; it looks at the purpose of these studies and the reasons why the FCM approach was undertaken.

3.3 Examples of FCM adoption

The theory of fuzzy cognitive maps has been adopted within a number of different fields, for diverse reasons. For example Dickerson and Kosko (1997) used FCMs to structure virtual worlds that change with time. Banini and Bearman (1998) developed a simple FCM to study the factors affecting rheological behaviour of suspension slurries in the mineral industry. Lee and Kim (1997) applied a bi-directional inference mechanism based on FCM, to a stock investment analysis problem. In the field of engineering, Pelaez and Bowles (1996) considered the FCM application, for the prediction of failure and the effects of the failure, in complex systems. Stylios and Groumpos, (1999a and 1999b) employed FCMs in the modelling of intelligent supervisory control systems (i.e. systems which perform the human operators' tasks in the supervision of systems). In the medical field, McCauley-Bell and Crumpton (2000) developed a fuzzy linguistic model, to predict the risk of Carpal Tunnel Syndrome (CTS) in an occupational setting. FCMs have also been used for planning and making decisions in political and social fields: Mohr (1997b) illustrated the use of FCMs in relation to political problems and analysis, and developed a FCM model of virtual soldiers in combat. Tsadiras, Kouskouvelis and Margaritis (2001) used FCM to develop a dynamic model of the Former Yugoslavian Republic of Macedonia (FYROM) Crisis, the model was considered to be able to support decision makers and political analysts with regard to their political decisions about the crisis.

Within Information Systems research fuzzy cognitive maps are considered a relatively new modelling approach. FCMs have been used to serve different purposes within a variety of organisational settings/domains. Khan, Quaddus, and Intrapairot, (2001) used an FCM for analysing the diffusion process of the data warehouse (i.e. the central repository of data) in a large banking establishment. Kardaras and Karakostas, (1999a) proposed the Fuzzy Information Systems Evaluation Model (FISEM), based on the Balanced Scorecard technique and FCM theory, to support the evaluation of information systems. It provided a measure base which could be customised to reflect the organisation's priorities. Sharif and Irani (1999) used FCM, as a approach to identify complex functional interrelationships associated with the justification of IT projects. Irani et al. (2002) used fuzzy cognitive mapping, as a technique to model IT/IS evaluation factors and show the interdependencies between the contributory justification factors. Kardaras and Karakostas (1999b) suggested the use of FCMs as an alterative approach to existing Strategic Planning of Information Systems (SISP) models. Stach and Kurgan (2004) used FCMs to describe and analyse the factors which affect progress in software projects. Lee and Han, (2000) used FCM to develop the EDIFCM, i.e. the Electronic Data Interchange-Control Design, in order to help in the recommendation of EDI controls that ensured high EDI performance, for those organisations implementing EDI. Lee, Kim, Chung and Kwon (2002) proposed the FCM approach in the field of web-mining. They used the inference logic of FCMs to propose WEMIA, a new web-mining inference amplification mechanism.

3.3.1 Main purposes of FCM related studies

From the examination of literature concerned with FCM applications, it appears that the primary goal of many of these studies has been to identify, consider and/or understand, the factors/variables and their relationships, pertaining to a particular problem area. The studies have subsequently used this knowledge to maximise benefits and/or predict risks and/or direct resources and/or formulate policies, in the respective domains/problem areas (Sharif and Irani, 1999; Kardaras and Karakostas, 1999a and 1999b; Irani et al., 2002; Khan et al. 2001; McCauley-Bell and Crumpton, 2000; Lee and Han, 2000; Tsadiras, et al. 2001, Banini and Bearman, 1998; Stach and Kurgan, 2004, etc). The line of questioning related to factors and variables and/or the desire to explore alternative situations or scenarios seen within some studies, are synonymous with the goals and questions proposed by this thesis, such as:

- Which factors are important? Is there any inter-dependence of the factors? And what is the extent of this dependence? (Banini and Bearman, 1998).
- What are the alternative ways to achieve a certain objective? What will be the effect on the organisation of the change i.e. increase or decrease of certain variables? What will be the consequences of changing the sign of a given variable? (Kardaras and Karakostas, 1999b).

This study is also concerned with factors in a domain and their interrelationships, i.e. the factors which influence the uptake of educational software within the school environment. The objectives of this thesis (presented in chapter 1) are concerned with the various combinations of factors and the extent to which each factor influences the adoption of educational software by students and teachers. In addition, the objectives also include the exploration of alternative scenarios is in terms of the resulting effects given an initial change in policy or investment related to the up-take of educational software in the school domain.

Given the aims of this study (see section 1.5.1) interesting parallels can be drawn to the aims of two other studies which have considered FCMs as a modelling approach. For example Khan, Quaddus, and Intrapairot, (2001), reported that despite substantial investment by organisations in data warehousing technology the current potential benefits were considered low, intangible and late to materialise. They contended that simulation of the data warehouse diffusion process by building a dynamic model would help to identify crucial variables in the system, so that resources could be directed accordingly in order to achieve maximum benefits of the data warehouse. Khan et al. (2001) used the FCM approach to build their dynamic model. Similarly Lee and Han, (2000) reported that despite the benefits claimed for EDI (Electronic Data Interchange), there was indication of mixed success for EDI adopters. In implementing EDI, an organisation achieves its goals, through a process known as EDI controls (classified into formal, informal and automated types). Lee and Han, (2000) contended that appropriate levels of these various controls should be determined according to their interdependency and impact on performance, otherwise it is inefficient for EDI managers to implement full controls which require significant resources. The purpose of their FCM was to help in the recommendation of EDI controls that ensured high EDI performance and such that resources could be directed accordingly.

Although the problem and domain area of this thesis is different to the ones discussed in the studies above, given that this thesis is concerned with the up-take of educational software in schools, the underlying purpose/ problem posed and the outcome sought in this thesis is similar. This thesis is concerned with providing the means by which resources and efforts can be directed to achieve a greater result, and in order to do so, it too is concerned with the relevant factors in the domain and their interrelationships. Given the context of this thesis, the FCM approach is a valid approach in addressing the particular nature of the aims and goals of this study. This study is concerned with identifying multiple factors, relationships and the extent of their influences, in modelling a problem domain which is complex and dynamic. It has been evident that a number of other studies with similar goals have drawn upon the theory of FCMs as an appropriate modelling method. Therefore there is a strong case to consider FCMs as a modelling approach for this study. The next section looks at why some of these studies adopted the FCM approach instead of traditional approaches and modelling techniques.

3.3.2 FCM over other traditional methods

The FCM theory has been adopted by some studies, in light of findings that traditional approaches or traditional modelling techniques have limitations and therefore are inappropriate for addressing the goals of these particular studies. For example Kardaras and Karakostas, (1999a and 1999b) report that traditional evaluation methods are based on strict financial measures, whereas an IS evaluation process needs to establish both quantitative and qualitative measures of worth to the organisation, and involve many stakeholder groups. While many current and past models have been presented to analyse IT from a strategic perspective and suggest new IT projects, these models fail to consider both IT and business perspectives; fail to deal with unexpected changes in the organisation and environment and with the complexity of the domain or process. Kardaras and Karakostas, (1999a and 1999b) therefore suggest the use of

FCMs as an alterative to existing approaches in their study. Irani et al. (2002), too report and argue that traditional appraisal techniques, for IT/IS investment justification process, are limited and they therefore also propose the use of fuzzy cognitive mapping, as an alternative modelling technique. Additional advantages which have been realised in these studies, with regard to considering FCMs instead of statistical approaches include: quantitative methods involve laborious accounting of each factor whereas it is easier to add further factors to an initial incomplete or incorrect FCM, and the effects of these factors can be seen quickly (Irani et al., 2002). The use of linguistic terms instead of quantitative terms, is considered to be easier for planners when they need to express their beliefs (Kosko, 1986; Kardaras and Karakostas, 1999b) and is easily accommodated by the FCM approach.

Structural equation modelling, one of the most commonly used statistical techniques in social and behavioural sciences, allows statistical models, represented as networks of relationships between sets of latent (hypothetical) variables, to be defined and tested. Craiger and Coovert (1994), report that there are limitations and problems associated with such classical statistical methods. These include, non-convergence of solutions and impossible parameter estimates, which occur often due to problems with model identification i.e. as to whether a unique set of parameter estimates can be determined from the model and data constraints: empirical under identification arising because the data is such that a unique set of parameters is unobtainable; theoretical under identification arising because the model specified does not allow for the determination of a unique set of parameter estimates. For example Tuijnman and Brummelhuis' (1993) study used the structural equation modelling technique (see section 2.6). Tuijnman and Brummelhuis' (1993) considered that it was impractical to hypothesize relationships involving those indicators/factors that couldn't be made operational because the data needed for their measurement was unavailable; they therefore contended the effects of such additional indicators/factors would pose challenges for future research. Craiger and Coovert (1994) argue that FCMs are a desirable alternative for the modelling of social and psychological processes, which can be complex and dynamic and in particular when traditional modelling techniques are impractical.

Furthermore it was seen in Tuijnman and Brummelhuis' (1993) study that any path in the model which was not statistically significant was removed. This as a course of action (as discussed before in chapter 2) is not agreeable to this thesis on the grounds that this study is concerned with modelling the factors and any influential relationship in the uptake of educational software in schools, as perceived by the relevant stakeholders, where the views and opinions of relevant stakeholders are considered to be important and consequential (as discussed in chapter 1). Therefore any factor and relationship considered by the stakeholder to be influential in the uptake of educational software, needs to be incorporated within any model that is to be developed as a result of this research, and therefore needs to be adequately elicited and addressed by the modelling approach which is to be adopted for this study.

3.3.3 FCM as a dynamic model

Another reason which makes the adoption of FCMs attractive, in addition to its ability to encapsulate both quantitative and qualitative aspects of a complex domain or process and overcome limitations of traditional approaches, is its ability to evolve as a model (see sections 3.2.1 and 3.2.2). FCM knowledge representation and inferencing structure reduces to simple vector-matrix operations, and allows extension to neural, statistical, or dynamical systems techniques (Kosko, 1992). Khan, Quaddus, and Intrapairot, (2001) suggest FCMs as an alternative modelling tool, because, not only can it represent relationships between variables but also captures the dynamic aspect of system behaviour. Kardaras and Karakostas, (1999b) report that FCM simulations can be used to examine the effects of specific alternatives. The dynamic ability of a FCM model, which can allow for the exploration of different alternatives and 'what-if' scenarios, is considered and has proved to be an important and useful characteristic within many studies. For example Stach and Kurgan (2004) conducted simulations of their FCM models to determine and analyse which factors affected the progress of a software development project. Banini and Bearman (1998) were able to classify critical factors in the study of slurry rheology, by running simulations of their model based on 'what-if' questions and alternative scenarios. Tsadiras, Kouskouvelis and Margaritis's (2001) simulated their model based on alternative political scenarios, resulting in respective predictions: the model was hence considered to be able to support decision makers and political analysts. Khan, Quaddus, and Intrapairot (2001) contended that simulation of their model, modelling the data warehouse diffusion process would help to identify crucial variables in the system, so that resources could be directed accordingly in order to achieve maximum benefits of the data warehouse. In addition help in the formulation of requisite policies for effective data warehouse diffusion in large organisations.

This thesis similarly, intends to devise a model which can allow for the exploration of alternative scenarios, whereby it is possible to see the impact on the up-take of educational software when certain factors within the model are changed (refer to objectives in section 1.5.1). Such a dynamic model will make it possible to explore either: the resulting effect of a proposed policy, investment change and/or simply to identify the crucial factors which have a greater impact on the uptake of educational software such that resources can be directed accordingly. Given that FCMs allow for the exploration of different possibilities and have been considered and used successfully as discussed previously make FCMs worth considering as a modelling approach within this study. The next section provides an overall summary of the benefits and drawbacks that have been realised from the use of FCMs as indicated within the literature. This will help to establish just cause for adopting the FCM modelling technique within this study, in addition to the arguments already presented above.

3.3.4 FCM benefits and drawbacks realised

3.3.4.1 Overview

Overall studies which advocate the use of the FCM approach, and many of those which have adopted FCMs generally concur that this approach offers a number of benefits: FCMs not only model causal relationships between variables (Khan, Quaddus, and Intrapairot, 2001; Kardaras and Karakostas, 1999b; Sharif and Irani, 1999 etc) but their fuzzy quality allows for the representation of hazy degrees of causality between variables, (Lee and Han, 2000). Given that these fuzzy degrees of causality can be expressed either quantitatively or qualitatively (Kosko, 1994) and that FCMs are not limited by the problems identified with model identification as seen in classical statistical methods (Craiger and Coovert, 1994), FCMs are useful for modelling systems which cannot be explained entirely mathematically or which need to represent both qualitative and quantitative information or model both tangible and intangible issues (Stylios and Groumpos, 1999b; Kardaras and Karakostas, 1999 etc). Thus FCMs are able to represent domains or processes or problems, which can be considered to be complex, vague and even incalculable (Sharif and Irani, 1999; Khan et al., 2001 etc). FCMs, therefore allow for the comprehensive modelling of qualitative knowledge governing strategic decision-making (Kardaras and Karakostas, 1999b), together with the ability to provide a holistic picture of the problem or domain under study (Banini and Bearman, 1998; McCauley-Bell and Crumpton, 2000; Irani et al. 2002; Mohr, 1997b; Tsadiras et al. 2001 etc) are able to provide a deeper understanding of the context of the domain/problem. FCMs can also allow systematic propagation, in particular forward and backward chaining because of their graph structure (Lee and Han, 2000).

Furthermore, as discussed previously, vector-matrix operations allow an FCM model to become a dynamic system (Kosko, 1994, 1992; Khan, Quaddus, and Intrapairot, 2001; Mohr, 1997b). Therefore an FCM model can capture the dynamic aspect of system behaviour (Khan, Quaddus, and Intrapairot, 2001). Given that parameters/factors within an FCM model can evolve and that FCMs allow for the exploration of alternatives (Kardaras and Karakostas,1999b; Irani et al., 2002 etc) this can enable a wider strategic perspective i.e. the prediction and reduction of risks or maximisation of benefits with regards to the problem domain can be considered and incorporated. In addition to these advantages offered by the FCM approach, Taber (1991) contends that perhaps the greatest case for the FCM approach is ease of use. The domain experts can draw diagrams instead of listing rules; there is a well defined procedure for processing the captured knowledge and all maps share a common structure. The next section takes a closer look at the FCM methodology, shedding light on the benefits advocated and the concerns that have been realised from its use.

3.3.4.2 The methodology

The FCM approach as a methodology has the advantage of relative simplicity and ease of development (Taber, 1991; Khan, Quaddus, and Intrapairot, 2001). Taber (1991) contends that the FCM methodology consists of the five stages, namely source selection, map acquisition, conversion to matrix form, inference and global knowledge base construction, where identifying suitable knowledge sources is a critical part of knowledge base development; domain experts can be selected based on cost, perceived expertise, availability and other criteria. Knowledge can be elicited from interview transcriptions or printed documents, even magazine articles are considered useful knowledge sources. Experts can quickly draw FCM pictures or respond to questionnaires; agree or disagree with the local causal structure; use linguistic terminology, which may be easier for them, in order to express their beliefs (Kosko, 1986; Kosko, 1992; Taber 1991). Furthermore FCMs allow experts to represent factual and evaluative concepts in an interactive framework i.e. allowing for feedback. A basic FCM can provide a quick and initial approximation of an expert's stated causal knowledge (Kosko, 1992).

Studies predominantly show that data for the construction of FCMs has been elicited from experts from the domain under study, based on their knowledge and/or practical experience and/or from the thorough analysis of relevant literature (Tsadiras et al. 2001, Khan, et al. 2001; Banini and Bearman, 1998; Kardaras and Karakostas's, 1999b etc). Modes for data collection often include interviews and the use of questionnaires which usually encapsulate the following steps: Identification of key concepts/issues/factors influencing the problem; Identification of causal relationships among the variables; and estimation of strength values i.e. weightings of each causal relationship. These estimates are often expressed in imprecise or fuzzy linguistic terms which can then be translated into numeric values in the range –1 to 1. Experts can also specify the activation level or value of the concepts/variables in terms of a number, amount or rate etc associated with the initial state of that concept/variable. Acceptable maps are then transformed from diagram to matrix form (Taber, 1991). FCMs basically can represent and decode an expert's knowledge and experience. Given the method for constructing FCMs, i.e.

based on experts' knowledge, they are therefore considered ideal for modelling/representing processes which depend on the experience and knowledge of relevant experts (Stylios and Groumpos, 1999a and 1999b).

Although an FCM is quick to transcribe an expert's knowledge, it can equally encode the expert's biases or ignorance, (Kosko, 1992; Banini and Bearman, 1998; Tsadiras et al., 2001). Kardaras and Karakostas's (1999b), considered it important to take into account the planners opinion to facilitate the development of a consensus with respect to concepts modelled in their FCM, but on the other hand to minimise planners' bias. Therefore fuzzy weights in their FCM show the belief which planners share with regard to the existence of a certain relationship, and not the magnitude of change that a variable may undergo because of its causal relationship with other variables, i.e. their questions to planners were based on: How strongly do you believe there exits a causal relationship between variable X and variable Y? Further problems can occur when experts differ in how they assign causal strengths to edges and which concepts they deem causally relevant (Kosko, 1992). A partial solution, to these problems, is provided by Kosko (1992) in the form of FCM combination whereby each expert's FCM is additively superimposed even if the FCM connection matrices $F_1, \ldots, F_k$ (where k is the number of different opinions) may not be conformable for addition. The following equation is used (Kosko, 1992; 1997):

$$F = \sum_{i=1}^{n} w_i F_i \qquad \textbf{Equation 8}$$

Where: Fi represents the augmented FCM matrix for expert/stakeholder i

n is equal to the number of experts/stakeholders

wi is equal to the credibility weight of expert/stakeholder i

This process will tend to cancel out combined conflicting opinions and given the law of large numbers, a consensus will emerge as the sample opinion approximates the underlying population opinion (Kosko, 1992; 1997; Taber, 1991). Taber contends that a combined FCM is stronger than an individual because the information is derived from multiple sources and more information[2] means a stronger case, making point errors less likely. Banini and Bearman (1998) too contend that a greater number of experts consulted, will lead to a better understanding of the system in question, and help to reduce the degree of ignorance and increase the reliability of the FCM. Ultimately given that individual FCMs pertaining to a particular domain can be combined means that FCMs not only allow for different stakeholder views to be incorporated (Kardaras

[2] This is true if the strong Law of Large Numbers holds. Large numbers of i.i.d. (independent and identically distributed) experts tend to produce stable edge weights. The i.i.d. assumption is reasonable since the experts are independent and focus on the same problem.

and Karakostas, 1999) but can provide a useful mechanism for combining information drawn from a number of sources to create an overall rich body of knowledge (Taber, 1991; Banini and Bearman, 1998; Lee and Han, 2000).

However there are issues with regards to the determination of credibility weights referred to as w in equation (8) above (Taber, 1991; 1987; Lee and Han, 2000). Taber (1991) and Taber and Siegel (1987) report that the estimation of credibility weights has been largely ignored by both FCM and expert system researchers, and that the use of $wi = 1$ is common. They argue there is little justification for assuming experts are equal given that they have varied credentials and experience. Their endeavours to address this issue is predominantly based on the knowledge itself and not the source, therefore towards establishing a knowledge credibility weighting as an alternative to an expert weighting.

In light of some of the concerns discussed above, Lee and Han (2000) derived causal relations among variables and the relative explanatory power of such relationships from a statistical approach rather than by integrating different FCMs. The methods for determining causal relationships from decision-makers' statements and purposefully prepared questionnaires, which are based on the assumption that the weights in the causal relationships can be accurately provided by the domain experts, were found by Lee and Han (2000) to be unsuitable for their study domain. This is because, they contended, EDI auditors or managers from their study domain would find it difficult to quantify the strength and direction of the interrelationships among EDI controls and performance. In addition traditional interviews and observations would be insufficient to deal with the complexities of EDI controls. They further contended that in order to develop a more reliable EDI control structure the expertise of a larger number of experts needed to be combined. They argued that the algorithmic ways of combining various FCMs to be incomplete given the difficultly of determining credibility weights. Although they recognised that there were methods of combining knowledge or estimation of weights, they contended these demanded a comparison of opinions from experts, and as the number of experts increased, the comparison of their opinions would become complex. They therefore argued for a statistical approach in developing their model. Linear Structural Relationships was used to determine the complex causal relationships among factors based on a large number of cases.

Tsadiras et al. (2001) state that the success of an FCM depends on the validity of the knowledge provided by experts and from the above discussions it can be seen that there are ways to address this issue i.e. the combination of FCMs and the incorporation of statistical approaches depending on the requirements of the particular study. Khan et al (2001) suggest that even when the FCM structure and available data set can be regarded as accurate and normal there needs to be careful consideration of the normalisation of raw data values to make them suitable for initialising FCM nodes. They make further recommendations with respect to the use of the FCM approach which include the consideration of the association of appropriate strengths to causal links (usually expressed in imprecise linguistic terms by domain experts).

Overall the above discussion has focused on the benefits and drawbacks which have been realised by some studies from their use of the FCM approach. It has also provided an overview of the FCM methodology and highlighted some of its qualities and areas of concern. However another issue for consideration, which has been gathered from the review of the literature, is the limited use of the FCM approach when it has been adopted. Despite the ease of the FCM methodology and the associated benefits of the FCM approach, (see 3.3.2, 3.3.3, 3.3.4.1 3 and .3.3.4.2) many of those who have advocated the use of FCMs and proceeded to use it have not exploited the full potential of the approach or there have been limitations in the use of the approach. This is in terms of the following:

1) In some studies the FCM models developed are simplistic, focusing on a few concepts/nodes where there is the possibility to explore further complexities in the domain under study. For example Stach and Kurgan (2004) in their study of the factors which affect the pace of work progress during a software project, developed an FCM model consisting of five concept nodes. Irani et al. (2002) in their study of the IT/IS investment evaluation process, based on a proposed conceptual model developed an FCM model displaying only the four major concepts, although each concept within the original conceptual model had actually encapsulated a number of company and project specific variables. Whereas in the study by Karadaras and Karakostas (1999b), in which they consider the simulation of the information systems strategic planning process using FCMs, they propose a 165 variables/ and 210 relationships from both business and IT domains, for their FCM model.

2) In terms of the strength (i.e. weightings see section 3.2) of relationships between factors, simple numerical weightings of value +1 or -1 have been favoured in the study by Lee, et al. (2002) instead of the range of (0, 1) positive and negative values that are feasible in FCMs and which can represent a more fuzzy weighting. Furthermore it has also been noted in the study by Zahir et al. (2002) the (+) and (–) signs, that have been applied to relationships, in their FCM model have been interpreted differently to those seen within the theory of FCMs and cognitive maps (see section 3.2), for example (+) is interpreted as 'has greater effect on' and (-) is interpreted as 'has lesser effect on'

3) In terms of aggregating/combining FCMs to create a single body of knowledge (see discussion above), the estimation of credibility weights wi =1 is common despite little justification for assuming experts are equal given that they have varied credentials and

experience and/or the issue is not addressed or explained clearly, as has been seen in studies such as Banini, and Bearman, (1998); Schneider et al, (1995), (1998); Lee and Kim, (1997); Stylios and Groumpos, (1999b), (2000) etc.

4) Some studies i.e. Kardaras and Karakostas, (1999a), Stylios, and Groumpos, (1999a), Irani et al. (2002) etc on developing their FCM model have not proceeded to the next step of exploring the dynamic potential of the FCM model by running simulations as is shown within the theory of FCMs (see sections 3.2.1 and 3.2.2). This may have been because they allocated linguistic terms such as strong, weak etc as weightings to the strengths of the relationships between factors when they developed their models. Whereas Tsadiras et al. (2001) have taken steps to convert linguistic weightings to numerical values which are essential for the mathematical FCM simulation process some studies have not proceeded in this manner. For example Kardaras and Karakostas, (1999b), contended that they avoided the use of real values for weights, applying linguistic terms to an ill-structured problem, but keeping both the positive and negative effects from which planners would be able to evaluate with scenarios instead of thresholding. While Pelaez and Bowles (1996) used the min~max inference approach[3] to evaluate confidence values with regards to the linguistic terms they used in their model, then proceeded to simulate their model.

5) Generally for those that do proceed with the simulation process the choice of using a simple threshold function (see section 3.2.1.1) such as the bivalent function, which gives a simple outcome of 0 or 1 for concept/node activation levels (see section 3.2) as simulation results, is common (Kosko, 1997; Mohr, 1997a, b). However this does not provide the true fuzzy conceptual node, which can otherwise be achieved when a logistic threshold function is used in the mathematical FCM simulation process (see section 3.2.1). This means that concepts within the model are either turned on or off, i.e. node values 0 or 1, whereas there is the potential within FCMs to have fuzzy nodes/concepts. Therefore the ability to exploit the degrees to which concepts can be turned on, is not utilised, especially when this could be applicable to concepts in the domain/problem under study for example in the Banini, and Bearman, (1998) study of the factors affecting slurry rheology.

The simplistic nature of some studies is understandable in the circumstances if only a simple understanding of the domain under study needed to be achieved, but given the potential of the

[3] Min the minimum operator is the indirect effect operation which amounts to specifying the weakest causal link in a path. Max the maximum operator is the total effect operation which amounts to specifying the strongest of the weakest links.

dynamic FCM it is seems that the use of the approach has been limited in a number of studies. Furthermore, even though the ease of the FCM methodology is recognised, especially in terms of developing empirically based models (as discussed in section 3.3.4.2), Narayanan and Liao (2005) report that there is a lack of empirically developed FCM models. In some instances where models have been empirically developed the details of the development such as the number of experts involved, the modes of data collection used, the assessment of credibility weightings used in combing FCMs, are not explained clearly i.e. Banini and Bearman (1998); Stach and Kurgan (2004) etc. While studies which have discussed or proposed other features for use within the FCM approach such as the study by Stylios, and Groumpos, (1999a) which proposes a new methodology for developing FCMs the work has generally been theoretical and the examples they have provided of models can be considered simple. There are a lack of studies which have taken the theoretical to the practical stage i.e. developed an empirically based FCM model and explored the dynamic potential of it in practical situations as can be seen in the studies by Khan, Quaddus, and Intrapairot, (2001) and Lee and Han, (2000).

Given that this thesis considers the use of the FCM approach and provides justification for its use in section 3.4, the discussion within this section has been important. This is because it has highlighted the areas within the FCM approach where some studies have been unable to utilise the approach fully in terms of portraying the true complexities of the study domain; in allocating a more realistic fuzzy value to the weighting of relationships in the model; in exploring the dynamic potential of the FCM model and in obtaining true fuzzy conceptual nodes which can represent the problem domain in a more realistic manner. Therefore this study will attempt to exploit and use the FCM approach to a fuller extent, and develop an FCM model empirically. In doing so the study will contribute to a field in which the number of empirically developed FCM models is limited.

3.4 Justification for adopting FCM as a modelling approach

The previous sections have discussed many benefits associated with the FCM approach, this section re-iterates and presents some of the main reasons which justify and make the case for adopting the FCM approach within this study stronger: Firstly, the objectives of this study are concerned with modelling the various combinations of factors and the extent to which these factor influence the adoption of educational software by students and teachers, FCMs allow for the modelling of such causal fuzzy relationships between variables, and have been successful in doing so as indicated by the literature. There are studies which have been discussed which have purposes or goals synonymous to those of this thesis, even though the specific problem or domain area may differ. Such studies have argued for and adopted FCM as an approach conducive to achieving their purposes; in effect this also poses a strong argument for and justifies the adoption of the FCM modelling approach within this thesis.

Secondly, this study is primarily governed by a pragmatic paradigm, which will be discussed in further detail in the next chapter, where there is a need to understand the multiple social constructions of knowledge and meaning. This study is concerned with modelling the factors and any influential relationship in the uptake of educational software in schools, as perceived by the relevant stakeholders, where the views and opinions of relevant stakeholders are considered to be important and consequential. Therefore statistical modelling techniques whereby factors, causal relationships are determined and based on strict quantitative measures are not considered to be appropriate for this study. FCMs provide an alternative to such traditional statistical methods and do not suffer the associated limitations as discussed earlier. Furthermore the school environment pertaining to this study problem is a social and complex domain where the adoption and up-take of educational ICTs involves both technical and human aspects, and would need to be modelled accordingly. Studies have indicated FCMs can model systems in domains which cannot be explained quantitatively or which need to represent both qualitative and quantitative information or model both tangible and intangible issues. Therefore in comparison to traditional quantitative modelling methods, overall FCMs can be considered appropriate for modelling the problem domain of this study.

Thirdly, this study is concerned with the school environment which consists of many stakeholder groups and their perceived views of the up-take of educational software. FCMs in this regard have been considered an ideal mechanism for incorporating different stakeholder views and for combining their knowledge. Lastly, this thesis contends that a dynamic model will make it possible to explore the resulting effect of a proposed policy or investment change and examine different investment/policy changes and/or simply help to identify crucial factors which have a greater effect on the uptake of educational software, so that resources can be directed accordingly. Therefore given that FCMs allow for and have been used successfully as dynamic models, is again a strong argument for justifying the adoption of FCMs in this thesis.

Evident from the studies examined and discussed, the FCM approach has many benefits to offer. Although there are concerns as well, these are overshadowed by the overwhelming number of benefits and features which make the use of FCMs particularly attractive and suitable for this study. However this does not mean that such concerns with regard to the determination of credibility weights etc can be ignored. Existing solutions to addressing such concerns can be drawn upon or even newer ways to tackling such concerns (given that FCMs offer a less than rigid methodology) can be developed as they arise within the context of this study, as will be discussed in chapter 6. Overall, based on the above discussions and in conclusion the use of FCMs is considered an appropriate approach for modelling the factors in the up-take of educational software in schools.

3.5 Summary

This chapter introduced the theory of FCMs by providing descriptions of its diagrammatic form and mathematical matrix representation. It presented the underlying vector-matrix operations of an FCMs dynamic process and the different states that can be reached as result of a stimulus. The chapter provided examples of FCM applications to show the variety of domains and studies which have used the FCM approach. It discussed the purposes of some of these studies, and drew parallels to those studies whose purposes were similar to those of this thesis. The following section examined why some studies adopted the FCM approach instead of traditional approaches and modelling techniques. It presented the concerns of this study in relation to such traditional modelling methods. Next, the dynamic ability of FCMs which is seen as an attractive and useful feature of the FCM approach by many studies was discussed and considered an important feature within the context of this study.

The following section provided an overall summary of the benefits and drawbacks that have been advocated and realised from the use of FCMs as indicated in the literature. The section also focused on the advantages and concerns surrounding the FCM methodology, in doing so, the section provided a brief overview of the FCM methodology. The section also highlighted the limited use of the FCM approach in some studies which had adopted it and advocated the use of the approach. The chapter concluded by justifying the use of FCMs as an appropriate modelling approach within the context of this study, by drawing on the advantages, concerns of the FCM approach and on earlier discussions. It highlighted, that although the determination of credibility weightings of participants is a concern within the FCM literature, this poses a challenge which would need to be addressed within the context of this study. This is because there are very strong arguments for adopting the FCM modelling approach for this particular study given that FCMs offer a modelling approach which is particularly suitable for achieving the aims and objectives of this study. The next chapter discusses the research paradigm, approach and methods considered and used in order to achieve and address the main aim and objectives of this study.

Chapter 4: Research Methodology

4.1 Introduction

This chapter presents and reviews the epistemological and ontological stances of positivist, postpositivist, interpretive and pragmatic research paradigms. In doing so it also highlights the differences between these paradigms. It presents the research approaches which use the philosophical assumptions associated with these paradigms and lists the strategies of inquiry and methods typically employed by these research approaches. The chapter then discusses why the mixed methods approach, associated with the pragmatic paradigm, is considered appropriate and undertaken for this particular study. This is followed by a detailed description of the methods used to conduct the empirical study for this thesis: the chapter discusses how and why the sample for the study was selected; the modes of data collection considered and used; the design of the instruments for data collection and the methods considered and used to analyse the empirical data. The chapter also discusses the simulation process chosen to conduct simulations for this study.

4.2 Research paradigms, approaches, strategies of inquiry and methods

In a research process the researcher is guided by a paradigm i.e. a worldview which is based on philosophical assumptions i.e. the paradigm guides the researcher's thinking and actions (Mertens, 1998). Positivism, postpositivism, interpretivism/constructivism and pragmatism are known paradigms. Positivists assume that one reality exists and that the researcher's role is to discover that reality (Guba and Lincoln, 1994). Importantly positivists look for the existence of a constant relationship between events, or, in the language of experimentation, between two variables. Some of their main assumptions include that science is largely based on quantitative data, derived from strict rules and procedures and all scientific propositions are based on facts (Robson, 2002). Early positivists assumed that the researcher and the subject of the study did not influence each other i.e. they were independent (Guba and Lincoln, 1994). However postpositivists agree that the reality which exists is known imperfectly because of the researcher's human limitations. The postpositivist paradigm contends that by following prescribed procedures rigorously, the researcher should not let biases influence the work. In positivist research quantitative methods are more widely used although qualitative methods can be used as well (Mertens, 1998).

Interpretivists/constructivists contend that the researcher's role is to understand the multiple social constructions of meaning and knowledge. Therefore, in order to obtain multiple perspectives they often use interview and observation methods. Furthermore they consider that the research participants help in the construction of the reality with the researcher (Robson, 2002) and they also emphasize that the research product is not independent of the value of the researchers (Mertens, 1998). Hence the researcher and subject/participant of the study both influence each other; therefore interpretivists/constructivists have a more personal, interactive mode of data collection. Qualitative methods such as interviews, observations are mainly associated with the interpretive/constructivist paradigm (Mertens, 1998).

The pragmatic paradigm is not limited to any one philosophy and reality. Pragmatic researchers have the freedom to choose methods and processes that best fit their purpose. They are able to draw from both quantitative and qualitative assumptions, subscribe to both quantitative and qualitative methods in the collection and analysis of their data, such that they are able to provide the best understanding of the research problem (Creswell, 2003).

Table 3 shows the main attributes and characteristics associated with positivism, postpositivism, interpretivism/constructivism and pragmatism, (from Tashakkori and Teddlie (1998)). The differences between each of these paradigms are highlighted in the following discussion which draws on Table 3.

In regard to research methods adopted under the different paradigms, positivists and postpositivists prefer to adopt quantitative methods, and constructivists prefer qualitative methods. For pragmatists the use of quantitative and/or qualitative methods is based on the current research question and the phase of the research cycle. They are at liberty to choose either or both methods as and when deemed useful for their purpose. Within a cycle of inference processes i.e. the research cycle, positivists and post positivists tend to move from general inferences (abstraction, generalizations or theory) through deductive logic to hypotheses or predictions of particular events/outcomes. Constructivists move from facts and observations through inductive logic to general inferences. Pragmatics believe they can choose inductive and deductive logic, depending on the question that needs to be answered, during the course of the research (Tashakkori and Teddlie, 1998).

Table 3 Comparison of four important paradigms used in social and behavioral sciences. (Source: Tashakkori and Teddlie (1998), pp. 23)

	Paradigms			
	Positivism	**Post positivism**	**Pragmatism**	**Constructivism**
Methods	Quantitative	Primarily Quantitative	Quantitative and Qualitative	Qualitative
Logic	Deductive	Primarily Deductive	Deductive and Inductive	Inductive
Epistemology	Objective point of view. Knower and known are dualism.	Modified dualism. Findings probably objectively "true".	Both objective and subjective points of view.	Subjective point of view. Knower and known are inseparable.
Axiology	Inquiry is value-free.	Inquiry involves values, but they may be controlled.	Values play a large role in interpreting results.	Inquiry is value bound.
Ontology	Naïve realism	Critical or transcendental realism.	Accept external reality. Choose explanations that best produce desired outcomes.	Relativism

In considering the epistemological stances (Guba and Lincoln, 1994) i.e. the nature of knowledge, relation between knower and would-be known, for positivists, the researcher and subject of the study are independent, however postpositivists recognize that the researcher's background knowledge can influence what is observed. Objectivity is important, for both positivists and postpositivists and therefore rigorous procedures are followed to prevent the researcher's bias from influencing the work (Mertons, 1998). For constructivists the researcher and the subject of study are intertwined, each influencing the other and where the point of view is subjective. Both of these different views are confronted by pragmatics, they argue that researchers can be both subjective and objective during the course of studying a research question: Where the two opposing poles need to be considered as a continuum instead, such that during a point in time a researcher can be more objective i.e. the researcher must be independent from the subject of the study, and during others more subjective i.e. the researcher can be more intertwined with the subject of study (Tashakkori and Teddlie, 1998). This is likely to happen when the researcher is able to use both qualitative and quantitative tools.

With regard to axiology i.e. the role of values, Table 3 shows that for positivists' inquiry is value-free, i.e. the belief is that researchers as impartial observers can objectively evaluate or predict actions or processes but cannot be involved in moral judgments and subjective opinion, the other aspect of this stance is the belief that positivist researchers are detached from the phenomena of interest (Orlikowski and Baroudi, 2002). For postpositivists values are important but that it is possible to control the extent to which values affect results and interpretations. For constructivists inquiry is value-bound, in the sense that all researchers are inherently implicated in the phenomena being studied, the beliefs, assumptions and interests of the researcher influence their line of inquiry or study. Pragmatists on the other hand guided by their personal values, study what they believe to be important, they study a topic in a manner which matches with their value system, including variables and units of analysis most suitable for obtaining a solution for their research problem. Their studies are also conducted in such a way that results are expected to be similar to their value system (Tashakkori and Teddlie, 1998).

With regards to the basic beliefs regarding the nature of reality i.e. ontology associated with the paradigms, positivists believe that one reality exists and the discovery of that reality lies with the researcher (defined as naïve realism) (Guba and Lincoln, 1994). The postpositivists too believe that a reality exists, but due to the researcher's human limitations, this reality is known imperfectly and probabilistically (defined as critical realism). For constructivists reality is socially structured, there are multiple mental constructions of social realities, which may change throughout the process of study, as their constructors change (defined as ontological relativism). In rejecting the idea that an objective reality exists, they take the position that the researcher's aim is to understand the multiple social constructions of meaning and knowledge (Guba and Lincoln, 1994; Mertons, 1998). Hence there are two extreme beliefs held between the paradigms, based on the nature of reality, one being that an objective reality exists and the other being multiple subjective realities exist. The pragmatists' perspective on reality is that they are in agreement with positivists and postpositivists in believing in an external reality. However, pragmatists do not accept that "truth" can be determined once and for all, and are unsure about whether one explanation of reality is better than another (Tashakkori and Teddlie, 1998; Cherryholmes, 1992). Tashakkori and Teddlie, (1998) contend that the pragmatist approach presents a very practical research philosophy: "study what interests you and is of value to you, study it in ways you deem appropriate and use the results in ways that bring about positive consequences within your value system"(pp.30).

The philosophical assumptions associated with the different paradigms, discussed above, are used by different research approaches. Qualitative approaches typically use constructivist assumptions. Quantitative approaches tend to use post positivist assumptions. Mixed method approaches typically use pragmatic assumptions. Within each of these research approaches, there are certain strategies of inquiry and methods which are typically used. Table 4 provides a summary of the strategies of inquiry and methods employed within qualitative, quantitative and mixed method approaches (Creswell, 2003). The following section discusses the reasons which have influenced this study to select a mixed methods approach and in doing so, justifies the pragmatic stance taken within this study.

4.3 Justification for selecting a mixed methods approach

With regards to the selection of the appropriate research approach and methods, in order to address its research aims and objectives (see section 1.5.1), the study considers the following: there is a need to be able to elicit information from relevant stakeholder groups, pertaining to a school environment, for the construction of the FCM model: the study, in recognising the importance of these relevant stakeholder groups, is concerned about understanding the way these stakeholders perceive the adoption of educational software, which factors they believe influence the use of educational software and whether their perceptions and views will lead to the identification of issues/factors or causal relationships required for the construction of the FCM. This could be described as a need to understand people experiencing a phenomenon within a social and cultural context i.e. the up-take of educational software in schools, by relevant stakeholder groups. This is very much reflective of a constructivist/interpretive stance.

Pouloudi (1998) reports that interpretive research allows issues of causality and human purpose to be addressed more appropriately by allowing for the study of problems in real-life settings. Furthermore Pouloudi (1998) contends that qualitative methods of research allow for a richer investigation and representation of stakeholders' views and perspectives. However the methods employed under the qualitative approach, alone, (seen in Table 4), such as the use of open-ended questions are considered insufficient for the construction of the FCM model. This is because, although a FCM model can be developed and represented qualitatively based on the perception of one expert or stakeholder, the aggregation of such individual FCMs to form a stronger FCM based on combined knowledge is mathematically based (as discussed in chapter 3). In addition the exploration of a dynamic FCM is only possible when the FCM model can be presented numerically in matrix form. In this respect, quantitative approaches (see Table 4) employing methods such as close-ended questions would allow for the generation of numeric data also necessary for the construction of the FCM model.

It is considered a constraint for this study in addressing its main goal if a choice has to be made between employing qualitative and quantitative methods. Olikowski and Baroudi, (2002) examined the research approaches and methods used for studying information technology in organisations, which identified 96.8% studies as adopting a positivist approach and 3.2% adopting an interpretive one. They highlight that by readily accepting research assumptions of a dominant perspective can inadvertently cause restrictions on research. They state that researchers need to have a perspective that is compatible with their own interests and predispositions. In view of the different research approaches and methods available, Galliers and Land (2002) too emphasise that the research methods must take into account the nature of the subject matter and the complexity of the real world we are dealing with.

Ultimately for the construction of a rich FCM model, within this thesis, there is a need to: (1). Study and understand the perceptions of the people i.e. the relevant stakeholder groups in the educational domain, in order to decipher relationships that exist and which can enrich the FCM model. This means dealing with the social construction of language and meaning, synonymous with the philosophical assumptions of the interpretive/constructivist paradigm used by qualitative approaches. (2). Generate numeric data required for the construction of the FCM model, based on the information elicited from relevant stakeholder groups. Therefore it is important to consider an approach, which will allow for some aspects of a qualitative and some aspects of a quantitative approach to work together in addressing the task in the best possible way. Hence this study, in light of the features and characteristics associated with a mixed methods research approach, presented in Tables 3 and 4 (Tashakkori and Teddlie, 1998; Creswell, 2003) and discussed in section 4.2 considers the mixed methods approach to be appropriate for addressing the issues discussed above and for achieving the goal of this particular study.

Table 4 Qualitative, quantitative and mixed methods approaches (Source: Creswell, (2003) pp. 19)

Tend to or Typically	Qualitative Approaches	Quantitative Approaches	Mixed Method Approaches
Use philosophical assumptions	Constructivist /Advocacy/ Participatory knowledge claims	Postpositivist knowledge claims	Pragmatic knowledge claims
Employ these strategies of inquiry	Phenomenology, grounded theory, ethnography, case study and narrative	Surveys and experiments	Sequential, concurrent and transformative
Employ these methods	Open ended questions emerging approaches, text or image data.	Close-ended questions, predetermined approaches, numeric data.	Both open- and closed-ended questions, both emerging and predetermined approaches and both quantitative and qualitative data and analysis.
Use of these practices of research, as the researcher	Positions himself or herself. Collects participant meanings. Focuses on a single concept or phenomenon. Brings personal values into the study. Studies the context or setting of participants. Validates the accuracy of findings. Makes interpretations of the data. Creates an agenda for change or reform collaborates with the participants.	Tests or verifies theories or explanations. Identifies variables to study. Relates variables in questions or hypotheses. Uses standards of validity and reliability. Observes and measures information numerically. Uses unbiased approaches. Employs statistical procedures.	Collects both quantitative and qualitative data. Develops a rationale for mixing. Integrates the data at different stages of inquiry. Presents visual pictures of the procedures in the study. Employs the practices of both qualitative and quantitative research.

A mixed methods approach allows for open-ended and closed-ended questions, both emerging and predetermined approaches and both quantitative and qualitative data and analysis. Mingers (2001) too advocates the use of such multi-methods given that all research settings are so complex and multi-dimensional that they would benefit from a range of methods. Since the research process is made up of different phases, different methods may be more useful for addressing the different problems that may be posed in different phases of the research process. Therefore, in adopting a mixed methods approach and based on the philosophical assumptions associated with the pragmatic paradigm, the study has the flexibility to choose either or both quantitative and/or qualitative methods as and when deemed appropriate for its purpose.

Within the mixed methods approach, as seen in Table 4, sequential, concurrent and transformative are strategies of inquiry which are typically used. In a sequential procedure the researcher having already obtained findings based on one method, than uses another method to expand their existing findings. For example, a quantitative method to test theories or concepts can be followed by a qualitative method involving the exploration of individuals or cases, the two phases are considered separate. In a concurrent (i.e. parallel/simultaneous) procedure the researcher combines both quantitative and qualitative data, in order to present a thorough analysis of the research problem. The data, both quantitative and qualitative, is collected at the same time and the information is integrated in the interpretation of the overall results. The researcher in the concurrent design can also nest one form of data within another. The transformative procedure can be described as one in which the researcher uses a theoretical lens, which provides a framework for topics of interest, methods for collecting data, and changes or results expected by the study. Within this lens the data collection method can involve a sequential or concurrent approach, and the design contains both qualitative and quantitative data (Creswell, 2003).

Different mixed method designs can also be formulated within these strategies of inquiry. Tashakkori and Teddlie (1998) state there are three main types of mixed methods designs (which can apply to typically to both data collection and analysis techniques): equivalent status designs, dominant – less dominant designs, and designs with multilevel use of approaches. An equivalent status design can contain a sequential procedure where qualitative methods are followed by quantitative methods or vice versa, or the design can contain concurrent (i.e. parallel/simultaneous) procedures involving quantitative and qualitative methods, but in this particular design the researcher uses the quantitative and qualitative methods equally in order to understand the phenomenon being studied. On the other hand dominant – less dominant designs occur when there is a one dominant paradigm and method in the field and a small part of the study is drawn from a different design. The overall design can consist of a sequential procedure where a dominant quantitative method is followed by a less dominant qualitative method or vice versa or a concurrent procedure where the quantitative method used is more dominant than the qualitative one or vice versa. Lastly, multilevel use of approaches occur in studies in which data from more than one level of organizations or groups are used to determine or make inferences about events and/or behaviors (Tashakkori and Teddlie, 1998). Ultimately this study adopts a concurrent procedure, of equivalent status design. The details of the methods used for data collection and analysis are described in the next section.

4.4 Description of methods employed to conduct the empirical study

This section details the methods used to gather and analyse the empirical data required for the construction of the FCM within this study. In doing so, it also draws on the FCM literature discussed in section 3.3.4.2 with regards to methods typically used in the development of FCMs, which guide the choice and the design of data collection methods and the methods of analysis employed within this study.

4.4.1 Sample Selection

Source selection is considered one of the first and critical steps of the FCM methodology; domain experts can be selected based on perceived expertise, availability and other criteria (Taber, 1991). Chapter 1 advocates the importance of stakeholder groups in any IS development or adoption and listed school students, school teachers, department heads, ICT co-ordinators and technical support staff as relevant stakeholder groups, in regard to the up-take of educational software, within the school domain. Such stakeholders have important roles in the adoption and up-take of educational software in schools, this is because they can directly affect the up-take of educational software or are affected by its up-take. Therefore it is the opinions and views of such stakeholders which are of importance to this study because they act as the source of information, so that the appropriate FCM model can be developed.

Given that such stakeholders pertain to the school environment, and the phenomenon of the up-take of educational software is being experienced in the school environment, the study draws its sample from three different schools. The schools are selected on the basis that they were representative of typical schools in England i.e. average schools; they are neither failing nor special schools. One of the schools is known for its part in the ICT Testbed project; a government project which allowed the school to invest in high levels of hardware and software, the other two schools vary in the level of ICT infrastructures and capability. The three schools as a cluster are considered representative of schools with different levels of ICT infrastructure and ICT adoption in England. In totality the three different domains, in terms of their level of ICT infrastructure and ICT capability, mean that the total sample being drawn will have a wider experience of ICT adoption and up-take of educational software given their different environments. This will ultimately contribute to a wider and richer source of data for the construction of the FCM. A detailed description of the three schools selected is provided in chapter 5.

In each school the participants include: A male and female student from each year group ranging from years 7-11, this would allow for both a male and female perspective given that there are noted differences in the ways students adopt ICTs based on gender (Mayer-Smith et al, 2000; Ordidge, 1997; Sutton, 1991; Furger 1998; Schofield 1995; Reinen and Plomp, 1993; Durndell et al., 1995 etc). The students are selected from within the normal educational distribution range. The staff participants include: four to five teaching staff, who vary in the positions they hold, the subjects they teach and in the number of years of teaching experience they possess, and include at least one head of department; one ICT-coordinator; and one ICT technician. Given that the participants have a cross section of roles in the adoption and uptake of educational software, it allows for the views of stakeholders at different levels of the school organisation to be obtained therefore supporting a better understanding of the phenomenon of educational software adoption and up-take in schools, and providing a rich data source for the construction of the FCM. The total sample consisted of 46 participants: 30 students and 16 staff members. A detailed description of the sample is provided in chapter 5.

This study in selecting its sample, has addressed some of the issues discussed in section 2.5, in terms of: including participants from all key stakeholder groups; selecting within each stakeholder group a range of participants with varying ages, experiences etc; and selecting schools with varying levels of ICT integration. Section 2.5 had highlighted the limitations associated with narrowly defined samples, found in some studies, in that their findings were limited in applicability. It had also discussed that a number of studies had not taken into account student opinions even though they are key stakeholders in this adoption. Hence this study by focusing on the perceptions/opinions of students in addition to the perceptions/opinions of other key stakeholder groups will attempt to contribute in terms of providing a richer understanding of and insight into the context of educational software adoption; an adoption which affects both teachers and students and the success of which can be measured in terms of the utilisation of educational software by both teachers and students.

With regards to the number of schools chosen for this study and the ultimate sample size, it is considered that: a sample drawn from only one school, i.e. research conducted within one school, would mean that the participants' opinions and views would be reflective of experiences pertaining to only that particular domain, therefore the richness of the data would be limited and the outcome would be limited in applicability. This is not the case by drawing a sample from three different schools as described and discussed above. Given that interviews, which are considered to be expensive in terms of time and efforts entailed, are considered as the main mode of data collection, drawing a sample from more than three schools is not considered practical given the time and resource constraints of this study. The total sample of 46 participants drawn from the three schools is enough to give the study the depth and the breadth without straining the research resources. The sample provides a fairly wide range of persons from whom data can be obtained and at the same time allows for an in-depth data collection from each participant in terms of conducting interviews.

The type of sampling used for this study, is known as purposive (non-random) sampling, described as the selection of individuals/groups based on specific questions/purposes of the research in lieu of random sampling and on the basis of the information available about these individuals and groups (Tashakkori and Teddlie, 1998). Denzin and Lincoln (1994) contend that researchers adopting an interpretive/constructivist paradigm tend to use a theoretical or purposive approach to sampling. The sampling activities begin with an identification of individuals, groups and settings where (and for whom) the processes being studied are likely to occur, as is evident in the sampling for this study.

Researchers adopting an interpretive paradigm typically select their samples with the goal of identifying information rich cases that will allow them to study a case in depth (Mertens, 1998). In an interpretive study, generalisation from the setting (usually one or a handful of field sites) to a population is not sought; the intent is to understand the deeper structure of a phenomenon, which it is believed, can be used to inform other settings (Orlikowski and Baroudi, 2002). The criteria used by Orlikowski and Baroudi, (2002) to classify interpretive studies was where the phenomenon of interest was examined in its natural setting and from the perspective of the participants. To an extent this study does adhere to some of these interpretive principles in its aim to construct the FCM model, as is seen in the determination of the sample population, which is acceptable given the pragmatic stance taken by this study.

4.4.2. Mode of data collection

FCM literature indicates that interviews are used as one of the main modes of data collection, as discussed in section 3.3.4.2. Interviews are considered techniques associated with both qualitative and quantitative methods (Easterby-Smith, Thorpe and Lowe, 2002). Interviews can be classified into three types fully structured, semi-structured, and unstructured, and can be undertaken in various forms such as personal interviews and face to face group interviewing (Denzin and Lincoln, 1998). The advantages of interviews are that: they allow for a one-to-one interaction between the researcher and the interviewee, there is opportunity for discussion and clarification; verification of themes and interpretations; incorporation of new questions as needed by the researcher, because interviews can be conducted in a conversational style, researchers can probe more easily for understanding additional information; they allow access to peoples' thoughts and ideas in their own words; it is targeted i.e. focus is on the topic of case study; it is insightful i.e. provides perceived causal inferences (Mertens, 1998; Yin, 1994). Finally Mertens' (1998) reports personal interviews are generally associated with highest response rates. There are however disadvantages of interviews such as inaccuracies due to poor recall, bias due to poorly constructed questions, response bias, reflexivity-interviewee gives the what the researcher wants to hear (Yin, 1994).

Questionnaires have also been indicated as another main source of data collection with FCM methodology literature (see section 3.3.4.2). McCracken, (1988) contends that the use of a questionnaire within an interview can be beneficial: it ensures that the researcher covers all the terrain in the same order for each participant; establishes channels for direction and scope of discourse; allows the investigator to give all attention to the informant's testimony.

Hence given the advantages associated with interviews; the use of interviews within FCM methodology and the flexibility to use questionnaires in interviews, it is considered appropriate to use interviews as a mode of data collection for this study. Semi-structured and fully structured interviews constitute the main source of data collection. The semi-structured interview, includes open-ended questions synonymous with qualitative methods, and is based on a topic guide (described in section 4.4.4) which sets an approximate agenda for the interview. The fully structured interview consists of the use of a questionnaire, which includes close-ended questions synonymous with quantitative methods, the design of which is described in detail in section 4.4.4.1. Each participant is subjected to the semi-structured interview followed immediately by the fully structured interview.

In the fully structured interviews the questionnaire is used as a self completing document, the researcher explains the structure of the questionnaire to the participant and the document is completed by the participant in the presence of the researcher. This allows for interaction between researcher and participant, and given the length of the questionnaire and possible complexity of some questions the researcher can deal with any queries the participant may have while completing the document. This ensures all the data required by the researcher is obtained and that the participant's responses are based on a clear understanding of all of the questions being posed to them. The interviews with participants who are staff are conducted on an individual basis, while the interviews with participants who are students are conducted on a group basis; the underlying reasons for this are explained in section 4.4.3. The details of interview durations, dates, and locations, with each of the participants are available in Appendix E. The average interview duration per participant, which included both the semi and fully structured interviews, usually lasted for one hour. The semi-structured interviews were tape–recorded and hand written notes were taken as well. The recorded interviews were transcribed soon after the interviews.

4.4.3 Access to schools and participants

There are issues related to access in educational settings for research purposes (Maruyama and Deno, 1992; Mertens, 1998). Maruyama and Deno (1992) contend that reaching an agreement with 'appropriate persons' for research to take place within the school and who will participate in the research, can be a long process. Even identifying such 'appropriate person or persons' who have the power to grant the access can be considered complex. Furthermore different schools can have different procedures for requesting access to students and staff for research purposes. Mertens (1998) contends researchers need to be aware of complications arising within such 'real life' situations that may affect sampling for the study. For example school systems will rarely allow a researcher to take all student participants and randomly assign them to conditions. Frequently researchers need to adjust sampling plans to work with intact groups, such as administering a treatment to an entire classroom.

This study, to an extent, did experience some of the issues aired above by Maruyama and Deno (1992) and Mertens (1998), with regards to the process of access to school sites and participants. The process involved was a cumbersome one, in terms of the formalities entailed and liaison with the appropriate persons who would then finally make it possible to gain access to the target participants. The details of the specific processes involved to gain access to the school sites for this study are described in chapter 5. The availability of participants for interview within school environments is also an issue for consideration: Members of staff are very busy within the school day, and time for interviews is limited. Scheduling of interviews had to be managed carefully so as to fit in with the time constraints of the staff participants' especially teaching staff, who even in their non-teaching periods have other duties.

In regard to interviewing students on an individual basis the following were matters for consideration: the extent of the complications that would arise in order to conduct unsupervised interviews with students on a one-to-one basis. For example, these would include, depending on the guidelines followed by each school, the school having to conduct a background check of the researcher and/or the school having to obtain written permission from the parents of each of the selected student participants to allow for the students to participate in unsupervised, one-to-one interviews with the researcher. This was the case in one school which obtained permission from parents of the students selected and made necessary background checks on the researcher, irrespective of whether a group or personal interview was to be conducted with the students. The other point for consideration in regard to conducting one-to-one interviews with the students was that arranging different interview times, dates and locations (i.e. rooms in which the interviews could take place and subject to availability) for each student would be a long and cumbersome task given the number of students in the sample.

It was therefore considered practical to conduct group interviews with the students in each of the schools. In the case where the schools were split on two sites the groups were formed accordingly i.e. students from each site were grouped separately, the interviews with each group was conducted on a particular date and time and in one particular location i.e. in one allocated room in the school site, therefore causing least possible disruption within the school. In addition permission had to be acquired from the teachers whose lessons the students would be absent from in order for them to participate in the study. Chapter 5 provides a description of the processes entailed to obtain access to the participants and of the research conducted in each of the schools, while details of interview durations, dates, and locations are available in the Appendix E.

There is a need to distinguish between group interviews and a focus group, in that focus groups are group interviews which rely not only on the format of the interview in terms of questions and answers, but on the interaction within the group (Stewart and Shamdasani, 1990). Focus groups is a guided discussion in which 5-7 questions are usually asked during a 1.5 to 2 hour session, the questions are semi-structured to ensure coverage of important issues yet allow for flexibility in responding to group initiated concerns. One of the benefits of focus group research is the additional insight gained from the interaction of ideas among group participants (Mertens, 1998), as was experienced to a certain extent within this study even though the intent was only to conduct group interviews.

4.4.4 Design of semi-structured and fully structured interviews

The design of the questions for the semi-structured and fully structured interviews is guided by the steps generally encapsulated in interviews and questionnaires indicated in the FCM literature (discussed in section 3.3.4.2) which include: the identification of key concepts/issues/factors influencing the problem; identification of causal relationships among the variables and the estimation of strength values i.e. weightings of each causal relationship. The estimates can be expressed in imprecise or fuzzy linguistic terms and the activation level or value of the concepts/variables can also be specified by the expert/stakeholder.

Firstly, there is a need to tailor some of the interview questions with respect to staff and student participants. For example in regard to obtaining background information the questions to put forward to students are different to those put forward to staff participants i.e. staff are asked about their academic background, years of work experience, areas in which they specialised, position held etc, which is not relevant to student participants. Furthermore given that interviews with students are conducted in groups, the background information related to the individual students' familiarity with and their use of ICTs and educational software, for each student is elicited via the questionnaire. The questionnaire proved to be indispensable, for collecting specific and ordered data from each participant within the group interviews. Whereas for staff members, background information related to their familiarity with and their use of ICTs and educational software is elicited within the semi-structured interviews as these are conducted on an individual basis.

Apart from the slight variations mentioned above, the topic guide/agenda for the semi-structured interviews generally focuses on eliciting information related to the following areas: the participant's background; the participant's general perceptions about ICT and educational software adoption and use in schools; the existing IT infrastructure and the use of ICT and educational software within the school; obstacles/barriers which participants perceive prevent the use and adoption of ICT and educational software within the school; and factors which play a part in ensuring good practice of ICT use and educational software. (The topic guide/agenda for the semi-structured interviews is available in Appendix A) Hence the responses from the semi-structured interviews, based on the topic agenda, in combination with the responses from the fully structured interview would provide the necessary data for the construction of a rich

FCM model. In addition to the semi-structured interviews sources such as the schools' prospectuses, ICT policy documents, schools websites, allowed for the collection of information about the school' background in relation to their ICT infrastructure and ICT capabilities offered.

4.4.4.1 Design of the questionnaire

The questionnaire, for use in the fully structured interviews, in addition to eliciting background information concentrates on: establishing which factors are considered by the participant to be influential in the use of educational software by teachers and students; eliciting the estimation of strength values i.e. weightings of each causal relationship, between such factors; and the 'use of educational software by teachers' and the 'use of educational software by students'.

The questionnaire presents a long list of factors based on: factors that emerged from the literature (discussed in section 2.5); a list of problems, presented by Davis (1993), in the use of computers related to hardware, software, instruction and organisation; and a preliminary study in the same area (available in Appendix D). Table 5 shows the complete list of the factors which are presented in the questionnaire, accompanied by their descriptions. (The details of the measures of these factors, in the context of this study i.e. as concepts/nodes within the FCM model, are presented in chapter 7, Table 33.) Regarding each factor, there are three types of closed questions posed in the questionnaire, which are classed as type A, B and C. (There is however a variation in the number of B type questions posed with respect to students' and staff questionnaires, which is discussed later) These questions are construed within the format of statements so that it is easier for the participants to understand:

- A type- typically asks at what level the particular factor would need to be operational or active in order for the minimum/basic level of 'educational software use by teachers' and 'educational software use by students' to take place. The choices given are 'Very High', 'High', 'Moderate', 'Small' and 'None'. From the response it would be possible to ascertain whether the factor is considered to be influential in the up-take of educational software by the participant.

- B type - asks for either an agreement or disagreement with the statement. From the response it would be possible to determine whether a direct or indirect relationship exists between the particular factor and 'educational software use by teachers' and 'educational software use by students'. For example: An increase in 'IT equipment' will increase 'software use by students'. The choices presented are 'Agree' or 'Disagree'.

- C type - is concerned with the allocation of strength values to the relationships. It asks, given a change in the particular factor, what would be the level of the effect on 'educational software use by teachers' and 'educational software use by students'. The choices given are 'Very Big', 'Big', 'Moderate', 'Small' and 'None'.

Given that experts find it easier to express their beliefs using linguistic terminology, as stated in FCM literature, (see section 3.3.4.2) the choices in the questionnaire have been presented as linguistic terms, similar to those used by Tsadiras et al., (2001). This enables the stakeholders to find it easier to understand, and to express their opinions about the issue linguistically, even if this means indicating i.e. circling, a linguistic option.

The questionnaire was piloted by an expert i.e. ex-school teacher. The comments received from the expert led to the following revisions: The font size in the questionnaire to be presented to student participants was increased from size 10 to 12, as the expert considered that students would then find the questionnaire easier to read. There was a reduction in the number of B type questions/statements within the student participants' questionnaire. This was because the expert considered that children may find it boring and/or find it strenuous to answer a lot of questions within one interview session. Therefore the number of questions within the questionnaire needed to be reduced. Given that the B type questions regarding most of the factors were assumed to give a response (explained in detail in section 6.2) indicating a positive i.e. direct relationship, it was considered that these could be reduced within the students questionnaire while still keeping the questions crucial for the elicitation of specific data required for the FCM construction, intact. Once the questionnaire had been revised it was used as a tool for data collection (the questionnaires used for staff and students are available in the appendices see Appendix B and Appendix C).

Table 5 List of the factors presented in the questionnaire, and their descriptions

Factor	Description of the factor
1. Availability and access to IT facilities	The availability of computer suites, the general technological and structural infrastructure, which enables staff and students to have access to computing facilities.
2. Availability of non-outdated hardware/IT equipment	The availability of machines especially newer machines in classrooms and in computing suites, for example the availability of laptops for use by teachers and/or to enable mobile computing suites etc.
3. Time to prepare lessons using software	The time allocated to and/or spent by teachers to prepare lessons which involve the integration of ICT, in particular educational software i.e. the time they need to evaluate the software and the time they need to organise these lessons.
4. Amount of ICT usage in school	The amount of general ICT usage, in subjects across the curriculum, such as word processing, the use of the internet for research purposes etc by both students and teachers in school.
5. Availability of Technical Support Staff	The number of technical support staff needed to maintain the computing facilities and/or the availability of technical expertise to deal with ICT related problems, which enables staff and students to have trouble-free access to and usage of the computing facilities.
6. Level of Teachers' ICT skills	The level of the ICT skills held by teachers. This ranges from teachers having no ICT skills to teachers being able to use ICT pedagogically in the classroom within the teaching practice at the highest level.
7. Teachers' training in ICT	The level of training provided for and received by teachers in the school. This ranges from teachers in the school receiving no ICT training to being trained in how to use ICTs in a pedagogically effective manner at the highest level.
8. Guidelines for integrating software into school curriculum	The guidelines for incorporating software into the teaching and learning practice i.e. level of instructions/guidelines in how to incorporate the use of educational software into the lesson plan and conduct the lesson within a classroom environment.

Factor	Description of the factor
9. Educational software ability to satisfy learning objectives	The educational software's ability to satisfy specified learning objectives as set out in the teacher's lesson plan.
10. Educational software meets curriculum req.	The extent to which educational software meets the learning requirements set out in the National Curriculum.
11. Availability of educational software	The educational software made available in school which covers both the depth and breadth of subjects across the curriculum.
12. Levels in the ease of use of educational software	The level of ease in using educational software ranging from software being very difficult to use to being very easy to use.
13. Interactivity level of educational software	The extent to which educational software is interactive and user friendly.
14. Entertainment value of educational software	The software has features which keeps the user engaged in a manner that is interesting and entertaining. This ranges from software which is not entertaining to software which is highly entertaining.
15. Educational software ability to monitor student progress	The educational software's ability to monitor the student's progress i.e. determine how well the student has responded to questions and record such results.
16. Educational soft. ability to remedy the user's misconception	The educational software's ability to provide remedial assistance to the student with the aim of correcting the student's misconception.
17. Availability of specialised educational software	The availability of educational software for specialised subjects, i.e. for subjects besides core subjects such as media studies, business studies, etc.
18. Educational soft. ability to adapt to students needs and preferences	The educational software's ability to ascertain the preferences of the student in regard to the options available and determine the actual need of the students based on the student's advancement level and adapt accordingly.
19. Educational software ability to satisfy learning requirements.	The educational software's ability to satisfy the learning requirements as set out in the teacher's lesson plan.
20. ICT culture in school	The culture of ICT in the school, concerned with the approach the school takes in promoting and encouraging

Factor	Description of the factor
	the integration of ICT in the teaching and learning practices i.e. via policies, arranging IT training, funding in ICT related areas, motivating people to use ICT etc.
21. Teachers' usage of ICT outside of school	The use of ICT by teachers outside school, for example at home, both for work and leisure purposes i.e. preparing lessons, using the internet for work related research or for personal use, etc.
22. Students' usage of ICT outside of school	The use of ICT by students outside school for example at home, both for school related matters and leisure purposes i.e. using the internet for research purposes or personal use, doing coursework/homework for school, using software for learning or recreational purposes etc.
23. Teachers' usage of educational software	The extent of educational software use by teachers in the school. This ranges from teachers using no educational software to teachers using very high levels i.e. using educational software in all lessons in school.
24. Students' usage of educational software	The extent of educational software use by students in the school. This ranges from students using no educational software to students using very high levels i.e. using educational software in all lessons in school.

In regard to type B questions which are reduced in the students' questionnaire it is worth mentioning that they are used extensively in the questionnaire presented to staff participants. Although it had been assumed that responses to most type B questions would indicate positive i.e. direct relationships, (explained in detail in section 6.2), the action of incorporating B type questions extensively in the staff questionnaire is as a means to check this assumption. The only instances when B type questions are used in the students' questionnaires, similar to that of staff questionnaires, is when it is not straightforward to assume a positive i.e. direct relationship or even if there is a relationship, and this is regarded as information which needs to be specifically elicited from the participant. These are in regard to the following possible interrelationships: 1). Between factor 'availability and access to ICT facilities' and factor 'teachers' ICT usage outside of school'. 2). Between factor 'availability and access to ICT facilities' and factor 'student's ICT usage outside of school'. 3). Between factor 'amount of ICT usage in school' and factor 'teachers' ICT usage outside of school'. 4). Between factor 'amount of ICT usage in school' and 'student's ICT usage outside of school'. 5). Between factor 'teacher usage of educational software' and factor 'student usage of educational software'. 6). Between factor 'student usage of educational software' and factor 'teacher usage of educational software'. Given the time constraints of the interviews the fully structured interview concentrates on the specific interrelationships between factors mentioned above in addition to the relationships between each of the factors listed in Table 5 and 'students' usage of educational software' and 'teachers' usage of educational software'. Other interrelationships are identified from the analysis of the data obtained from the semi-structured interviews.

4.4.5 Data Analysis

The next step to consider is the methods of analysis required, in order to extract from the empirical data gathered the information required for the construction of the FCM model. The manner in which the questionnaires for the fully structured interviews has been designed, is to provide specific data, straightforward to interpret and convert into information required for the construction of individual FCMs. A step by step elicitation of the data from the fully structured interviews, and its conversion into information for the development of the FCM model is described in chapter 6. The measures used to convert the linguistic terms, used to describe strength values associated with the weightings of relationships, into numerical values have been based on the conversion values used by Tsadiras et al., (2001) and is discussed in section 6.2.

For the analysis of the data gathered from the semi-structured interviews appropriate methods of analysis need to be chosen that will explicitly provide information for the construction of the FCM model. Tsadiras, Kouskouvelis and Margaritis, (2001) state that the two main methods for the construction of FCMs are a) the questionnaire method (i.e. domain experts are interviewed and questionnaires are completed) and b) the documentary coding method (Wrightson, 1976) (i.e. the systematic encoding of assertions, in documents, made by specific persons on specific topics). Given that the transcriptions derived from the semi-structured interviews, can be construed as documents in which assertions have been made by stakeholders on the adoption and use of educational software, the documentary coding method is considered an appropriate method for eliciting specific data pertaining to the construction of the FCM model.

Wrightson, (1976) contends that coding is the first step in the process of building a cognitive map, (i.e. considered as the basic structure of a fuzzy cognitive map, described in section 3.2). The coder needs to perceive the text structurally and by content. The sentences, phrases or paragraphs that are of interest are those that assert a causal relationship i.e. ‘A’ affects ‘B’ negatively or positively. A sentence structure which parallels such a relationship grammatically in English is Subject/Verb/Object, while in coder terminology the most basic structure is Cause Concept/Linkage/Effect Concept. The cause concept and effect concepts must be represented as variables i.e. have the potential to take on different values. For example the ‘availability of IT facilities’ is a valid concept because it can be ‘high’ or ‘small’. Within coding concepts the alternative values of variables for example ‘high’ or ‘little’ do not need to be specified if it is understood, otherwise it needs to be included in the description of the variable (Variables, i.e. termed factors in this study have been described in Table 5 and their respective measures have been described and presented in chapter 7, Table 33.). However Wrightson (1976) adds that there are cases in which the phrase, sentence or group of sentences do not constitute relationships in a grammatical and structural sense. In these instances, Wrightson (1976) recommends the best approach is to use content analysis and within the analysis to ask the fundamental question “does the thrust of the phrase, sentence, etc. imply a relationship, and if it does then to code the relationship accordingly.

Content analysis is a classical procedure for analysing textual material (Flick, 1998; Holsti, 1976; Krippendorf, 1980). Krippendorf, (1980) defines content analysis as “a research technique for making replicable and valid inferences from the data to their context” (Krippendorf, 1980, p.21). The procedures involved within content analysis include counting the frequency of words, paraphrasing, grouping similar paraphrases, etc. (Flick, 1998; Holsti, 1976; Krippendorf, 1980). Easterby-Smith, et al., (2002) contend that content analysis of qualitative data is time consuming, and requires good written field notes or verbatim transcripts to be available. However the method does allow key features to be derived from the data and at the same time allow for some of the richness of the material to remain. In this study the transcripts of the semi-structured interviews are available, and in line with the recommendation by Wrightson (1976), content analysis, is used in combination with the documentary coding method to analyze the qualitative data from the semi-structured interviews to provide information for the construction of the FCM model. The analysis of the data and the development of the model are discussed in detail in chapter 6.

4.5 The simulation method adopted

The discussion in sections 3.3.3. and 3.3.4 clearly indicated that the dynamic ability of the FCM allows for the exploration of different alternatives and 'what-if' scenarios, and has been considered and proved to be an important and useful characteristic within many studies. In highlighting (refer to section 3.3.4.2) that a number of studies have not utilised the full potential of an FCM model as they have not exploited its dynamic ability and in providing justification for using FCMs as a modelling approach for this study in section 3.4, this thesis has emphasised the importance and relevance of utilising the dynamic feature of the FCM model within this particular study. Therefore it is necessary to consider the simulation process which will play a fundamental role in exploiting the dynamic ability of an FCM model.

Given that this thesis adheres to the principles and procedures within the FCM theory in constructing an FCM model it also adopts the simulation process as described within the FCM literature. Sections 3.2.1 and 3.2.2 outline the mathematical procedures that are entailed in the simulation of an FCM model. Where an FCM state vector A at time step $(t+1)$ is computed by multiplying the state vector $A(t)$ (i.e. the state vector A at time step t) by connection FCM matrix, and a threshold function is applied to normalise the state value i.e.

$A(t+1) = S\,[A(t).\,F]$ Equation 9

Where $A(t)$ = the state vector $(1 \times n)$ of concepts at some time step t

F= the FCM connection matrix $(n \times n)$.

S= the threshold or non-linear transformation function

Therefore to explore the effects for example of a policy or investment, by allowing the FCM model to evolve, the simulation process is initiated by changing the node activation levels of the factors within the state vector A which have been affected by the policy or investment change. Therefore A0 represents the state vector at $t = 0$ then $A(t+1) = S\,[A(t).\,F]$ is calculated for t = 0, 1, 2, and so on until the FCM reaches either a state of equilibrium, a limit cycle, or a chaotic state (refer to section 3.2.2). The exact details and description of the simulation process used to conduct the simulation of the constructed FCM model, in exploring different scenarios within this thesis is provided in section 7.4.1.

4.6 Summary

This chapter presented and reviewed the epistemological and ontological stances of positivist, interpretive and pragmatic research paradigms and highlighted the differences between them. It listed quantitative, qualitative and mixed methods approaches as research approaches which use the philosophical assumptions associated with these paradigms, and provided a list of the strategies of inquiry and methods typically employed by these research approaches. The chapter discussed and provided justification for the mixed methods research approach adopted within this study. This was followed by a detailed description of the methods used to conduct the empirical study for this thesis. The chapter discussed the reasons for selecting the particular sample, and the reasons for drawing the particular sample from a range of different schools. It provided reasons for the sample size and for the number of field sites chosen. The chapter then discussed the reasons for choosing interviews as the main source of data collection and gave a general description of what this entailed i.e. a semi-structured interview based on a topic guide and a fully structured interview based on a questionnaire. Then issues related to access to educational settings were discussed in order to explain why group interviews were considered for student participants. This was followed by a detailed description of the topic guide used within the semi-structured interviews and of the design of the questionnaire. The differences which existed in the topic guide and questionnaire, for student participants and staff participants were also explained. The chapter provided details of the methods chosen to analyse the data, which included the documentary coding method and content analysis. Finally the chapter provided details of the simulation process that was chosen to conduct the simulation of the FCM model.

The outcome of implementing the strategies of enquiry and adopting these methods of data collection and analysis are discussed in chapters 5 and 6. Chapter 5 provides a detailed description of the empirical research conducted, the backgrounds of the field sites and of their ICT infrastructure and capabilities, a statistical summary description of the sample and a detailed description of the participants' backgrounds. Chapter 6 provides a detailed description of the step-by-step analysis of the empirical data, the output of which is used in the construction of the FCM model.

Chapter 5: Description of the schools, the participants and research conducted

5.1 Introduction

Chapter 4 discussed and justified the research approach adopted for this study. It discussed the selection of the sample for the empirical study and outlined the methods for data collection. It discussed the methods of analysis required to extract relevant information from the empirical data, for the development of the fuzzy cognitive map modeling the up-take of educational software in schools. This chapter describes the research that took place with participants from three different schools, referred to as schools A, B and C respectively.

The next section provides the backgrounds of each school and gives an insight into the current level of their ICT infrastructures and ICT capabilities in terms of the number of computer suites, number of computers, other types of equipment available, state of the network, accessibility to the internet, availability of technical support, ICT based lessons and/or courses offered etc. The subsequent section compares the three schools; it highlights similarities and differences. It establishes that the three schools are typical of schools in their respective boroughs and in England.

The chapter then describes the ways in which the schools were approached and the manner in which the research was conducted with participating staff and students from each school. This is followed by a statistical summary description of the research participants and a brief discussion to provide an overall view of the sample which participated and provided empirical data for this study. The chapter then presents a description of each of its participants, which in addition to demographic information such as sex and age, provides information related to ICT experience, training etc which has been elicited during the fully structured interviews. It concludes by emphasizing the importance of the contents of this chapter, given that some of the information presented is drawn upon later in the thesis in the determination of the participants' credibility weightings, which is discussed in chapter 6.

5.2 Background of schools A, B and C

Section 5.2 presents the backgrounds of schools A, B and C, including an overview of their current level of ICT infrastructure and ICT capabilities, based on information extracted from documents such as the schools' prospectuses, from the schools' websites and from the semi-structured interviews conducted with participants, described in section 4.4.4. In doing so, the section provides a general view of the domains in which the empirical study for this thesis has been conducted and an understanding of the environments pertaining to the participants of this study.

School A is described as a mixed secondary comprehensive school, taking all pupils regardless of ability and aptitude, from the ages 11 to 18. It has community school status i.e. is maintained by the local education authority (LEA), which also has main responsibility for deciding arrangements for admitting pupils. Located within the London Borough of Barking and Dagenham, school A was founded in 1922, and was the first co-educational grammar school in England. The school has approximately 1650 pupils; it draws pupils from a large number of primary and secondary schools from its borough, taking in about 270 pupils each year. The school operates on two sites with Years7-8 on one site and Years 9-13 on another. In 1997 the school was awarded Specialist Sports College status. This was followed by a number of awards which include: the Schools' Curriculum Award, Investors in People Award, two Government's Achievement Awards for Excellence, Sports mark Gold, the Technology Colleges Trust "Most Improved Schools" and the "Most Value-added Schools" Awards. In 2002, School A was invited by the government to become a Beacon School in order to share their expertise and success.

More recently school A has been selected by the Department for Education and Skills (DfES) as one of only five secondary schools in the country to be an ICT Test Bed Pilot School. The ICT Test Bed project is a multimillion pound project designed to run over four years, September 2002-August 2006. The test bed schools under the project will receive funds to invest in high levels of IT hardware and software and will receive help and support to make the most effective use of this investment. The aim of the project is to examine how effective use of ICT can support the wider Government agenda of school reform (DfES, 2003). At the time of this research, school A had been allocated over £2 million to spend over three years on computer technology equipment. This has meant that school A has been able to procure, and still continues to procure, state-of-the-art technologies, relevant resources and allow for the professional development of its staff.

There are currently over 400 computers in the school, which will probably increase over the next few years. Data projectors and teaching desks containing audio visual equipment, graphic tablets to aid and enhance teaching and learning, have also been fitted in classrooms across the school. Furthermore, as a result of recent upgrades to the network, the school has a 100Mb pipeline providing fast internet access. Teaching staff at the school have each been provided with computers i.e. either laptop or desk top to aid them with their teaching. There have also been efforts to provide students with as much access to computers as possible, including the refurbishment of the library, which now accommodates 26 brand new PC's, 3 colour laser printers and a data projector and screen. In order to cope with all the new equipment, network and upgrades school A has increased its technical support staff by 200%. It also has a web developer to design, build and maintain the school internet and intranet websites, in addition to developing online curriculum for the school. Discrete ICT lessons are taught to pupils, and is part of the compulsory core curriculum for year groups 10 and 11. There is regular use of 'Maths Alive' educational software in the mathematics lessons for year groups 7-9.

School B is also a mixed secondary comprehensive school taking pupils from ages 11 to 18, regardless of ability and aptitude. It has Voluntary Aided status i.e. is maintained by the LEA, with a foundation which appoints most of the governing body which controls and administers the admission of students. School B located, in the Borough of Hillingdon, was created as a result of the merger of two schools in 1977, and operates on two sites with Years7-9 on one site and Years 10-13 on another. It draws on pupils from Hillingdon and neighbouring boroughs and has approximately 1155 pupils. School B has received awards and recognition over the last couple of years, such as the: 'Investor in People' status; DfEE Achievement Award and the silver Arts Mark, because of the high quality of creative arts in the school. In 2003 the school's bid to become a Specialist Science College was accepted by the DfES, which led to an increased range of opportunities in Mathematics, Science, Information Technology and other subjects at the school.

In regard to ICT infrastructure and ICT capabilities, school B has a computer network which is being upgraded and extended to meet the increasing IT demands in all areas including in its' extra curricular clubs. It has two IT suites in the upper school, each fully equipped for a class of 30 students. The lower school also has two computer suites with about 26 computers each. There are 7-10 computers in a number of other rooms, for example design and technology department have 10 computers in their central room. The school also has some laptops for students and intends to procure more. Laptops, as part of the national 'Laptops for teachers' scheme, have also been allocated to staff, but need to be shared. For example, three laptops have been allocated to the Science department to be shared between its 13-14 members of staff. In addition the school has some specific software packages and a few multimedia projectors. The library provides access to the internet and multimedia resources. Students can access computers during lunch hours by joining the school's ICT clubs. The school has recently employed one IT technician who serves both sites of the school, before this the school did not employ a full time technician, and they are now currently advertising for another technician. Recently the school had been allocated £27,000 for teacher training as a part of a government scheme in which teachers were trained in the use of ICT in the classroom. The GCSE Business Studies and IT courses offered at the school are concerned with many factors which include the acquisition of communication skills, the use of computer programs to gain an understanding of data bases, computer graphics and word processing. Discrete ICT lessons are given to students in year groups 7-9 on a rota basis, they have an ICT lesson per week for about a term and a half and then they swap to either food technology or wood technology. The ICT lessons to these pupils are not offered all year round.

School C is also described as a mixed secondary comprehensive, taking pupils of all ability and aptitude, from ages 11 to 18. The school has Foundation School status, i.e. is maintained by the LEA but where the admission of students is controlled and administered by the governing body. The school situated in the Borough of Hillingdon originally opened in 1907 as a co-educational secondary grammar school for just 150 pupils. After the First World War the school moved to larger premises as the number of people in the locality increased. The school remained a grammar school until 1977, and achieved grant-maintained status in 1990. The school now has roughly 1150 pupils. Designated by the DfES, school C has became an Arts College specialising in Music and Performing Arts; it offers special opportunities in the Arts, which are not found in non-specialist schools. It has received the Arts Council 'Artsmark Gold' quality assurance award in recognition of its outstanding achievement in the Arts. In addition, the school has also received the Sport England 'Sportsmark Gold' quality assurance award in recognition of sporting achievements.

School C, in regard to the level of ICT infrastructure and its ICT capabilities, has three main IT suites, each with 30 computers. There are computers in the library, GNVQ area, Careers Room and Business Studies Department and six computers in the staff room. There are 60 wireless laptops available for classroom use as well. In total school B has 300 plus computers on the network and provides Internet access. In addition the school has access to digital cameras, scanners, graphics tablets, high quality laser printers, CD-ROM titles and a range of other software. It employs two technicians to mange the computers and network. The school's ICT department has an open access policy, so students are free to use the ICT facilities throughout the school day, from before the start of registration and through lunchtimes and breaks. Most teachers in the school are now computer literate and as part of the national 'Laptop scheme' teachers at the top of the hierarchy have been given laptops. Discrete ICT lessons are taught to years 7-12 as well as pupils using ICT in all subject areas. All pupils from years 7-9 have one ICT lesson a week, pupils learn to use Microsoft Word, Excel and Access, among other applications, including Art Packages and Outlook Express. ICT can be taken at GCSE, AS Level or A Level. The pupils from year 7 to year 13 are given their own email account at the school (subject to parental agreement) and access to the World Wide Web.

This section has provided the backgrounds of the schools A, B and C, which participated in this study. It has also presented a picture of the current ICT status in each school. The next section compares the three schools, highlighting any similarities and drawing attention to any major differences.

5.3 Comparison of schools A, B and C

In this section, comparisons are made between schools A, B and C, by drawing on statistical information provided by the government and on the available background information of each school. Firstly however, five tables are presented: Tables 6 and 7 with the added narrative provide some information about terms such as 'Key Stages' (KS) and 'Levels of Achievement' in order to provide a basic understanding of the academic and schooling system in England, and importantly because reference will be made to these terms later within this section; Table 8 provides information which will help to gain an insight into the schools in terms of size, academic achievement and standards in comparison to each other. Tables 9 and 10 will help to compare the achievements of schools A, B and C between each other and in comparison to the achievements of average schools in their borough and in England as a whole.

In England pupils aged 5-16 in state schools must be taught the National Curriculum. This is divided into four 'Key Stages' based on children's ages, see Table 6 below:

Table 6 Pupils' age groups, year groups and the associated Key Stages of the National Curriculum (Source, DfES, 2004b)

Year Group	Reception	1	2	3	4	5	6	7	8	9	10	11
Age group of pupils at end of year	5	6	7	8	9	10	11	12	13	14	15	16
Key Stage	Key Stage 1			Key Stage 2				Key Stage 3			Key Stage 4	

For example at Key Stage 3 pupils must be taught: English, mathematics, science, history, geography, design and technology, ICT, modern foreign languages art and design, music, physical education, citizenship and religious education. The National Curriculum also sets standards of achievement in each subject. The standards range from Levels 1-8. Pupils progress to higher levels as they learn more and become older, as seen in Table 7 below:

Table 7 Pupils' ages and the expected levels of achievement (DfES, 2004b)

Ages	**Expected to achieve Level**
Most 7 year olds	Level 2
Most 11 year olds	Level 4
Most 14 year olds	Level 5 or 6

Table 8 Statistical background information for Schools A, B and C for the year 2003 (DfES, 2004b)

Background Information	School A	School B	School C
Total number of pupils	1618	1190	1152
Number of pupils aged 13	270	183	184
GCSE/GNVQ			
Number of pupils aged 15 at the start of the school year	268	184	175
% of 15 year old pupils achieving 5 or more grades A*-C (GCSE/GNVQ) the standard normally need for advanced study	60%	78%	55%
% of 15 year old pupils achieving 5 or more passes at grades A*-G (GCSE/GNVQ)	96%	96%	89%
% of 15 year old pupils achieving no passes (GCSE/GNVQ)	3%	1%	3%

Based on the available information it is evident that schools A, B and C are all mixed secondary comprehensive schools. They all take students from ages ranging 11-18 regardless of ability and aptitude. Although they may have slight variations in their status regarding the admissions authority body in their school, they are all maintained by the LEA (local education authority). From Table 8 it can be seen that schools A, B and C all have more than a 1000 students. School B with a total of 1190 pupils and school C with 1152 pupils are of similar size (in terms of student numbers). School A is larger with a total of 1618 pupils. However in comparing school A with other schools within its borough i.e. in the borough of Barking and Dagenham, it's size in terms of student numbers represents a size which is typical of schools from that borough. Most schools within the borough of Barking and Dagenham have a total number of pupils, in excess of 1000, which is usually closer to the 1600 figure (DfES, 2004b). School B and C both from the borough of Hillingdon, also represent sizes which are typical of sizes of schools in their borough; most schools within Hillingdon borough have roughly a total of 1100 pupils (DfES, 2004b). This establishes that all three schools A, B and C are fairly large schools, and their size, in terms of student numbers, is typical to that of other schools in their respective boroughs.

Table 9 Extract of the Secondary School Performance Tables 2003-Key Stage (KS) 3 Results of Schools A, B and C, including the relevant borough averages and the England average (DfES, 2004b)

	No. of eligible pupils			**% achieving Level 5 or above**						**Average point score**
	Total	**SEN with statements**	**SEN without statements**	**English**		**Maths**		**Science**		
		%	%	L5+	A/D	L5+	A/D	L5+	A/D	
LEA Average for London Borough of Barking and Dagenham				62%		61%		59%		32.0
School A	269	0.7%	7.4%	72%	2%	68%	2%	71%	2%	33.9
LEA Average for London Borough of Hillingdon				65%		73%		67%		33.5
School B	183	3.3%	9.3%	80%	1%	92%	1%	92%	0%	37.3
School C	182	6.6%	0.5%	60%	2%	74%	2%	68%	2%	33.1
England Average				69%		71%		68%		34.3

Key 1 Explanation to Table 9 (source DfES, 2004b)

Table 9 shows: the number of pupils at the end of Key Stage 3 eligible to be assessed in May 2003 (All pupils aged 13 or 14 - including those with special educational needs are eligible for assessment under the National Curriculum when they reach the end of KS3); the percentage of eligible pupils with special educational needs with and without statements; and the percentage of eligible pupils in each subject who achieved Level 5 or above in English, mathematics and science tests. Level 5 or 6 is the level of achievement expected of most pupils at the end of KS3 (see Tables 6 and 7).

SEN- Refers to pupils with Special Educational Needs

L – Level of achievement

A/D- Percentage of pupils absent or disapplied. The schools' results seen in the table above are based on the results of all pupils at the end of Key Stage 3, and includes in the calculations even those who were absent on the day of the test or disapplied from the National Curriculum. The schools' results can therefore be considered to be

affected. To take this into account, the percentage of eligible pupils who were absent or disapplied is shown alongside the percentage achieving Level 5 or above. The higher the percentage of pupils absent or disapplied, the more a school's results may have been affected by pupils with no test results

Average point score- Provides a picture of the Key Stage 3 achievements of pupils of all abilities. The average point score allows easier discrimination between schools, particularly those with similar percentages. For example, a score of 35 means on average, pupils who took KS3 tests at the school achieved mostly Level 5 or Level 6. It is calculated by dividing the total number of points achieved by all pupils eligible for KS3 assessment in each subject by the number of eligible pupils in each subject.

Table 10 Extract of the Secondary School Performance Tables 2003- Key Stage 2 to Key Stage 3 Value Added, of Schools A, B and C, including the relevant borough averages (DfES, 2004b)

	Key Stage 2 to Key Stage 3 Value Added	
	Measure	Coverage
LEA Average for London Borough of Barking and Dagenham	98.2	
LEA Average for London Borough of Hillingdon	98.9	
School A	99.1	97%
School B	100.5	98%
School C	99.0	97%

Key 2 Explanation to Table 10 (source DfES, 2004b)

Explanation of value added measure- A way of measuring the progress that pupils have made between taking assessment tests when they are aged 10 or 11 (KS2) and assessment tests when they are aged 13 or 14 (KS3). Value added measures allow for comparisons between schools with different pupil intakes. For example, pupils attending school A may achieve results in KS3 tests above the expected level while pupils at school B may achieve below. In value added terms however, the pupils at school B may have made more progress than pupils relative to their KS2 starting point and therefore have a higher value added `score' than school A.

Key Stage 2 to Key Stage 3 measure- Each pupil's value added score is based on comparing their KS3 performance with the median - or middle - performance of other pupils with the same or similar results at KS2. The individual scores are averaged to give a score for the school that is represented as a number based around 100. This indicates the value the school has added on average for their pupils. Scores above 100 represent schools where pupils on average made more progress than similar pupils nationally, while scores below 100 represent schools where pupils made less progress. For example a measure of 101 means that on average each of

the school's pupils made one term's more progress between KS2 and KS3 than the median for pupils with similar KS2 attainment. A score of 99 means that the school's pupils made a term's less progress. As a guide, at KS2 to KS3, schools with 50 or more pupils in the value added measure, scores of 99.2 to 101.0 are broadly average while for schools with 100+ pupils, scores of 99.5 to 100.7 are broadly average

Key Stage 2 to Key Stage 3 coverage- The percentage of pupils eligible for KS3 assessment that are included in the value added calculation. It gives an indication of schools where the value added measures may be unrepresentative. A low coverage indicator means that information was not available to calculate the value added scores of many of the school's pupils, and so these pupils could not be included in the school value added calculation.

In considering the achievements at each of the schools A, B and C shown in Tables 8, 9 and 10: The percentage of pupils achieving grades A*-C at GCSE/GNVQ are 60%, 78% and 55% for schools A, B and C respectively. The average Key Stage 3 point score for school A is 33.9; for school B is 37.3 and for school C is 33.1. For school A, its point score in comparison to the average point score of 32 of its borough (Barking and Dagenham), is slightly higher. While in comparison to the Hillingdon borough average point score of 33.5, school C's score is slightly lower. In comparison to the England average point score of 34.3 the point scores of schools A and C although lower are relatively close, while school B's point score is fairly high. In examining Table 10, the value added measures seen are 99.1, 100.5 and 99 for schools A, B and C respectively. In comparison to the LEA average measure of 98.2 for the borough of Barking and Dagenham, school A' measure is slightly higher. School B and C's measures in comparison to the LEA average measure of 98.9 for their borough of Hillingdon, are also slightly higher. So pupils in schools A, B and C on average made more progress than similar pupils within their respective boroughs. Nationally, school B made more progress given that its score is above 100, while schools A and C in comparison made less progress given that their scores were below 100 (refer to Key 2).

It can therefore be inferred from the statistical data examined and discussion above that schools A, B and C are schools which to an extent can be considered to be typical of schools within their boroughs in terms of size i.e. pupil numbers. In regard to KS2 to KS3 value added measures and in performances at KS3, school A and C's results can be considered typical to those in its borough and in England, while school B's results indicate it is academically performing better than average schools in its borough and in England. In comparison to each other, school A has a larger number of pupils than schools B and C; school B's percentage of GCSE passes at grades A*-C, Key Stage 3 point score and value added measure is higher than that of school A and school C. However it should be noted that the percentage of pupils eligible for KS3 assessment that were included in the value added calculation for both schools A and C were 1% lower than that of school B i.e. the percentages given for coverage were 97% for schools A and C and 98% for school B. Overall it can be contended that schools A, B and C are all mixed comprehensive schools maintained by the LEA, they are neither special nor failing schools and can be considered to be representative of typical secondary comprehensive/state schools in England. Other differences between the schools are of course due to their history, location, culture, building structure etc., some of which have been described in section 5.2.

One important difference to be noted is regarding the current level of ICT infrastructure and ICT capabilities in the schools. From the discussion in section 5.2, it is clear that the schools A, B and C are at different points of the spectrum in relation to the levels of ICT infrastructure, capabilities and culture existing within each of the schools. School A is at one extreme of the spectrum in that, being part of the ICT test bed project has meant that it has the latest technological equipment. It currently has 400 PCs, an upgraded network providing fast internet access, an increased technical support staff, has provided each teaching staff with a laptop or desk top and is charged with a culture to promote the technologies in its environment. School C is a school holding an Arts College status; specialising in Music and Performing Arts, which accordingly is reflected in its culture. It has 300 plus computers, a range of software and its students have open access to facilities in its ICT department throughout the school day. Although the school provides details of ICT related lessons with students in its school, and relevant options available, these are basic requirements that now form part of the National Curriculum with regard to ICT as a taught subject and/or with regards to its use within other subjects of the curriculum. School B at another end of the spectrum, recently acquired a

Specialist Science College status, which is to lead to a range of opportunities in subjects such as maths, sciences and information technology. Its network is being upgraded and it has only recently employed an IT technician, teachers have to share computers among themselves and year groups 7-9 are taught discrete ICT lesson on a rota basis.

That schools A, B and C can be seen to be at different points of the spectrum in relation to their ICT capabilities as discussed above is of benefit to this study. The benefit is twofold: Firstly schools in England are at different levels of ICT implementation/integration, therefore the three schools A, B and C as a cluster would be representative of such typical schools in England. Secondly, this study will be able to encapsulate the views of participants who, because of their environment, will have differing experiences of ICT and therefore the study will be able to gain and provide a richer/wider insight into the adoption and use of educational technologies in schools. The next section discusses the research conducted in schools A, B and C. It discusses the stages involved from initial contact with the schools through to the overall processes involved to gain access to the participants and conduct the empirical research.

5.4 Description of the research conducted

Personal contact led to effective introductions at schools A, B and C. The schools were provided with documents outlining the thesis research proposal, the methods that would be used for data collection and the number and type of participants that would be required for the study. This was followed by scoping meetings with relevant members of staff: at school A, meetings took place with the school's ICT-coordinator; at school B, the initial meeting was conducted with the Headmaster and subsequent meetings took place with the personal contact who was also a member of the teaching staff; at school C meetings were conducted with a contact who was a member of the teaching staff. These meetings led to negotiating relevant access with both students and staff at the schools.

All the schools were provided with the criteria of the participants that were required for this study (described in section 4.4.1): male and female students, from each year group 7 to 11; staff members consisting of at least one ICT technician, one ICT co-ordinator, and four to five other teachers, with different backgrounds in terms of subject specialities, number of years of work experience and positions held within the school. The ICT co-ordinator at school A and the personal contact at school B were responsible for selecting pupils and approaching members of staff that met the required criteria and mediating mutually convenient times during which the empirical study could be conducted. At school C the contact was responsible for selecting, organising access and timings for the research with students only, with regards to the staff member participants the contact provided a list of names of people who were willing to participate and met the required criteria. In this instance the staff on the list were contacted directly with regard to arranging interview dates and times either by telephone and/or by correspondence.

Two different group interviews were arranged with students at each of the schools A and B, given that both schools A and B are based on two different sites. At school A, one group interview was conducted with pupils from years 7 to 8 at the lower school, which was arranged by the head of the lower school and another group interview with pupils from years 9 to 11 at the upper school which was arranged by the ICT co-ordinator. At school B, one group interview was conducted with pupils from years 7 to 9 at the lower school and another group interview with pupils from years 10 to 11 at the upper school. Given that school C was located on one site it was possible to conduct one group interview with pupils from years 7 to 11 at one particular time. In all three schools, with regards to conducting research with the students the arrangements included the provision of a room or seating place to accommodate the student participants, and for the students to obtain leave from their lessons with the permission of the relevant classroom teacher, on the specified date. In the case of school C, permission was also obtained from the parents of the students participating. Each group interview with students included a semi-structured interview followed by a fully structured interview, and lasted for about 1 hour.

The interviews, with the staff members at schools A, B and C, who met the necessary criteria and who were willing to participate, were scheduled, based on their free teaching periods within the school day. The interviews with staff members were conducted on an individual basis and included a semi-structured interview followed by a fully structured interview. The duration of the interviews with the staff participants varied between 40mins-1.5hrs. The exact details of the research with all of the participants in terms of the rationale for selecting them, how they were approached, the time, date, location and nature of the interviews conducted with them are presented in Appendix E.

5.5 Statistical summary description of research participants

This section provides a statistical summary description of the sample participating in this study. Table 11 presents statistical information about the student participants and Table 12 presents statistical information about staff participants, based on data elicited from the fully structured interviews. There are separate tables because the information pertaining to student and staff bodies are different in that in addition to providing demographic information as to gender, age and/or year group, students have been asked about lessons they attend, their experience of software and ICT use in lessons in school and at home, whereas staff have been asked about their areas of expertise, years of work experience and trainings related to ICT. The information presented in both tables, together provide an overview of the whole sample.

Table 11 shows that the sample of students participating in this study have been balanced carefully between each of the schools in terms of gender and year group: a male and female from each year group, 7-11 from each school has participated. The total number of students in the sample is 30. All students indicated that they have access to a computer at school, and 29 students indicated they had access to a computer at home. 93% of the total number of students participating indicated that they used ICT at home and 73% of the total number of students indicated that they had experience of using educational software at home. In this regard it is seen that 90% of students from school A and 80% of students from school C use educational software at home in comparison to 50% of students from school B. The sample of students participating are seen to attend most of the taught subjects in school specified in the National Curriculum, except for Humanities. The table also highlights the use of educational software and ICT within these taught subjects, as indicated by the participants for example: 50% of students attending Art lessons in school A have had experience of using educational software in that subject compared to 13% at school B and 17% at school C; 14% of students at school B and 25% at school C attending the taught subject of citizenship have had experience of using subject-specific software, whereas although 70% of students in school A, attend citizenship lessons in school A, none of them have had the experience of using educational software in the subject; in the subject of mathematics attended by all students in the sample, 80% of students from school A have experienced the use of subject-specific software in comparison to 40% of students from schools B and C. Overall the table provides a picture of the students in the sample, of their access to computers at school and home, and their use of ICT and educational software at home and in taught curriculum subjects as a whole and according to each of the schools A, B and C.

Table 12 shows that the total number of staff participants in the sample was 16, of these 81% are male and 19% are female. 38% of the participants fall in the 30-39 age group, 19% are aged

20-29, 19% are 40-49, while 25% are 50-59. In terms of years of work experience the sample reflects a variety of participants ranging from newly qualified teachers having less than 2 years work experience, to those with more than 20 years of experience in the field. The sample also includes teachers from a range of different subject backgrounds; 1 Art teacher, 1 Design and Technology, 1 History, 5 ICT, 3 Mathematics, 1 Modern Foreign Language, 1 Science, 1 Business and 1 Media Studies teacher. 94% of the staff participating indicated that they have access to a computer at school, and 81% have access to a computer at home. In regard to ICT related training 38% of the staff sample had achieved ICT competencies as part of the Qualified Teacher award, 62% indicated that they had not. The reason for this is that it has been introduced only fairly recently for those training to become a teacher, therefore teachers who qualified more than 10 years ago, for example, would not have been subject to the scheme. 50% of teachers in the sample indicated that they had received computer related training as part of the NOF (New Opportunities Fund) scheme, and of those who had received the training 87.5% completed it. In addition 62% of the sample indicated that they had received other computer related training.

Overall Tables 11 and 12 give an overview of the sample as a whole, in terms of the number of students and staff, their gender and ages; their experience of ICT, for teachers in terms of their training and for students in terms of ICT and educational software use in curriculum subjects. Information, with regard to the staff participants' use of educational software and ICT, has been elicited as part of the semi-structured interviews and will be referred to in chapter 6. The following section presents detailed background information pertaining to each individual participant.

Table 11 Summary description of student participants

School	**A**	**B**	**C**	**Total as %**
Sex				
Male	5	5	5	50% (15 participants)
Female	5	5	5	50% (15 participants)
Total no. of student participants	10	10	10	100% (30 participants)
Year Group				
7	2	2	2	20% (6 participants)
8	2	2	2	20% (6 participants)
9	2	2	2	20% (6 participants)
10	2	2	2	20% (6 participants)
11	2	2	2	20% (6 participants)
Have access to computer at home	100% (YES)	90% (YES) 10% (NO)	100% (YES)	97% (YES) 3% (NO)
Have access to computer at school	100% (YES)	100% (YES)	100% (YES)	100% (YES)
Use ICT i.e. general software packages, the internet, games etc at home or outside of school.	90% (YES) 10% (NO)	90% (YES) 10% (NO)	100% (YES)	93% (YES) 7% (NO)
Use educational software packages at home or outside of school.	90% (YES) 10% (NO)	50% (YES) 50% (NO)	80% (YES) 20% (NO)	73% (YES) 27% (NO)
Currently taught the following subjects in school:				
Art	80%	80%	60%	73%
Citizenship	70%	70%	80%	73%
Design and Technology	70%	80%	70%	73%
English	100%	100%	100%	100%
Geography	60%	70%	80%	70%
History	70%	70%	80%	73%
Information technology	90%	100%	90%	93%
Mathematics	100%	100%	100%	100%
Modern Foreign languages	90%	80%	100%	90%
Music	60%	60%	60%	60%

School	**A**	**B**	**C**	**Total as %**
Physical Education	100%	90%	100%	97%
Religious Education	60%	100%	90%	83%
Science	100%	100%	100%	100%
Business	20%	10%	0	10%
Drama	10%	10%	20%	13%
Child Development	10%	0	0	33%
Textiles	10%	0	0	33%
Media Studies	0	0	10%	33%
Have experience of using educational software packages in the following taught subjects in school:	Percentage of those attending the taught subject who have used edu. software.	Percentage of those attending the taught subject who have used edu. software.	Percentage of those attending the taught subject who have used edu. software.	Percentage of those attending the taught subject who have used edu. software.
Art	50%	13%	17%	27%
Citizenship	0	14%	25%	14%
Design and Technology	43%	75%	29%	50%
English	0	30%	50%	27%
Geography	17%	29%	38%	29%
History	0	14%	13%	9%
Information technology	56%	80%	89%	75%
Mathematics	80%	40%	40%	53%
Modern Foreign languages	44%	38%	80%	56%
Music	33%	0	17%	17%
Physical Education	0	0	10%	4%
Science	0	20%	90%	37%
Business	50%	100%	0	67%
Have experience of using general ICT in the following subjects in school:	Percentage of those attending the taught subject who have used ICT	Percentage of those attending the taught subject who have used ICT	Percentage of those attending the taught subject who have used ICT	Percentage of those attending the taught subject who have used ICT
English	40%	0	0	13%
Physical Education	10%	0	0	4%
Religious Education	17%	0	0	4%
Science	10%	0	0	3%
Drama	100%	0	0	100%
Child Development	100%	0	0	100%
Textiles	100%	0	0	100%

Table 12 Summary description of staff participants

School	A	B	C	Total as %
Sex				
Male	5	5	3	81%
Female	1	0	2	19%
Total no. of staff participants	6	5	5	100% (16 participants)
Age				
20-29	0	0	3	19%
30-39	3	3	0	38%
40-49	2	1	0	19%
50-59	1	1	2	25%
60-up	0	0	0	0
Years of work experience				
=<2	1	0	3	25%
=<5	1	0	1	13%
=<10	0	2	0	13%
=<15	2	2	0	25%
=<20	1	1	1	19%
=<25	0	0	0	0
>25	1	0	0	6%
Have access to computer at home	6 YES	3YES 1 NO 1 N/A	4 YES 1 NO	81% (YES) 13% (NO) 6% (N/A)
Have access to computer at work	6 YES	4YES 1 N/A	5 YES	94%(YES) 6% (N/A)
Teach the following subjects in school:				
Art	0	0	1	6.25% (1 participant)
Design and Technology	0	1	0	6.25% (1 participant)
History	0	0	1	6.25% (1 participant)
Information technology	2	2	1	31.25% (5 participants)
Mathematics	2	1	0	18.75% (3 participants)
Modern Foreign languages	1	0	0	6.25% (1 participant)
Science	0	1	0	6.25% (1 participant)
Business	0	1	0	6.25% (1 participant)

School	A	B	C	Total as %
Media Studies	0	0	1	6.25% (1 participant)
Have achieved ICT competencies which form part of Qualified Teachers award	2 YES 4 NO	1 YES 4 NO	3 YES 2 NO	38% (YES) 62% (NO)
Have received computer related training as part of the NOF (New Opportunities Fund) scheme	3 YES 3 NO	4 YES 1 NO	1 YES 4 NO	50% (YES) 50% (YES)
Have completed NOF training	2 YES	4 YES	1 YES	87.5% of those who received the NOF training
Have received other computer related training	5 YES 1 NO	3 YES 2 NO	2 YES 3 NO	62% (YES) 38% (NO)

5.6 Description of research participants

Tables 13 to 18 presents details on the background of all participants in the study sample. The information is based on data from the fully structured interviews. Although a summary description of the sample was provided in section 5.5, the information was statistical and grouped according to each school. However, in the tables below, not only are the backgrounds of each participant provided but the participant is also identifiable with a unique participant id. This is important so that it is possible to link the fuzzy cognitive maps, derived for each participant in the sample to the participant's particular background and ultimately to his/her credibility weighting. The information presented within this chapter and the tables below will form a crucial part in the development of the combined fuzzy cognitive map, modelling the factors in the up-take of educational software in schools. As mentioned in sections 3.3.4.2 and 3.4, credibility weightings are an integral part of combining individual FCMs, and are considered to be a matter of concern which need to be addressed within the context of this thesis. In this regard chapter 6 will discuss the criteria for determining participants' credibility weightings and will draw heavily on the information presented within this chapter and importantly from Tables 13-18 presented below to determine and allocate credibility weightings i.e. values based on experience and expertise, to each of the participants.

Table 13 Background description of the staff participants at school A

Participant Id.	Position/Role	Gender	Age	Areas of expertise	Years of experience in the field	QT award received	NOF training received	Other computer Related training received	Computer access at work	Computer access at home
StaffA1	ICT coordinator/ICT teacher	Male	40-49	Mathematics	18	N/A	Yes and completed	Yes	Yes	Yes
StaffA2	Head of key stage 3 French/Teacher of Modern Foreign Languages French and German	Male	30-39	French	5	No	Yes but not completed	Yes	Yes	Yes
StaffA3	Department Head/Assistant Head Teacher/Teacher of Mathematics	Male	40-49	Mathematics	18	Yes	Yes and completed	Yes	Yes	Yes
StaffA4	Teacher of Mathematics	Female	30-39	Mathematics	14	N/A	No	Yes	Yes	Yes
StaffA5	Teacher of ICT	Male	30-39	ICT	2	Yes	No	No	Yes	Yes
StaffA6	ICT Technician	Male	50-59	Networking/ Desktops/ Servers	35	N/A	N/A	Yes	Yes	Yes

Table 14 Background description of the staff participants at school B

Participant Id.	Position	Gender	Age	Areas of expertise	Years of experience in the field	QT award received	NOF training received	Other computer Related training received	Computer access at work	Computer access at home
StaffB1	ICT Coordinator/Head of Department/Teacher of Business and ICT	Male	30-39	Business and Finance	8	N/A	Yes and completed	Yes	Yes	Yes
StaffB2	Second in department/Teacher of Sciences	Male	30-39	Chemist	15	N/A	Yes but not completed	Yes	Yes	Yes
StaffB3	Head of Year 10/Teacher of Mathematics and ICT	Male	40-49	Mathematics and Statistics	17	Yes	Yes and completed	Yes	Yes	Yes
StaffB4	Head of Design and Technology/Teacher of Design and Technology	Male	50-59	Graphics, Resistant Materials, Electronics and ICT	15	N/A	Yes but not completed	Yes	Yes	Yes
StaffB5	ICT Technician	Male	20-29	Operating Systems, NT, servers	6 years work experience but only 6 months in school.	N/A	N/A	Yes	Yes	Yes

Table 15 Background description of the staff participants at school C

Participant Id.	Position	Gender	Age	Areas of expertise	Years of experience in the field	QT award received	NOF training received	Other computer Related training received	Computer access at work	Computer access at home
StaffC1	Director of ICT/Teacher of ICT	Male	50-59	IT, Mathematics, Business Studies	20	Yes	Yes and completed	Yes	Yes	Yes
StaffC2	Teacher of Social Sciences	Female	20-29	Social Science	2	Yes	No	No	Yes	No
StaffC3	Teacher of History	Female	20-29	History and English	1	Yes	No	No	Yes	Yes
StaffC4	Teacher of Art	Male	20-29	Art and Design	2	Yes	No	Yes	Yes	Yes
StaffC5	ICT Technician	Male	50-59	IT	4	N/A	N/A	No	Yes	Yes

Table 16 Background description of the student participants at school A

Participant Id.	Gender	Year Group In School	Computer access at school	Experience of educational software use in the following subjects taught at school	Experience of general ICT use in the following subjects taught at school	Computer access at home	Experience of general ICT incl. software e.g. Internet, games packages use at home i.e. outside of school	Experience of educational software use at home i.e. outside of school
StuA1	Female	7	Yes	Mathematics, Modern Foreign Languages	English (word processor)	Yes	Yes	Yes
StuA2	Male	7	Yes	Mathematics, Modern Foreign Language	English (word processor)	Yes	Yes	Yes
StuA3	Female	8	Yes	IT , Mathematics	N/A	Yes	No	Yes
StuA4	Male	8	Yes	IT, Mathematics	Religious Education (word processor)	Yes	Yes	Yes
StuA5	Female	9	Yes	Art, Design and Technology, IT, Modern Foreign Languages, Music	N/A	Yes	Yes	Yes
StuA6	Male	9	Yes	Art, Design and Technology, Geography, IT, Music	N/A	Yes	Yes	No
StuA7	Female	10	Yes	Art, Mathematics	English, Physical Education, Drama, Child Development (word processor), Textiles	Yes	Yes	Yes
StuA8	Male	10	Yes	Art, Mathematics	N/A	Yes	Yes	Yes
StuA9	Female	11	Yes	IT, Mathematics, Modern Foreign Languages, Business	English, Science (word processor)	Yes	Yes	Yes
StuA10	Male	11	Yes	D&T, Mathematics	N/A	Yes	Yes	Yes

Table 17 Background description of the student participants at school B

Participant Id.	Gender	Year Group In School	Computer access at school	Experience of educational software use in the following subjects taught at school	Experience of general ICT use in the following subjects taught at school	Computer access at home	Experience of general ICT incl. software e.g. Internet, games packages use at home i.e. outside of school	Experience of educational software use at home i.e. outside of school
StuB1	Female	7	Yes	Mathematics, Modern Foreign Languages	N/A	Yes	Yes	Yes
StuB2	Male	7	Yes	Design and Technology, English, IT, Mathematics	N/A	Yes	Yes	No
StuB3	Female	8	Yes	Design and Technology, IT	N/A	No	No	No
StuB4	Male	8	Yes	Design and Technology, IT	N/A	Yes	Yes	Yes
StuB5	Female	9	Yes	Art, Design and Technology, English, Geography, History, IT, Mathematics, Modern Foreign Languages	N/A	Yes	Yes	No
StuB6	Male	9	Yes	Citizenship, Design and Technology, English, Geography, IT, Mathematics, Modern Foreign Languages	N/A	Yes	Yes	Yes
StuB7	Female	10	Yes	IT, Science	N/A	Yes	Yes	Yes
StuB8	Male	10	Yes	Design and Technology, IT	N/A	Yes	Yes	Yes
StuB9	Female	11	Yes	D&T, IT	N/A	Yes	Yes	No
StuB10	Male	11	Yes	IT, Business	N/A	Yes	Yes	No

Table 18 Background description of the student participants at school C

Participant Id.	Gender	Year Group In School	Computer access at school	Experience of educational software use in the following subjects taught at school	Experience of general ICT use in the following subjects taught at school	Computer access at home	Experience of general ICT incl. software e.g. Internet, games packages use at home i.e. outside of school	Experience of educational software use at home i.e. outside of school
StuC1	Female	7	Yes	Art, MFL, Science	N/A	Yes	Yes	No
StuC2	Male	7	Yes	Humanities, IT, Music	N/A	Yes	Yes	Yes
StuC3	Female	8	Yes	English, Geography, MFL, Science	N/A	Yes	Yes	Yes
StuC4	Male	8	Yes	D&T, English, IT, Mathematics, MFL, Science	N/A	Yes	Yes	No
StuC5	Female	9	Yes	Citizenship, English, Geography, IT, MFL, Science	N/A	Yes	Yes	Yes
StuC6	Male	9	Yes	Geography, IT, MFL, Science	N/A	Yes	Yes	Yes
StuC7	Female	10	Yes	Citizenship, IT, Mathematics, MFL, Science	N/A	Yes	Yes	No
StuC8	Male	10	Yes	English, IT, Mathematics, MFL, Physical Education, Science	N/A	Yes	Yes	Yes
StuC9	Female	11	Yes	Citizenship, English, History, IT, Science	N/A	Yes	Yes	Yes
StuC10	Male	11	Yes	IT, Mathematics, MFL, Science	N/A	Yes	Yes	Yes

5.7 Summary

This chapter has provided an insight and understanding of the domains, in which the empirical study for this research has been conducted, by presenting the backgrounds of schools A, B and C, which includes an overview of their current level of ICT infrastructure and ICT capabilities. It has drawn comparisons between schools A, B and C, and with average schools in their respective boroughs in England. The chapter has established that the three schools from which participants have been drawn for this study, are representative of typical secondary schools in England, they are neither special nor failing schools. They do however have their own characteristics and specialities, for which they have been recognised and awarded for by relevant bodies. Although differences were noted between the schools in regard to ICT infrastructure and capabilities, this was considered of benefit to this study. This because schools in England are at different levels of ICT implementation/integration, therefore the three schools as a cluster would be representative of such typical schools. In addition this study would be able to provide a richer and wider insight into the adoption and use of educational technologies in schools by drawing on the views of participants who have differing experiences of ICT, because of their particular environments.

The chapter described the research conducted at the schools from the stages of initial contact through to the overall processes involved to gain access to the participants and conduct the interviews. It next presented and discussed the statistical summary descriptions of the sample. This was followed by detailed background descriptions of each individual participant, presented within tables. The section emphasised the importance of the information within this chapter, given that the presented material will be drawn upon, in the determination of participants' credibility weightings, which is to be discussed next in chapter 6.

Chapter 6: Development of the FCM model

6.1 Introduction

This chapter describes the overall construction of the FCM modelling the up-take of educational software in schools. It draws on the empirical data which has been collated by the methods discussed in chapter 4 and the information presented in chapter 5. The analysis of the empirical data and construction of the FCM model are described in three phases. The next section discusses the first phase of the FCM development which involves the construction of individual FCMs for each participant based on the empirical data gathered from the fully structured interviews. The following section describes the second phase of the FCM development which is concerned with the aggregation of the individual FCMs: It addresses the issue of determining participants' credibility weightings, an area of concern highlighted in chapter 3. The section presents the criteria, developed for determining the credibility weightings of participants within the context of this study. It draws upon the participants' background information presented in chapter 5 to allocate credibility weightings based on the criteria set out. The values are then used in the aggregation of the individual FCMs to form one main model. The last section discuses the third phase of the FCM development, which involves further additions and refinement of the FCM model based on the analysis of the empirical data collated from the semi-structured interviews. It presents a framework for determining the strength weightings of the relationships identified from the analysis. The chapter incorporates the newly identified and weighted relationships into the model derived from the second development phase and presents the final FCM model for this study.

6.2 First phase of main FCM development: Construction of individual FCMs

The initial phase of the FCM development consists of developing FCMs for each individual participant based on the empirical data gathered from the fully structured interviews. The fully structured interviews, as discussed in section 4.4.4.1, had been designed to elicit specific details pertaining to the development of a basic FCM modelling the factors influencing the use of educational software by teachers and students. The data which was recorded in tabular form was examined and relevant information was extracted, towards creating individual FCMs, in four consecutive steps for each participant, which included: Firstly the examination of the participant's responses to questions classed as 'type A' questions (described in section 4.4.4.1) for each factor, which typically asked if the particular factor would need to be operational or active at a certain level for the minimum/basic level of educational software use to take place, here any responses besides a 'no' answer would therefore indicate that the participant considered the factor to be influential in the domain of educational software use in schools. An example of this step, in the FCM development for participant StuB10 is considered and presented as follows: Participant StuB10's responses to 'A type' questions recorded in tabular form can be seen in Table 20; from the responses, it is clear that all 24 factors listed, according to StuB10, are influential to a certain extent in the use of educational software by teachers and students, and would therefore need to be incorporated in StuB10's FCM model; at this stage a model arising from this specific data would result in the basic map (see Figure 7). This is an example of the first step taken towards constructing FCMs for each individual participant.

The second step included the examination of the data to elicit whether relationships arising between concepts (as seen in the step 1map, Figure 7) are either positive or negative: Where an increase in the causal concept leading to an increase in the effect concept is considered a positive relationship and a positive sign is assigned to the relationship. While an increase in the causal concept leading to a decrease in the effect concept is considered a negative relationship and a negative sign is assigned to the relationship. It had been assumed, as mentioned in section 4.4.4.1, that in most cases it was logical that positive relationships would arise as a consequence of the responses to questions and statements asked in the fully structured interviews. This is because the factors which would pertain to concepts in the FCM, if considered relevant by the participant, had been defined in the fully structured interviews in a manner which was designed to subsequently lead to a positive relationship, as advocated by Kosko(1986). For example: the first factor-related question in the fully structured interviews was concerned with 'IT facilities and access' and whether it influenced 'Teachers' usage of educational software' and 'Students' usage of educational software', here the factor was phrased/defined as the 'Availability of IT facilities and access' instead of 'Lack of IT facilities and access'. If 'Lack of IT facilities and access' had been used, and if a relationship was indicated by the participant between 'Lack of IT facilities and access' and for example 'Teacher usage of educational software' then it would be a negative one, see example Figure 5 i.e. if the causal concept increases the effect concept decreases.

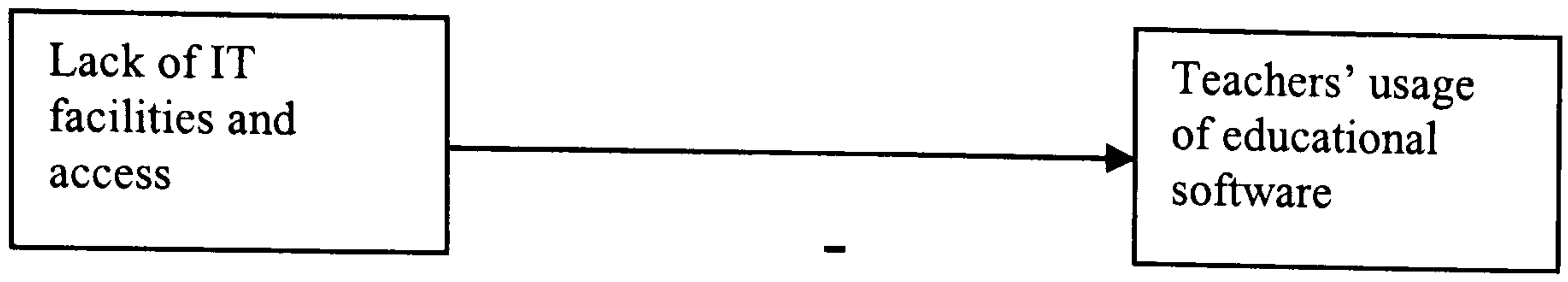


Figure 5 Example of a negative relationship between concepts

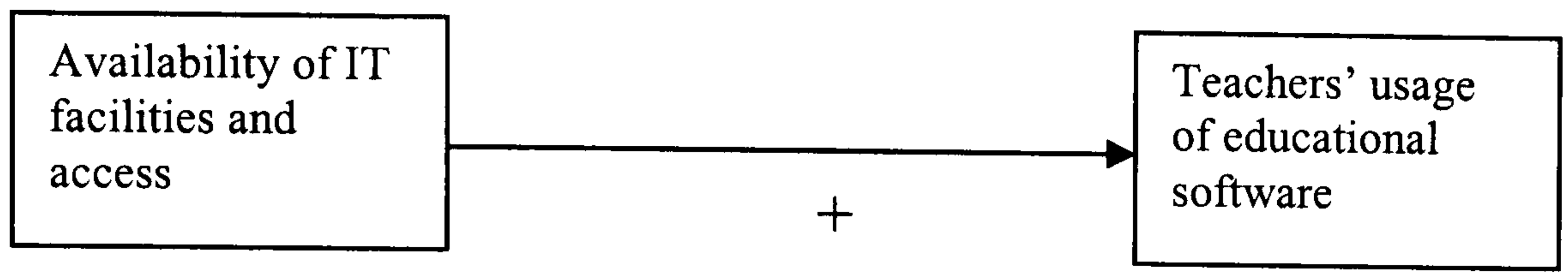


Figure 6 Example of a positive relationship between concepts

But by using the phrase 'Availability of IT facilities and access' an equivalent but positive causal relationship arises i.e. as the causal concept increases the effect concept increases, as seen above in Figure 6. This adheres to the rule given by Kosko (1986) to replace as far as possible every negative relationship with a positive one by modifying the concept pertaining to the relationship with its abstract negation or complement. For example:

$C_i \xrightarrow[-]{} C_j$ is replaced with $C_i \xrightarrow[+]{} \sim C_j$ where $\sim C_j$ is thought of as the abstract negation or complement set of C_j.

As a means of checking, that it was logical to assume that most of the relationships which would arise would be positive, staff participants had been asked to provide additional information, by responding, in their fully structured interviews, to a statement classed as type B (described in section 4.4.4.1) for each possible relationship. From the analysis of this information, most relationships which had been assumed to be logically positive, if they did exist for the staff participant, were confirmed to be positive from their responses. The only exception that arose was for the relationship between the causal concept 'Entertainment value of educational software' and the effect concept 'Teacher usage of educational software' for which, although most of the participants considered it to be a positive relationship, a few staff, considered the relationship to be a negative one.

However there were also certain relationships, for which it was not straight forward or logical to assume that these relationships would be positive, if they did exist according to the participant. Described in section 4.4.4.1, these were relationships that could arise: 1) Between factor 'availability and access to ICT facilities' and factor 'teachers' ICT usage outside of school'. 2) Between factor 'availability and access to ICT facilities' and factor 'student's ICT usage outside of school'. 3) Between factor 'amount of ICT usage in school' and factor 'teachers' ICT usage outside of school'. 4) Between factor 'amount of ICT usage in school' and 'student's ICT usage outside of school'. 5). Between factor 'teacher usage of educational software' and factor 'student usage of educational software'. 6) Between factor 'student usage of educational software' and factor 'teacher usage of educational software'. In regard to these particular relationships, students in addition to the staff also provided specific information, in the form of a response to a type B statement, from which it was possible to determine whether positive or negative relationships existed between these factors according to the participant.

Therefore in the case of staff participants, from their responses to type B statements, and by considering their overall responses to type A questions and type C statements, concerning each particular factor and possible relationship, it was possible to allocate negative or positive signs to relationships in their maps at step 1. In the case of students, most relationships were considered positive except for those specific ones mentioned above, for which their responses to B type statements and their overall responses to type A questions and type C statements, concerning each particular factor and possible relationship, was considered. For example, if the participant agreed to a B type statement, i.e. that an increase in the 'availability and access to ICT facilities' led to an increase in the 'teacher's usage of educational software' this meant that the relationship between the two concepts/factors was positive and would be assigned a positive sign.

If the participant did not agree to the B type statement, then the response to question classed as type A i.e. the level of 'availability and access to ICT facilities' the participant considered needed to be operational in order for 'teacher's usage of educational software' to occur was examined again, if a response 'no' had been obtained then it was considered that the participant did not consider the factor 'availability and access to ICT facilities' to be influential or that the participant considered that the factor did not have to be activated/increased in order for the basic level of the 'effect concept' to occur. This was followed by the examination of the response to the statement classed as type C which would be concerned with allocating a strength value to the relationship between 'availability and access to ICT facilities' and 'teacher's usage of educational software', by the participant. A response besides 'no' would mean that the participant still considered the factor to have an influence on the effect concept and it would therefore be deduced to be a negative influence and therefore a negative sign would be assigned to the relationship.

For example from the analysis of the empirical data for StuB10 most relationships were considered to be positive except for, the relationship between 'Availability and access to ICT facilities' and 'Student's usage of ICT at home' and the relationship between 'Amount of ICT usage in school' and 'Student's usage of ICT outside school', which were both considered to be negative and therefore a negative sign was assigned to the relationships. Given that most relationships were positive it was considered necessary to only assign a negative sign to a negative relationship in order to distinguish between the two types, i.e. the positive relationship was not assigned a positive notation, given that a positive numerical integer, is recognised without a '+' sign.

The third step included consideration of participants' responses to statements classed as type C (described in section 4.4.4.1), concerned with the allocation of strength values to relationships, the data was recorded in tabular form for each participant. Table 21 shows, as an example, the data recorded for participant StuB10, where the strength value for each relationship, in linguistic terms such as none, small, moderate, big or very big, allocated by StuB10, is presented . At this stage it was possible to present FCM maps for each participant by revising their basic maps derived at step 1, by inserting the positive or negative signs deduced from step 2 and the linguistic strength values associated with each relationship from the tables formed in step 3. Figure 8 shows the FCM constructed for StuB10 as an example.

Step four of the development of individual FCMs involved the conversion of the individuals FCMs derived at step 3, in which the strength weightings of the relationships had been expressed in linguistic terms, into FCMs in which the strength values were expressed numerically. This was a necessary step because the FCMs of individual participants would need to be aggregated in the second phase towards forming the main FCM model. Therefore each individual FCM would need to be represented in numeric terms i.e. in the form of a matrix in order for the aggregation which is mathematically based (discussed in section 3.2.1) to take place. In line with commonly used relationship weighting values for FCMs which range between 0 and 1 (discussed in section 3.2) and by drawing upon the conversion values used by Tsadiras, et al, (2001) the following conversion measures seen in Table 19 below were used: Where the five linguistic terms which had been used by participants in the study, were equated to values ranging from a minimum value of 0 to a maximum value of 1, rising in equal measurements of 0.25.

Table 19 Fuzzy conversion measures for relationship weightings

Fuzzy linguistic terms used to describe the strength values (weightings) of relationships (used in questionnaires)	None	Small	Moderate	Big	Very Big
Fuzzy numerical weights	0	0.25	0.5	0.75	1

These conversion measures were used to transform the participants' FCMs derived at step 3 to numeric FCMs. Each individual participant's FCM was then presented as a matrix. An example of StuB10's FCM matrix representation is seen in Figure 9, where Fn refers to the factor listed in Table 20 where n =1...24. While each cell in the *i*th row and *j*th column represents the weighting of the relationship between the causal concept i.e. factor in the *i*th row, and the effect concept i.e. factor in the *j*th column. For example value 0.25 seen in the cell of the 1st row and 21st column, is the weighting for the relationship between causal concept i.e. factor 1, and effect concept i.e. factor 21, previously linguistically termed as 'small' (refer to Table 21) by StuB10. This step marked the final step, in the construction of each individual FCM. The first phase was considered complete when individual FCMs, represented in matrix form, had been developed for all participants in the study (The full set of these individual FCMs are available in Appendix F). The second phase of the main FCM development concerned with the aggregation of these individual FCMs is discussed in detail in the next section.

Table 20 StuB10's responses to type A questions from the fully structured interview

Factors and their operational/activation levels in order for Factors 23 and 24 to occur:	Factor 23. Teachers' usage of educational software	Factor 24. Students' usage of educational software
1. Availability and access to IT facilities	Moderate	High
2. Availability of non-outdated hardware/IT equipment	Moderate	Moderate
3. Time to prepare lessons using software	Small	
4. Amount of ICT usage in school	Moderate	High
5. Availability of Technical Support Staff	High	High
6. Level of Teachers' ICT skills	High	High
7. Teachers' training in ICT	High	High
8. Guidelines for integrating software into school curriculum	Very High	Very High
9. Educational software ability to satisfy learning objectives	High	High
10. Educational software meets curriculum req.	High	High
11. Availability of educational software	High	High
12. Levels in the ease of use of educational software	High	High
13. Interactivity level of educational software	Moderate	Moderate
14. Entertainment value of educational software	Moderate	Moderate
15. Educational software ability to monitor student progress	High	High
16. Educational soft. ability to remedy the user's misconception	High	High
17. Availability of specialised educational software	High	High
18. Educational soft. ability to adapt to students needs and preferences	High	High
19. Educational software ability to satisfy learning requirements.	High	High
20. ICT culture in school	High	High
21. Teachers' usage of ICT outside of school	High	
22. Students' usage of ICT outside of school		High
23. Teachers' usage of educational software		High
24. Students' usage of educational software	High	

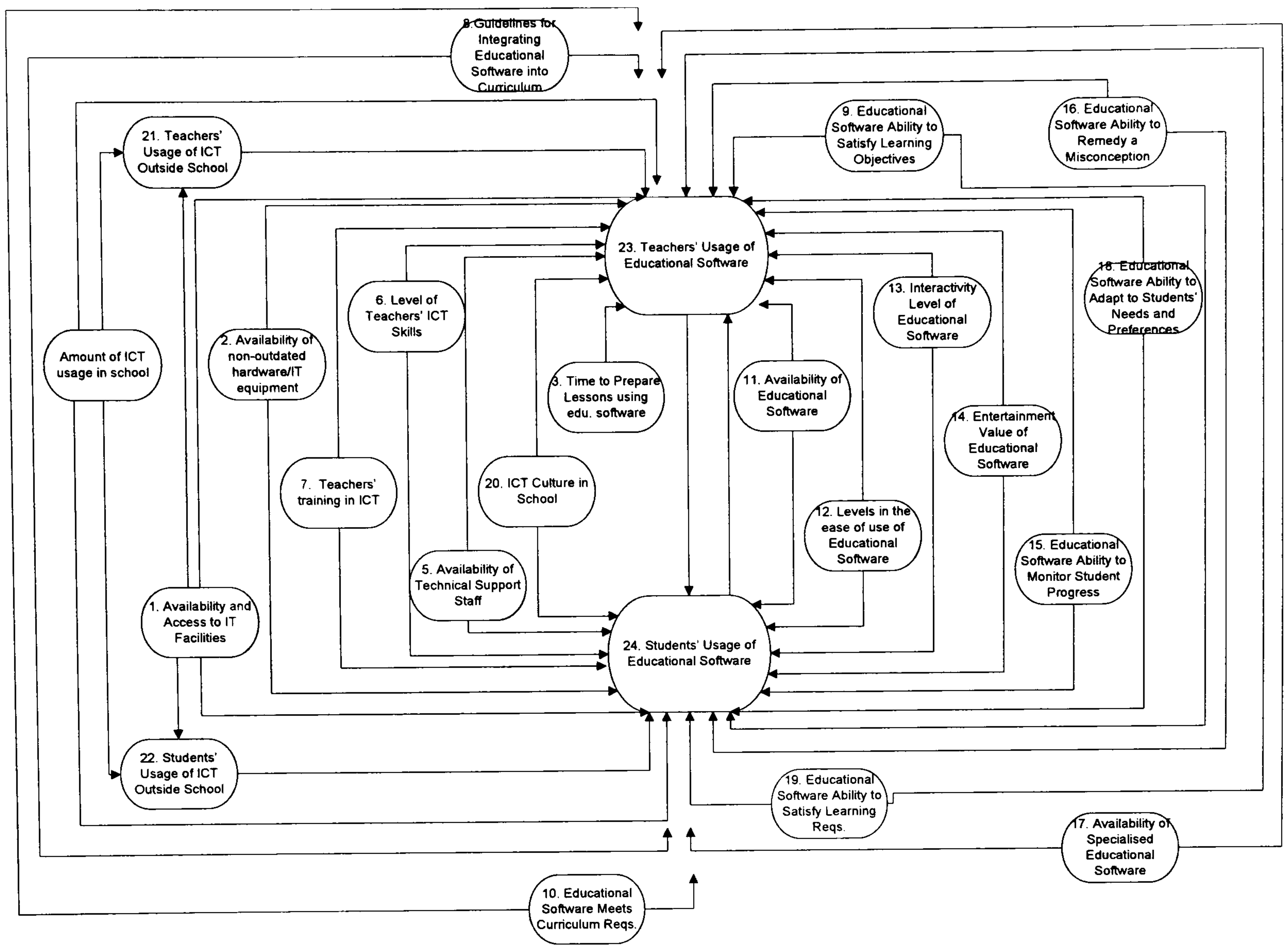
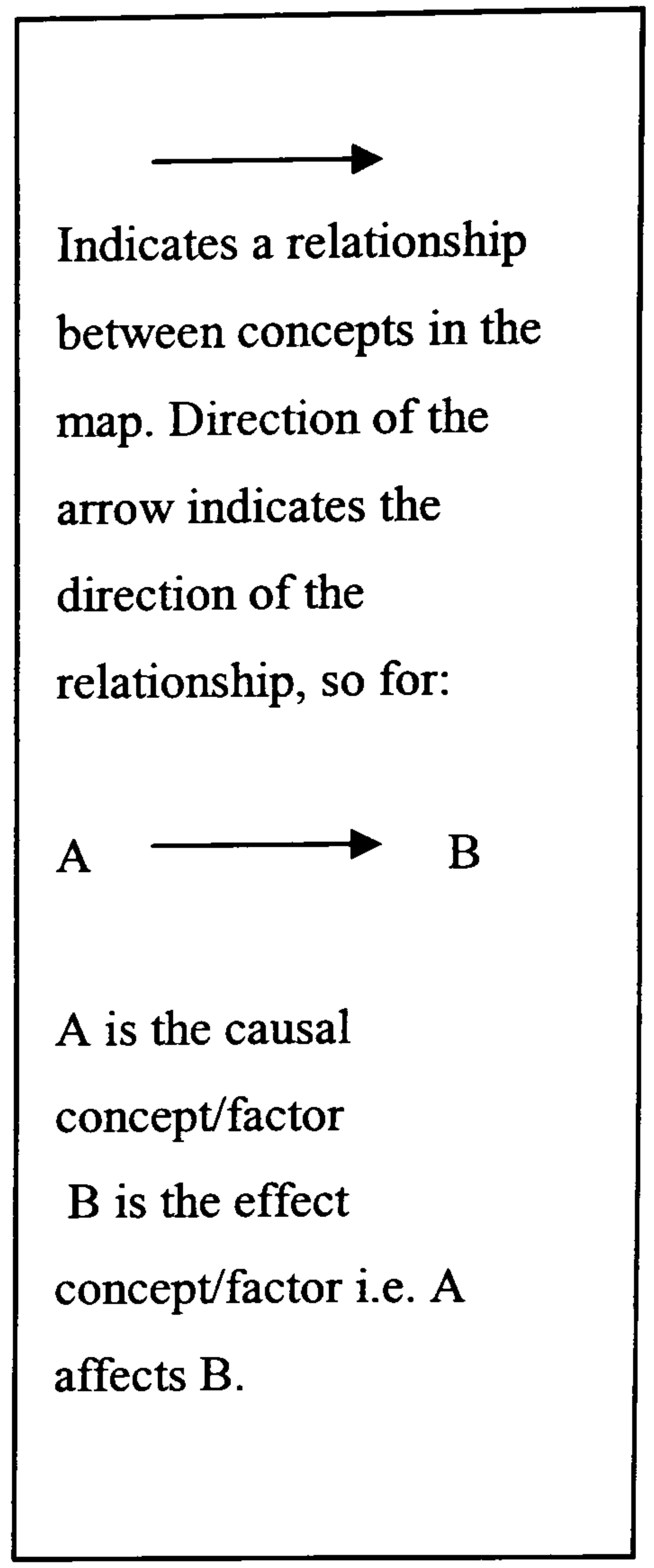


Figure 7 StuB10's map derived at step 1

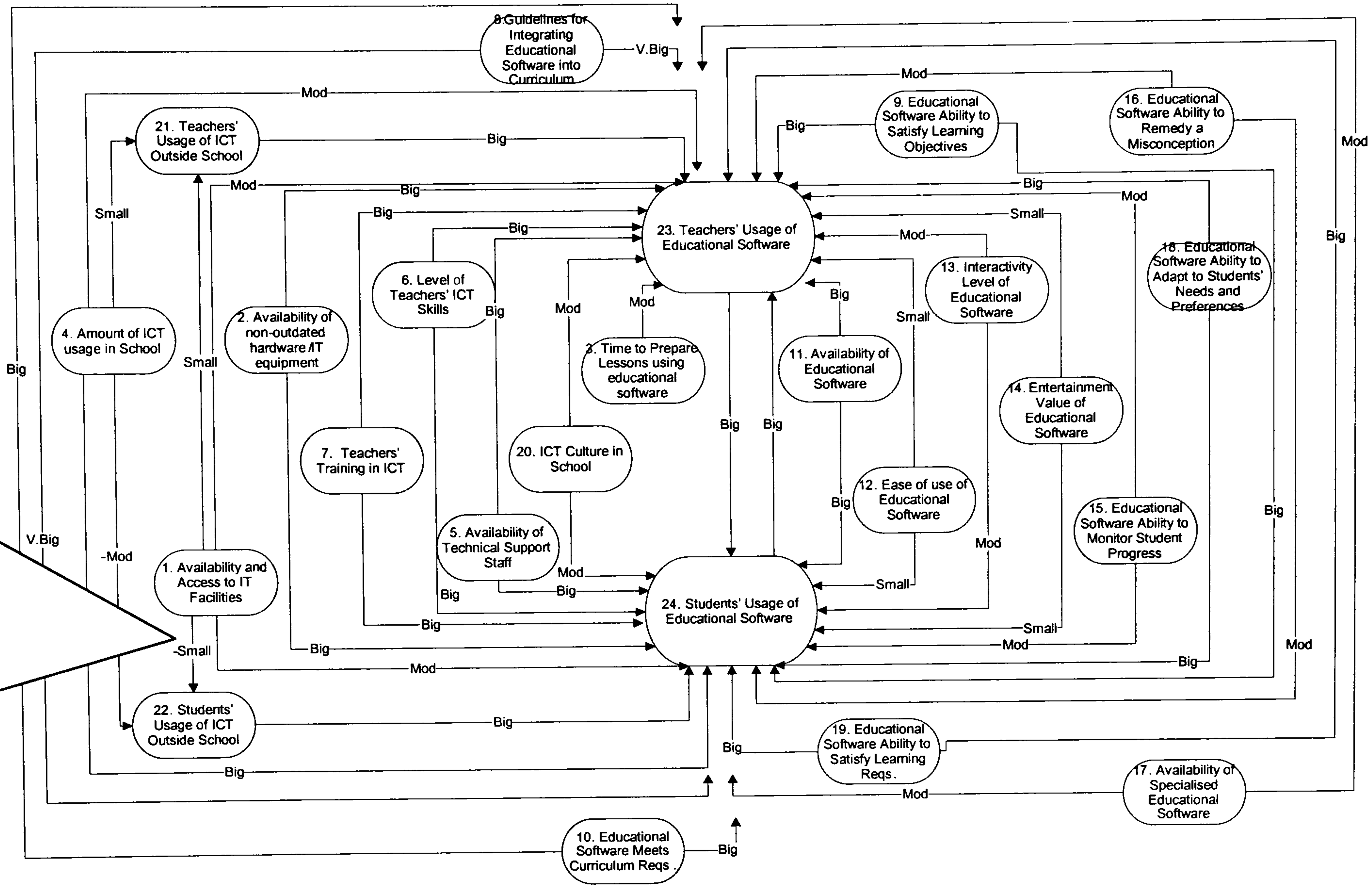


Key 3 to Figure 7

Table 21 Data recorded at step 3 related to the strength weights allocated to relationships by participant StuB10

Strength of relationships between influencing factors listed below and affected factors 21, 22, 23 and 24.	**Factor 23.**	**Factor 24.**	**Factor 21.**	**Factor 22.**
1. Availability and access to IT facilities	Moderate	Moderate	Small	Small
2. Availability of non-outdated hardware/IT equipment	Big	Big		
3. Time to prepare lessons using software	Moderate			
4. Amount of ICT usage in school	Moderate	Big	Small	Moderate
5. Availability of Technical Support Staff	Big	Big		
6. Level of Teachers' ICT skills	Big	Big		
7. Teachers' training in ICT	Big	Big		
8. Guidelines for integrating software into school curriculum	Very Big	Very Big		
9. Educational software ability to satisfy learning objectives	Big	Big		
10. Educational software meets curriculum req.	Big	Big		
11. Availability of educational software	Big	Big		
12. Levels in the ease of use of educational software	Small	Small		
13. Interactivity level of educational software	Moderate	Moderate		
14. Entertainment value of educational software	Small	Small		
15. Educational software ability to monitor student progress	Moderate	Moderate		
16. Educational soft. ability to remedy the user's misconception	Moderate	Moderate		
17. Availability of specialised educational software	Moderate	Moderate		
18. Educational soft. ability to adapt to students needs and preferences	Big	Big		
19. Educational software ability to satisfy learning requirements.	Big	Big		
20. ICT culture in school	Moderate	Moderate		
21. Teachers' usage of ICT outside of school	Big			
22. Students' usage of ICT outside of school		Big		
23. Teachers' usage of educational software		Big		
24. Students' usage of educational software	Big			

The following has been highlighted as an example: The term '- Small' indicates that there is a negative relationship between Factors 1 and 22 i.e. an indirect relationship exists and the strength of this relationship i.e. the effect that Factor 1 has on Factor 22 is small.



Key 4 to Figure 8

V.Big= Very Big effect
Big= Big effect
Mod=Moderate effect
Small=Small effect

Figure 8 StuB10's FCM map derived at step 3

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	-0.25	0.5	0.5
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	-0.5	0.5	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0

Figure 9 FCM matrix representation for participant StuB10

6.3 Second phase of main FCM development: Aggregation of individual FCMs

Following the construction of the individual fuzzy cognitive maps based on the perceptions of each of the different participants, the second phase of main FCM development involves the process of aggregating the individual FCMs to form one main FCM model. The process of combining FCMs, introduced earlier in section 3.3.4.2, is based on the following equation (Kosko, 1992, 1997):

$$F = \sum_{i=1}^{n} w_i F_i \qquad \textbf{Equation 8}$$

Where: Fi represents the augmented FCM matrix for expert/stakeholder i

n is equal to the number of experts/stakeholders

wi is equal to the credibility weight of expert/stakeholder i

At this point in the study, the individual FCM for each participant with respect to the Fi variable, seen in equation (8), is readily available. However the variable wi needs to be addressed. Given that some experts may be more credible than others, their contribution is multiplied with a credibility weight wi before combining it with other expert opinions, the weights state the relative value of the particular FCM in the virtual world. Credibility weights need not be in (0,1) (Kosko 1992,1997) but the value has to be non-negative. Such weights wi may come from professional rankings or test results (Kosko, 1992, 1997).

As discussed in, section 3.3.4.2, although credibility weighting is recognised to be important, it has been reported to be largely ignored by FCM researchers (Taber and Siegel, 1987). Although many have combined FCMs in their work, the use of wi=1 is common (Taber and Siegel, 1987), and there is a general lack of description as to how credibility of the experts have been addressed or determined in many studies i.e. Banini and Bearman, 1998; Schneider et al, 1995, 1998; Lee and Kim, 1997; Stylios and Groumpos, 1999b, 2000, etc. Most work which has addressed expert credibility weights has been mathematically based (Taber and Siegel, 1987; Silva, 1995a and 1995b; Kosko, 1995; Taber, 1991) and can be considered overly complex for the layman. In addition, even in the endeavours by Taber and Siegel, (1987) and Taber, (1991), their work has led to the credibility weighting of the knowledge rather than the source. The knowledge (for example an answer to a question) obtained from the expert would be checked against an approved and correct version of the answer, and allocated a mathematically based weighting. This method of allocating weightings however would not be suitable if the knowledge that is to be gathered from stakeholders in the field cannot be compared to a right or wrong answer, because such an answer does not exist i.e. the knowledge is subjective, is based on perceptions and opinions, as is the case within this thesis.

Lee and Han (2000), as discussed in section 3.3.4.2., aired concerns about the issue of determining credibility weightings, their approach was to use a statistical method for developing their FCM modelling EDI controls and performance. However their other reason for using the statistical approach was that they considered it would be difficult for the experts in their particular study to provide accurate data which was essential to model the complexities of the EDI controls. This is not the case within this thesis, on the contrary, given that the FCM modelling the educational software use in schools is aimed to be developed based on the perceptions of the relevant stakeholders.

Given that participants within this study, have varying credentials and experiences, even in relation to their positions in terms of being either a staff or a student member, it is not reasonable to assume credibility weightings of $wi=1$ for all participants. It is also not appropriate within the context of this study to adopt the existing approaches to determine or overcome the credibility weighing problem as discussed above. Therefore given that, Kosko (1997) states that credibility weights may come from professional rankings or test results; the assumption taken is that the manner in which expert credibility weights can be determined is flexible. The study therefore proceeds to establish the necessary criteria for determining and allocating the credibility weights to the participants within the context of this study.

6.3.1 Criteria to determine participant credibility weightings

Given the concerns posed by the issue of credibility weightings, and its importance in the aggregation of FCMs, this section sets out certain criteria which will help to determine the credibility of the experts/stakeholders within the context of this study. Tables 22 and 23 list criteria for students and staff respectively; provide explanations as to why each criterion is important in relation to this particular study; provide guidelines as to the means from which it will be possible to establish if the criteria is applicable to the participant; show an associated numerical value which is to be assigned to the participant if the participant meets that particular criteria. The overall credibility weightings of each participant can therefore be determined by drawing on Table 22 for students and Table 23 for staff and by totalling the numerical values which have been assigned based on each criterion met by the participant.

Table 22 Criteria to be used in the determination of credibility weights of student participants

Criteria for Student participants	**Why this criterion is important in determining the credibility of the participant for this particular research?**	**Means to be used to determine whether this criterion is applicable to the participant?**	**Numerical value associated with the criterion (See Key 5 below)**
A. The participant uses general software packages such as games etc, the internet outside of the school environment i.e. at home.	Experience of computer usage and general software usage indicates the participant's general experience in handling other software and therefore the individual is in a position to reflect on issues such as usability, interactivity and such features which are also existent in educational software packages.	Based on a direct response from participant in the fully structured interview conducted.	1
B. The participant uses educational software packages, outside of school i.e. at home.	Experience of educational software usage indicates the participant's general experience in handling software for educational purposes even if it is not in school. Therefore the participant is in a position to reflect on issues such as usability, interactivity etc and pedagogical features which are existent in educational software packages.	Based on a direct response from participant in the fully structured interview conducted.	2
Only one of the options from C, D and E can be applicable:			
C. Participant currently or in the past, has had some experience of using educational packages in lessons.	The participant has experience of some educational software usage in an educational environment for educational purposes, and is in a position to reflect on these experiences when providing information for this research.	Based on a direct response from participant in the fully structured interview conducted.	3

Criteria for Student participants	**Why this criterion is important in determining the credibility of the participant for this particular research?**	**Means to be used to determine whether this criterion is applicable to the participant?**	**Numerical value associated with the criterion (See Key 5 below)**
D. Participant currently or in the past, has had experience of using educational packages in lessons on a regular basis.	The participant has experience of regular educational software usage in an educational environment for educational purposes, and is in a position to reflect on these experiences when providing information for this research.	Based on current situ of ICT facilities in school; general insight of ICT adoption across the curriculum gathered from semi-structured interviews with staff and student participants; semi-structured interview conducted with the participant and on a direct response from participant in the fully structured interview conducted.	4
E. Participant currently or in the past, has had experience of using educational packages in lessons extensively.	The participant has experience of extensive educational software usage in an educational environment for educational purposes, and is in a position to reflect on these experiences when providing information for this research.	Based on current situ of ICT facilities in school; general insight of ICT adoption across the curriculum gathered from semi-structured interviews with staff and student participants; semi-structured interview conducted with the participant and on a direct response from participant in the fully structured interview conducted.	5

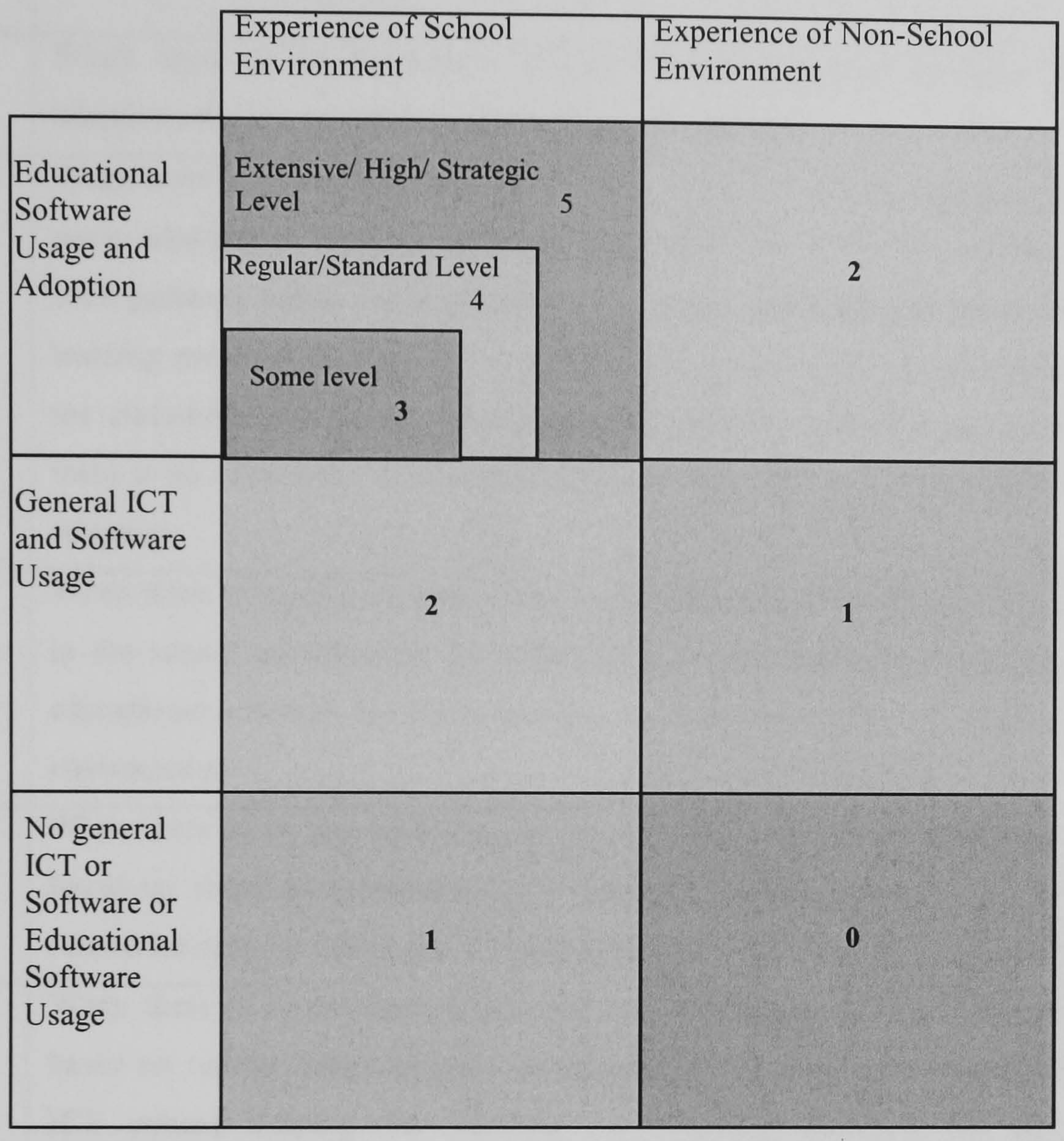
Table 23 Criteria to be used in the determination of credibility weights of staff participants

Criteria for Staff participants	**Why this criterion is important in determining the credibility of the participant for this particular research?**	**Means to be used to determine whether this criterion is applicable to the participant?**	**Numerical value associated with the criterion (See Key 5 below)**
G. The participant possesses professional qualifications in ICT/ICT related studies	The participant has a high level of ICT understanding and offers insight and information to this research based on an academic rationale.	Based on a direct response from participant in the fully structured interview conducted.	2
H. The participant has a background working with ICT in general.	Participant has past experience, skill and knowledge of ICT. Even though the participant may have been in a different environment with a different ICT adoption, the participant may have come across areas/issues which are similar to the areas/issues surrounding the school environment and its adoption of ICT and educational software. Therefore the participant can reflect on these experiences and contribute to this research	Based on a direct response from participant in the fully and semi structured interviews conducted.	1
I. The participant is currently working with general ICT in school.	The participant is working with ICT and experiencing the use of ICT in the school environment. The participant is in a good position as he/she experiences ICT adoption in the school first hand and is more aware of the current situation of the adoption and its uses in the school. Therefore the individual can reflect on these experiences and contribute to this research.	Based on a direct response from participant in the fully and semi structured interviews conducted.	2

Criteria for Staff participants	**Why this criterion is important in determining the credibility of the participant for this particular research?**	**Means to be used to determine whether this criterion is applicable to the participant?**	**Numerical value associated with the criterion (See Key 5 below)**
J. The participant is currently involved with ICT and educational software in the curriculum in terms of planning and decision making.	The participant is involved in the planning and decision-making with regard to using ICT and educational software in the curriculum. The participant is in a good position as he or she has awareness and a thorough understanding of the current situation of educational software adoption in schools and can reflect on planning and decision-making experiences and contribute to this research.	Based on a direct response from participant in the fully and semi structured interviews conducted.	5
The participant has had specific IT related training such as those listed below:	Participant has a certain level of ICT proficiency, knowledge, and skills, which is geared towards using ICT specifically in schools for teaching and learning, and therefore the individual is in a good position to contribute to this research by reflecting on this specific knowledge and training.	Based on a direct response from participant in the fully structured interview conducted.	
K. QT award	See above	See above	4
To choose only one option from L or M:			
L. NOF training incomplete	See above	See above	3
M. NOF training completed	See above	See above	4

Criteria for Staff participants	**Why this criterion is important in determining the credibility of the participant for this particular research?**	**Means to be used to determine whether this criterion is applicable to the participant?**	**Numerical value associated with the criterion (See Key 5 below)**
N. The participant has had additional computer training.	Participant has a certain level of ICT proficiency, knowledge and skills, and therefore is in a position to contribute to this research by reflecting on this knowledge and skills.	Based on a direct response from participant in the fully structured interview conducted.	1
O. The participant has a number of years of teaching experience.	The participant has the experience of working in a school environment and in the teaching process. Therefore the participant has awareness of the classroom environment, experience of integrating materials in teaching, awareness of students with differing abilities, understanding of the educational needs of the students and generally the education system etc. The participant can reflect on these experiences in contributing to this research.	Based on semi-structure interview conducted with the participant.	Exception to the Key- a value of 0.5 is to be assigned per teaching year (where the minimum value is set at 1, given the experience of being in a school environment).
To choose only one option from C, D and E:			
C. Participant currently or in the past, has had some experience of using educational packages in teaching and learning practices or evaluating it for such purposes	The participant has experience of some educational software usage in an educational environment for educational purposes, and is in a position to reflect on these experiences when providing information for this research.	Based on semi-structure interview conducted with the participant.	3

Criteria for Staff participants	**Why this criterion is important in determining the credibility of the participant for this particular research?**	**Means to be used to determine whether this criterion is applicable to the participant?**	**Numerical value associated with the criterion (See Key 5 below)**
D. Participant currently or in the past, has had experience of using educational packages in teaching and learning practices or evaluating it for such purposes, on a regular basis.	The participant has experience of regular educational software usage in an educational environment for educational purposes, and is in a position to reflect on these experiences when providing information for this research.	Based on semi-structure interview conducted with the participant.	4
E. Participant currently or in the past, has had experience of using educational packages in teaching and learning practices or evaluating it for such purposes, extensively.	The participant has experience of extensive educational software usage in an educational environment for educational purposes, and is in a position to reflect on these experiences when providing information for this research.	Based on semi-structure interview conducted with the participant.	5



Key 5 to Tables 22 and 23

The above key shows the numerical values which have been used in Tables 22 and 23: 0- indicates the lowest value, 5- indicates the highest value that can be allocated for each criterion met. The values 0, 1, 2, 3, 4, 5 displayed and used in key 5 and in the credibility tables 22 and 23 have been chosen because they are simple integer values which are ordinal in nature. The numbers do not have any intrinsic value they are only to show the relative value when determining credibility weightings of the participants i.e. the value of their expertise with regards to this particular domain of study. The key can be adapted for other studies where the number values can be different to the ones seen above, as long as they are ordinal and provide a measure of the relative value for weighting a participant's expertise for example, values 5, 10, 15, 20 and 25 could have been used as well. A more detailed explanation of key 5 is provided in Table 24.

Table 24 Detailed explanation to Key 5

Numerical Values	**Explanation of Key 5 to Tables 22 and 23, as to how the numerical values have been determined**
Value 0	When there is no experience of ICT/general software/educational software adoption and no experience of the school environment.
Value 1	When there is experience and/or knowledge of ICT or general software, based on some adoption or training, however this experience and/or knowledge has not been gathered within a school environment and is not related to the teaching and learning practices in a school. Or when there is experience and/or knowledge of the classroom and school environment for teaching and learning purposes but there is no experience of or knowledge related to ICT and educational software adoption.
Value 2	When there is experience and/or knowledge of ICT but not educational software, in the school environment. Or when there is experience and/or knowledge of educational software but the experience has not been gathered within a school environment.
Value 3	When there is or has been experience and knowledge of educational software based on some usage/adoption of educational software or some level of ICT related training for teaching and learning purposes, in the school environment.
Value 4	When there is or has been experience and knowledge of educational software based on regular usage/adoption of educational software or a standard level of ICT related training for teaching and learning purposes, in the school environment.
Value 5	When there is or has been experience and knowledge of educational software based on extensive usage/adoption of educational software or a higher level of ICT related training for teaching and learning purposes or at a strategic level, in the school environment.

6.3.2 Allocation of participant credibility weightings

By drawing on the relevant background information presented in chapter 5, from Tables 13, 14, 15, 16, 17, 18 and the empirical data from the semi-structured interviews as suggested by Tables 22 and 23 it was possible to elicit for each participant whether they met the criteria listed in the relevant Tables 22 and 23. If they met the criteria then the associated numerical value was assigned to them, this is seen in Tables 25 and 26 which also show the final credibility weightings allocated to each participant. Table 25 shows the final allocated credibility weightings based on the criteria satisfied by each student participant. Table 26 shows the allocation for staff participants.

Table 25 Credibility weightings assigned to student participants

Student Participants	Criteria from Table 22					Credibility Weighting/Value
	A	B	C	D	E	
StuA1	1	2	N/A	4	N/A	7
StuA2	1	2	N/A	4	N/A	7
StuA3	0	2	N/A	4	N/A	6
StuA4	1	2	N/A	4	N/A	7
StuA5	1	2	N/A	4	N/A	7
StuA6	1	0	N/A	4	N/A	5
StuA7	1	2	3	N/A	N/A	6
StuA8	1	2	3	N/A	N/A	6
StuA9	1	2	3	N/A	N/A	6
StuA10	1	2	3	N/A	N/A	6
StuB1	1	2	3	N/A	N/A	6
StuB2	1	0	3	N/A	N/A	4
StuB3	0	0	3	N/A	N/A	3
StuB4	1	2	3	N/A	N/A	6
StuB5	1	0	3	N/A	N/A	4
StuB6	1	2	3	N/A	N/A	6
StuB7	1	2	3	N/A	N/A	6
StuB8	1	2	3	N/A	N/A	6
StuB9	1	0	3	N/A	N/A	4
StuB10	1	0	3	N/A	N/A	4
StuC1	1	0	3	N/A	N/A	4
StuC2	1	2	3	N/A	N/A	6
StuC3	1	2	3	N/A	N/A	6
StuC4	1	0	3	N/A	N/A	4
StuC5	1	2	3	N/A	N/A	6
StuC6	1	2	3	N/A	N/A	6
StuC7	1	0	3	N/A	N/A	4
StuC8	1	2	3	N/A	N/A	6
StuC9	1	2	3	N/A	N/A	6
StuC10	1	2	3	N/A	N/A	6

Table 26 Credibility weightings assigned to staff participants

Staff Participants	Criteria From Table 23												Credibility Weighting/Value
	G	H	I	J	K	L	M	N	O	C	D	E	
StaffA1	N/A	N/A	2	5	N/A	N/A	4	1	7.5	3	N/A	N/A	22.5
StaffA2	N/A	N/A	N/A	5	N/A	N/A	4	1	9	N/A	4	N/A	23
StaffA3	N/A	N/A	N/A	N/A	N/A	3	N/A	1	2.5	3	N/A	N/A	9.5
StaffA4	2	N/A	2	N/A	4	N/A	N/A	N/A	1	3	N/A	N/A	12
StaffA5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	7	N/A	4	N/A	12
StaffA6	2	1	2	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	6
StaffB1	N/A	N/A	2	5	N/A	N/A	4	N/A	4	3	N/A	N/A	18
StaffB2	N/A	N/A	2	N/A	N/A	N/A	4	1	8.5	3	N/A	N/A	18.5
StaffB3	N/A	N/A	N/A	N/A	N/A	N/A	4	1	7.5	N/A	4	N/A	16.5
StaffB4	2	N/A	N/A	N/A	N/A	N/A	4	1	7.5	N/A	4	N/A	18.5
StaffB5	2	1	2	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	6
StaffC1	N/A	N/A	2	5	N/A	N/A	4	1	10	3	N/A	N/A	25
StaffC2	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A	1	3	N/A	N/A	8
StaffC3	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A	1(min)	3	N/A	N/A	8
StaffC4	N/A	N/A	N/A	N/A	4	N/A	N/A	1	1	N/A	4	N/A	10
StaffC5	2	1	2	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	8

Having determined the credibility weight values of the participants it is possible now to use the following equation (Kosko, 1992, 1997):

$$F = \sum_{i=1}^{n} w_i F_i \qquad \textbf{Equation 8}$$

Each individual FCM matrix representation, developed at phase 2, is multiplied, with the relevant credibility weighing for the participant, obtained from either Table 25 or 26. For example StuB10's FCM matrix presented in Figure 9 is multiplied by StuB10's credibility weighting 4, obtained from Table 25. Once all the individual FCMs matrices were multiplied with relevant credibility weightings, the resulting matrices were summed. The single matrix arising from this calculation is seen in Figure 10. This was followed by a normalisation step whereby the matrix was divided by the total credibility weight, according to equation (9) (Tsadiras and Margaritis, 1997), where the sum of all the participants' credibility weights was taken to equal to 387.5, as given in Table 27. This was the final step in phase 2 towards the development of main FCM model. The FCM model i.e. the matrix representation which resulted from normalisation of the aggregated weighted individual FCM matrices is presented in Figure 11.

$$F = \frac{\sum_{i=1}^{n} F_i w_i}{\sum_{i=1}^{n} w_i} \qquad \textbf{Equation 10}$$

Table 27 Cumulative credibility weightings of each of the stakeholder groups at each of the participating schools

Stakeholder Groups	School A	School B	School C	Total Credibility Weighting
Students	63	49	54	166
Staff	85	77.5	59	221.5
Total Credibility Weighting	148	126.5	113	387.5

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.75	-11.88	283.38	302.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	229.75	286
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	276.63	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-16.38	3	265.5	267.13
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	264.5	246.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	280.63	266.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	292.5	287
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	172.75	182.75
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	259.25	257.5
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	257.88	249.25
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	264.38	267.5
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	294.5	285.13
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	249.5	287.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77.375	281.38
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	200.5	189
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	217.88	226
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	252.88	232.25
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	216.38	228.88
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	245.88	229.25
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	252.5	264.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	249	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	255.5
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	245.5
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	129.88	0

Figure 10 FCM matrix resulting from the aggregation of weighted individual FCMs

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0148	-0.031	0.7313	0.7813
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5929	0.7381
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7139	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.042	0.0077	0.6852	0.6894
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6826	0.6368
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7242	0.6884
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7548	0.7406
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4458	0.4716
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.669	0.6645
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6655	0.6432
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6823	0.6903
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.76	0.7358
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6439	0.7426
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1997	0.7261
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5174	0.4877
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5623	0.5832
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6526	0.5994
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5584	0.5906
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6345	0.5916
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6516	0.6832
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6426	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6594
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6335
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3352	0

Figure 11 FCM matrix resulting from the normalisation of the aggregated weighted individual FCMs at end of phase 2

6.4 Third phase of the main FCM development: Identification of additional relationships and refinement of the model

The last phase of the FCM development involves making additions to the existing FCM model, based on the results from the analysis of the empirical data gathered from semi-structured interviews. The 'documentary coding method' (Wrightson, 1976) and content analysis were used in the analysis of the empirical data as discussed in section 4.4.5. This section firstly presents Table 28 which lists the relationships between the factors which have been identified as a result of this analysis. The table in addition provides examples of the empirical evidence from which the relationships were identified and additional narrative to explain the assertions made by the empirical evidence. The complete list of statements from the empirical data, based on which interrelationship was identified is available in Appendix G.

Table 28 Identified relationships, examples of supporting empirical evidence and associated assertions

Relationship	Example of empirical evidence	Assertion/Explanation
Factor 1: Availability and access to facilities ***affects*** Factor 2. Availability of equipment	*"...we are constrained by brick walls that we can only put kit* [referring to computers, computing equipment] *into rooms where we can have them. And this causes incredibly tightened space..... So our constraints at the moment on access is not to do with kit, but more with classrooms available to put the kit in."(StaffA1)* *"we have 60 wireless laptops..... its difficult to physically to move the trolleys along the corridors where you have to go up and down stairs."(StaffC5)*	The assertion that can be deduced from such extracts is that if there is not enough classrooms or space available than the amount of computing equipment that can be made available is limited. When more space is made available then computing equipment can be put in such spaces. Therefore an increase in space/classrooms can cause more computing equipment to also be available in schools. Furthermore there needs to bee an appropriate structural infrastructure available otherwise even accessing a mobile computing suite in the form of laptops, may become difficult, therefore affecting the availability of the IT equipment for the particular class which requires it. The deduction therefore is that a direct (i.e. positive) causal relationship exists between factor 1 and factor 2.

Relationship	Example of empirical evidence	Assertion/Explanation
Factor 1: Availability and access to facilities ***affects*** Factor 4. Amount of ICT usage in School	"*... a lot of teachers were very very willing to use more ICT in their teaching but because of the lack of accessibility made it all very difficult."(StaffA3)* *"I think people do want to use IT but I think logistically with the room booking it is really difficult, it's a headache." (StaffC2)* "[Refers to ICT use] *About once every month or something, not that often...... Because there are other classes using them at the same time." (StuC4)*	Statements such as these indicate that the amount of ICT usage, especially for whole classroom teaching is limited as computer suites are usually heavily booked. This is mainly because there are limited number of computer suites available, therefore certain year groups and subjects such as ICT are given priority over the rest of the school so some subjects and younger year groups cannot use as much ICT as they would like. Even when there is equipment available such as laptops, accessibility to such equipment may not be straightforward due to the structural infrastructure of the school and can affect the use of ICT in school. When there is access to and availability of ICT facilities, there is varied use of ICT in the school. These reasons suggest that the availability and access to IT facilities does have an effect on the amount of ICT usage in schools. It can therefore be deduced that a direct (i.e. positive) causal relationship exists between factor 1 and factor 4.
Factor 1: Availability and access to facilities *affects* Factor 11. Availability of educational software	" [Refers to what the additional facilities allow] *As far as subject specific software is, yes, for instance the science department paid £2500 for a piece of software that is the bees knees.. So we are looking at each department in turn and making sure they have what they require" (StaffA1)*	The availability and access to computing facilities allow and initiate departments to purchase and/or download educational software from the internet, therefore making educational software available in the school. Hence there is a direct causal relationship between factor 1 and factor 11.

Relationship	Example of empirical evidence	Assertion/Explanation
Factor 1: Availability and access to facilities ***affects*** Factor 20. ICT culture in school	*"It is written in the schemes of work, staff are supposed to do it but there are then the issues of access to machinery and software."(StaffB2)*	Suggestions to use ICT in school, and not just for teaching and learning, can be construed as steps towards promoting a certain level of ICT culture within the school. However the lack of availability and access to facilities inhibits such an ICT culture from evolving. So, it is deuced that there is a direct causal relationship between factor 1 and factor 20.
Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 3. Time to prepare lessons	*"Absolutely, I think it* [referring to laptops] *makes it more realistic. I think prior to that there was a certain feeling that if you can get on a school computer during the day to either bring up whatever you wanted to do in the lesson the next day or practise or write a letter, and it didn't really go ahead. Now I think people have that advantage they are able to go home and in their own time see what they want to do the next day and bring it in and teach it and I think that has been very successful"(StaffA3)*	The allocation of new IT equipment such as laptops means that teachers have more flexibility in the way they can prepare for lessons, especially those incorporating the use of ICT. They do not need to constrain themselves to preparing lessons during school times and on school computers but are able to prepare lessons at a time and pace which is suitable for them, which they were unable to do before. Therefore there is a direct causal relationship between factor 2 and factor 3.

Relationship	Example of empirical evidence	Assertion/Explanation
Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 4. Amount of ICT usage in School	*"It's the teaching equipment in the classrooms that makes a difference and also actually the fact they were given a PC each to use at home or a lap top. That's almost kind of, um; even the most reluctant users are still doing bits and pieces on it and beginning to use it for worksheets and PowerPoint presentations". (StaffA1)* *".. you cannot, very rarely can do a nice, simple IT lesson because either the equipment is not working properly, you haven't got enough equipment.." (StaffB4)* *"...in my classroom when I need to use something and none of us would have a computer because they would all be booked and it would hard to do my coursework in that lesson, if there was more computers it would be much easier." (StuA7)*	The assertions indicate the availability of IT equipment does lead to some form of ICT usage. When there aren't enough computers available, especially for whole classroom use, or even amongst staff and if the available equipment is not in working order, then the amount of ICT that is used in school for lessons is inhibited or limited. Therefore a direct causal relationship exists between factor 2 and factor 4.
Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 6. Level of teachers' ICT skills	"[Referring to IT equipment]*...had an waking up effect, but I think a lot of the staff who were reliant on very old traditional methods, I think they've become to adopt themselves more unusual methods involving ICT and there is a tendency to go in that direction. And equally said it's a learning curve as well because we are learning an awful lot."(StaffA3)*	The statements indicate that the availability of computing equipment in the classrooms has led to staff and teachers making attempts to use ICT, inducing a kind of a change in their skills, they are now more able to handle equipment and use ICT, than before. So, a direct causal relationship exists between factor 2 and factor 6.

Relationship	Example of empirical evidence	Assertion/Explanation
Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 7. Teachers' training in ICT	*"As far as hardware training is concerned we have to make sure the kit* [refers to computing equipment] *is used properly…… " (StaffA1)* *"There is a workshop….. Everyone has to go to it, so what we are going to do is one of my colleagues is going to demonstrate it* [refering to IT equipment], *and we are going to split up into groups and the more experienced colleague that has really used it will encourage the others." (StaffA2)*	The introduction of new/state of the art IT equipment initiates some form of training, so as to enable staff to be able to operate the equipment and incorporate ICT within their teaching practices. Therefore a direct causal relationship exists between factor 2 and factor 7
Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 11. Availability of educational software	*"..I think over the next year that's where the main emphasis will be on, now that we've got the kit in place what* [refers to educational and generic software] *are we going to use with it"(StaffA1)*	The availability of IT equipment i.e. the hardware means that there is then consideration by staff about obtaining software both educational and generic and making it available to the school for teaching and learning practices. Hence there is a direct causal relationship between factor 2 and factor 11.

Relationship	Example of empirical evidence	Assertion/Explanation
Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 21. Teachers' ICT usage outside of school	*"Absolutely, I think it* [referring to laptops] ... *Now I think people have that advantage they are able to go home and in their own time see what they want to do the next day and bring it in and teach it and I think that has been very successful"(StaffA3)*	The allocation of computer equipment such as laptops to teachers means that they are now able to use ICT outside of the school hours and its' environment. There is a direct causal relationship between factor 2 and factor 21.
Factor 4: Amount of ICT usage in school ***affects*** Factor 7. Teachers' training in ICT	*"...have used it* [refers to ICT] *in the classroom and have seen a lot happening by the use of software and therefore I'm going to give myself time out to get to the next section* [refers to training]*"(StaffA3)*	The assertion here is that the use of ICT including the use of generic and educational software allows teachers to see and realise the extent of what may be achieved by using ICT, if it is used and utilised properly, from which they are enticed towards pursuing necessary or further training. Hence there is a direct causal relationship between factor 4 and factor 7.
Factor 4: Amount of ICT usage in school ***affects*** Factor 11. Availability of educational software	*"What we see here is that more and more people are using the net for educational support whereas two or three years ago we stuck to sort of CD ROMs and run software from the server. We see more and more now where people access the net and accessing applications directly from the net."(StaffC5)*	Greater use of ICT, such as accessing the internet, allows educational software applications to be downloaded from the internet, this then leads to more educational software being made available in the school. Hence there is a direct causal relationship between factor 4 and factor 11.

Relationship	Example of empirical evidence	Assertion/Explanation
Factor 5: Availability of Technical Support Staff ***affects*** Factor 1. Availability and access to ICT facilities	*"What we* [referring to technical support staff] *do is look after the school network, install software where applicable.... we're responsible for making sure that the computers work alright, printers work ok, all the hardware works ok. We're responsible for installing new printers and new hardware, responsible for keeping network up to date wherever possible........They (schools) should be aware that they do need to spend money to get trained professional people to make things run smoothly." (StaffC5)*	The assertion that can be deduced from such extracts is that the availability of technical support staff is necessary to ensure that the school network and IT equipment, including both hardware and software are in working order and running smoothly allowing staff and students in the school to have access to the available IT facilities as and when required by them. There exists a direct causal relationship between factor 5 and factor 1.
Factor 5: Availability of Technical Support Staff ***affects*** Factor 2. Availability of IT equipment	*"its been more of a hardware issue and getting the hardware up to date......when I got here I realised that there are a lot of things that need changing and they are unaware of what is needed but I've got my point across .... I've researched several laptops by different manufacturers.... I've put in a recommendation to what is suitable for the school." (StaffB5)*	The assertion that can be deduced from such a statement is that prior to the availability of technical staff at the school, the school were unaware of changes that were needed with regard to their IT equipment and school network. The availability of technical support staff within schools can allow for the expertise of technical support staff to be exercised on ICT related matters. This can lead to changes or improvements in the computing facilities and specifically from the assertion lead to the availability of more state of the art or upgraded equipment in the school. Hence there is a direct causal relationship between factor 5 and factor 2.

Relationship	Example of empirical evidence	Assertion/Explanation
Factor 6. Level of Teachers' ICT skills ***affects*** Factor 11. Availability of educational software	*".. so once we get to grips with the kit. And I think most members of the staff are beginning to get to grips with kit completely, and then we can think of looking at what software we need."(StaffA1)*	Once teachers acquire a level of ICT skills, such that they are able to and feel comfortable in operating computing equipment, this then leads them to identifying educational software that they can then use within their teaching practices and consequently make the software available in the school. Hence there is a direct causal relationship between factor 6 and factor 11.
Factor 6. Level of Teachers' ICT skills ***affects*** Factor 20. ICT culture in school	*"...my particular head of department's IT skills are not particularly advanced in the sense that she could particularly lead in the department sessions on ICT and adoption of software to advance our lessons or teaching."(StaffA3)*	The statement suggests that when persons who are responsible for introducing a change or initiative in an environment are limited in their ICT skills, then a culture of ICT which could be promoted in that environment is also limited. Therefore there is a direct causal relationship between factor 6 and factor 20.
Factor 7. Teachers' training in ICT ***affects*** Factor 4. Amount of ICT usage in School	*"I think really the teachers need to be trained how to use ICT properly,.... maybe some of the older staff as well who are not using ICT is for various reasons, one of which maybe because they're unsure of how to use it and I think they need training in basic ICT so they can then pass that on to the kids."(StaffC5)* *"..they* [refers to teachers] *are now using their self training* [refers to ICT related training] *and bringing that into schools into their lessons."(StaffA3)*	Such extracts indicate that teachers, who haven't received training, would be unable to or be inhibited about using ICT and software in their teaching practices. The training of teachers in ICT, also in regard to managing pupils using computing facilities does affect the amount of ICT they would use in schools, so there is a direct causal relationship between factor 7 and factor 4.

Relationship	Example of empirical evidence	Assertion/Explanation
Factor 7. Teachers' training in ICT ***affects*** Factor 6. Level of teachers' ICT skills	*"I actually feel the training was useless at this school at least because the training was meant to get us to use IT in the classroom, it wasn't training us for the skills needed to use IT. What I mean by that is it wasn't to teach us how to use the word processing package it was how are you going to use the word processing package in the classroom. Well if you couldn't use the word processing packages to start of with, how are you going to integrate it into a classroom environment?" (StaffB3)*	Levels of ICT training enable staff to build on the skills they need not only to operate computing equipment, but perform tasks on the computer, use software applications and use ICT to advance their teaching practices. There is a direct causal relationship between factor 7 and factor 6.
Factor 11. Availability of educational software ***affects*** Factor 6. Level of teachers' ICT skills	*"..yes software was available, again more limited for German than for French, there was an awful lot more for French than for German. So the French teacher was able to develop a sense of ICT a lot faster, I believe than the German teacher."(StaffA3)*	The assertion from such statements is that the availability of a variety of educational software allows teachers to use and experiment with a variety of software. This enables them to understand ICT and consequently develop ICT skills at a better rate compared to those who are exposed to only a limited amount of educational software. Therefore there exists a direct causal relationship between factor 11 and factor 6.

Relationship	**Example of empirical evidence**	**Assertion/Explanation**
Factor 11. Availability of educational software ***affects*** Factor 7. Teachers' training in ICT	*"For instance I'm going to buy a piece of software for year 7 and what I'm going to suggest is that we all have whole day training on it which will have to be funded by the school but I'm not going to buy it unless that's part of the package."(StaffB1)* *"Yes it's a part of our package; it* [refers to educational software package] *includes training, and any subsequent updates"(StaffA5)*	Educational software packages can include training as part of the package. So, the availability of such educational software within the school can lead to further ICT related training for teachers. There is a direct causal relationship between factor 11 and factor 7.
Factor 20. ICT culture in school ***affects*** Factor 1. Availability and access to IT facilities	*"I think up until recently this school didn't take ICT very seriously and we had a poor network with poor quality hardware."(StaffC5)* *"I think certainly now that this school has started to take IT seriously as an important part of the infrastructure to this school just as the central heating is."(StaffC5)*	A lack of ICT culture in a school can mean that ICT is not considered to be important; this is then reflected in the way IT is facilitated within the school, such as having a poor network service and equipment etc. When there is recognition of ICT i.e. an evolving culture of ICT, then there are changes and improvements in the IT facilities. Therefore there is a direct causal relationship between factor 20 and factor 1.

Relationship	Example of empirical evidence	Assertion/Explanation
Factor 20. ICT culture in school ***affects*** Factor 2. Availability of non-outdated hardware/IT equipment	*"I think there is encouragement. I mean there is the delivering of laptops so teachers are getting those"(StaffC3)* *"I think up until recently this school didn't take ICT very seriously.... We used to buy second user machines, this is before I came, which have proved to be nothing but problems really"(StaffC5)*	The statements suggest that when there is a lack of ICT culture in a school this is reflected in the quality of its IT facilities and equipment. Whereas when steps are taken to promote an IT culture, this can lead to more and newer IT equipment becoming available in the school. Therefore there is a relationship between factor 20 and factor 2.
Factor 20. ICT culture in school ***affects*** Factor 4. Amount of ICT usage in School	*"Our IT teachers encourage us to go on the internet a bit more to find out how to use it and the available sites and hyper-links that you can get. In maths they* [refers to maths teachers] *encourage us to go on these maths revision games that are available on the school websites"(StuB3)* *"Having seen the department in work you can see the ones that do actually believe in the power of ICT and they are ones using it as much."(StaffA2)*	The use of ICT is influenced by the level of ICT culture adopted by persons within the school or department. When there is a lack of ICT culture there is not much emphasis on the use of ICT. Environments in which there is a culture of ICTshow there is use of ICT and it is encouraged and propagated. There exists a direct causal relationship between factor 20 and 4.

Relationship	Example of empirical evidence	Assertion/Explanation
Factor 20. ICT culture in school ***affects*** Factor 5. Availability of Technical Support Staff	*"Its back to the political within the school, the deputy head in charge of that, many years ago decided we would never need a technician and she was also in charge of finance so she made sure we never had a technician."(StaffB2)*	ICT culture, especially among persons of authority within the school, can influence the ways in which ICT is implemented and run within the school including the availability of technical staff who are meant to support this implementation. From the statement above the deputy head's lack of ICT culture resulted in the unavailability of technical support staff in the school. There is a direct causal relationship between factor 20 and factor 5.
Factor 20. ICT culture in school ***affects*** Factor 7. Teachers' training in ICT	*"... another NQT was talking about how she felt that how she had gone from a lot of ICT training* [refers to previous environment] *and then she's gone to the kind of not having that kind of support in ICT....No there isn't a system put in place, I guess if you have an interest you can request a skills workshop or something like that, but there is nothing that is kind of integrated in this school that I am aware of"(StaffC3)*	From such phrases the assertion deduced is that, the amount of training and support teachers receive can depend on the ICT cultural stance taken by schools, in the way they offer and promote short and long term courses and workshops related to ICT training for their staff. When there is a higher level of ICT culture in a school then training in ICT is put into force otherwise there is a lack of emphasis on training and in the support that is provided. There is a direct causal relationship between factor 20 and factor 7.
Factor 21. Teachers' ICT usage outside of school ***affects*** Factor 6. Level of Teachers' ICT skills	*"..that I think a lot of teachers themselves develop professionally themselves, obviously a majority of households now have a computer at home, and I think they have gone away developed themselves professionally with their ICT skills using packages they well may have bought themselves. And they are now using their self training and bringing that into schools into their lessons."(StaffA3)*	The statements suggest that teachers' use of ICT, in their own time outside of school, enables them to learn more about ICT therefore leading them to develop or enhance their ICT skills further. There is a direct causal relationship between factor 21 and factor 6.

Relationship	**Example of empirical evidence**	**Assertion/Explanation**
Factor 23. Teachers' usage of educational software ***affects*** Factor 11. Availability of educational software	*"..the ultimate problem is the shortage of educational software in schools. I think the more you have them, the more you are exposed to them the more you are going to put into practice and the more you are going to want to find educational software which is appropriate for your lessons." (StaffC3)*	The assertion that can be deduced from the extracts is that prior use of particular educational software or regular use of variety educational software can enable teachers to judge the quality and suitability of software, and consequently lead to them obtaining appropriate educational software for use in the school. Therefore usage of educational software by teachers, can lead to educational software being made available for the school. Hence there is a direct causal relationship between factor 23 and factor 11. (This statement confirms there is a feedback/loop relationship, between factors 11 and 23 relationship, given that it has already been established that factor 11 affects factor 23 i.e. the availability of educational software influences teachers use of educational software, as seen in the FCM presented in Figure 11, at the end of phase 2)

6.4.1 Framework to determine strength weightings of identified relationships

Having identified further relationships from the empirical data the next step is to determine the strengths of these relationships i.e. assign weightings to these relationships, in accordance with the characteristics of fuzzy cognitive maps. For this, the study develops a framework which is presented within Table 29, for determining and allocating weighting values to these relationships. The framework, based on a similar premise advocated by Bassey (2001) (discussed in section 2.7), allows the researcher to exercise judgement about the strengths of the identified relationship. Bassey (2001) contends that the likelihood of an outcome occurring can be indicated by a best-estimate-of-trustworthiness (BET), given in a fuzzy form or range by the researcher, based on the researcher's judgement stemming from literature and experience.

According to the framework set out in Table 29, the researcher is required to first make a judgement about the strength of the identified relationship based on: the evidence that led to the identification of the relationship; the relationship itself i.e. is it logical/obvious that a change in the causal concept/factor would have a) a very big effect b) a big effect, c) a moderate effect, d) a small effect, on the effect concept/factor, based on the researchers experience of the literature and the field in which the study was conducted. The researcher, then accordingly indicates a fuzzy weighting to the relationship from the range of numeric values 0, 0.25, 0.5, 0.75 and 1, or the linguistic alternatives which have been used consistently as fuzzy relationship strength values within this study. This weighting value is subsequently reaffirmed or adjusted by following the appropriate paths set out in Table 29, which is based on the empirical evidence (available in the Appendix G) in terms of the number of statements in support of the particular relationship, and the credibility of participants making such assertions. The weightings which are finally assigned to the identified relationships, as a result of following this framework are presented in Table 30.

Subsequently, the identified relationships and their associated strength weightings from Table 30 are added to the existing FCM model. The refined and final FCM model resulting from this third and last phase is presented in Figure 12 and its matrix form is presented in Figure 13.

Table 29 Framework to determine strength values of identified relationships

Stage 1. Allocate a reasonable value based on the nature of the relationship and the accompanying comments. (Then accordingly follow the appropriate path downwards in the table)	Very Big (1)	Big (0.75)	Moderate (0.5)	Small (0.25)
Stage 2a. If there are a high number of comments made by persons with the following credibility weightings:	High number of comments >= 5		High number of comments >= 5	
High credibility weights i.e. those with weights >= 14[4]	A high number of comments coupled with high credibility weights suggests there is a strong argument for the recognition of this relationship and consequently the strength of this relationship, therefore based on the comments if it is reasonable to see that the choice made at stage 1 is strongly applicable than the corresponding strength value is to be assigned		A high number of comments coupled with high credibility weights suggests there is a strong argument for the recognition of this relationship and consequently the strength of this relationship, therefore based on the comments if it is reasonable to allocate a higher strength value such as 'very big' or 'big' to the relationship then the corresponding strength value is to be assigned	
Low credibility weights i.e. those with weights < 14	A high number of comments coupled with low credibility weights suggest there is an argument for the recognition of this relationship and consequently the strength of this relationship, however the relationship is based on the comments of persons with low credibility weights. Therefore based on the comments if it is reasonable to allocate a lower strength value i.e. from 'very big' to 'big' or from 'big' to 'moderate', to the relationship then the corresponding strength value is to be assigned		A high number of comments coupled with low credibility weights suggest there is an argument for the recognition of this relationship and consequently the strength of this relationship, however the relationship is based on the comments of persons with low credibility weights. Therefore based on the comments if it is logical to see that one of the choices made at stage 1 is applicable than the corresponding strength value is to be assigned.	

[4] Given that the credibility weights of the participants worked out previously in section 6.2 range from 3 the lowest credibility value to 25 being the highest, therefore taking a mid value of 14 as a mark, such that credibility values above and equal to 14 are considered high and those below 14 are considered low.

OR Stage 2b. If there are a low number of comments made by persons with the following credibility weightings:	Low number of comments < 5	Low number of comments < 5
High credibility weights i.e. those with weights >= 14	A low number of comments coupled with high credibility weights suggests there is a strong argument for the recognition of this relationship and consequently the strength of this relationship, therefore based on the comments if it is reasonable to see that the choice made at stage 1 is strongly applicable than the corresponding strength value is to be assigned	A low number of comments coupled with high credibility weights suggests there is a strong argument for the recognition of this relationship and consequently the strength of this relationship, therefore based on the comments if it is reasonable to allocate a higher strength value i.e. from 'small' to 'moderate' or from 'moderate' to 'big', to the relationship then the corresponding strength value is to be assigned
Low credibility weights i.e. those with weights < 14	A low number of comments coupled with low credibility weights suggest there is an argument for the recognition of this relationship and consequently the strength of this relationship, however the relationship is based on the comments of few persons with low credibility weights. Therefore based on the comments if it is reasonable to allocate a lower strength value i.e. from 'very big' to 'big' or from 'big' to 'moderate', to the relationship then the corresponding strength value is to be assigned	A low number of comments coupled with low credibility weights suggest there is an argument for the recognition of this relationship and consequently the strength of this relationship, however the relationship is based on the comments of few persons with low credibility weights. Therefore based on the comments if it is reasonable to see that the choice made at stage 1 is applicable than the corresponding strength value is to be assigned.

(NB 'High credibility weights' in the table above will be applicable when there are a mixture of comments from persons with high and low credibility weights)

Table 30 Strength values i.e. weightings assigned to identified relationships

Identified Relationship	Stage 1. Initial allocation for the strength of the relationship	Consider no. of comments	Consider no. of high credibility weights	Consider no. of low credibility weights	Strength value assigned
Factor 1: Availability and access to facilities ***affects*** Factor 2. Availability of equipment	Big	Low	2	1	0.75
Factor 1: Availability and access to facilities ***affects*** Factor 4. Amount of ICT usage in School	Big	High	7	11	0.75
Factor 1: Availability and access to facilities ***affects*** Factor 11. Availability of educational software	Big	Low	3	0	0.75
Factor 1: Availability and access to facilities ***affects*** Factor 20. ICT culture in school	Big	Low	2	0	0.75
Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 3. Time to prepare lessons	Small	Low	0	1	0.25
Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 4. Amount of ICT usage in School	Big	High	4	6	0.75
Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 6. Level of teachers' ICT skills	Big	Low	3	1	0.75
Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 7. Teachers' training in ICT	Small	Low	2	1	0.5

Identified Relationship	Stage 1. Initial allocation for the strength of the relationship	Consider no. of comments	Consider no. of high credibility weights	Consider no. of low credibility weights	Strength value assigned
Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 11. Availability of educational software	Small	Low	3	0	0.5
Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 21. Teachers' ICT usage outside of school	Moderate	Low	0	1	0.5
Factor 4: Amount of ICT usage in school ***affects*** Factor 7. Teachers' training in ICT	Small	Low	0	1	0.25
Factor 4: Amount of ICT usage in school ***affects*** Factor 11. Availability of educational software	Moderate	Low	0	1	0.5
Factor 5: Availability of Technical Support Staff ***affects*** Factor 1. Availability and access to ICT facilities	Big	Low	1	2	0.75
Factor 5: Availability of Technical Support Staff ***affects*** Factor 2. Availability of IT equipment	Moderate	Low	0	1	0.5
Factor 6. Level of Teachers' ICT skills ***affects*** Factor 11. Availability of educational software	Small	Low	1	0	0.5
Factor 6. Level of Teachers' ICT skills ***affects*** Factor 20. ICT culture in school	Big	Low	0	1	0.5
Factor 7. Teachers' training in ICT ***affects*** Factor 4. Amount of ICT usage in School	Very Big	High	0	5	0.75

Identified Relationship	Stage 1. Initial allocation for the strength of the relationship	Consider no. of comments	Consider no. of high credibility weights	Consider no. of low credibility weights	Strength value assigned
Factor 7. Teachers' training in ICT ***affects*** Factor 6. Level of teachers' ICT skills	Big	Low	1	1	0.75
Factor 11. Availability of educational software ***affects*** Factor 6. Level of teachers' ICT skills	Small	Low	0	1	0.25
Factor 11. Availability of educational software ***affects*** Factor 7. Teachers' training in ICT	Small	Low	1	1	0.5
Factor 20. ICT culture in school ***affects*** Factor 1. Availability and access to IT facilities	Very Big	Low	0	2	0.75
Factor 20. ICT culture in school ***affects*** Factor 2. Availability of non-outdated hardware/IT equipment	Very Big	Low	0	2	0.75
Factor 20. ICT culture in school ***affects*** Factor 4. Amount of ICT usage in School	Big	Low	2	2	0.75
Factor 20. ICT culture in school ***affects*** Factor 5. Availability of Technical Support Staff	Big	Low	1	0	0.75
Factor 20. ICT culture in school ***affects*** Factor 7. Teachers' training in ICT	Big	Low	1	1	0.75
Factor 21. Teachers' ICT usage outside of school ***affects*** Factor 6. Level of Teachers' ICT skills	Big	Low	1	1	0.75
Factor 23. Teachers' usage of educational software ***affects*** Factor 11. Availability of educational software	Big	Low	1	1	0.75

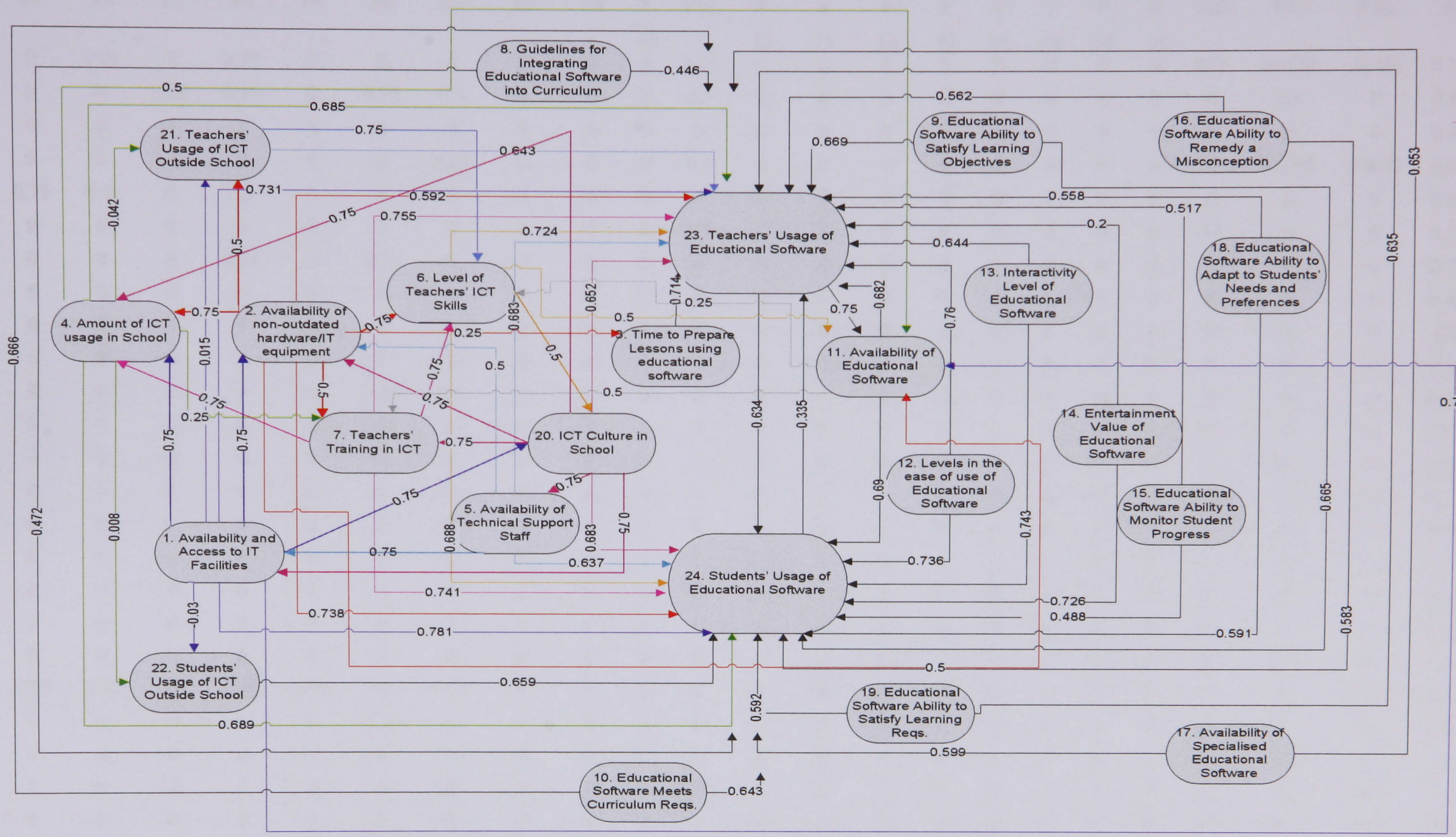


Figure 12 Fuzzy Cognitive Map modelling the factors in the adoption of educational software in schools

(Please note the different colours used in the figure are for ease of reference and serve no other purpose)

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F 10	F11	F 12	F 13	F 14	F 15	F 16	F 17	F 18	F 19	F20	F21	F22	F23	F24
F1	0	0.75	0	0.75	0	0	0	0	0	0	0.75	0	0	0	0	0	0	0	0	0.75	0.0148	-0.031	0.7313	0.7813
F2	0	0	0.25	0.75	0	0.75	0.5	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0.5	0	0.5929	0.7381
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7139	0
F4	0	0	0	0	0	0	0.25	0	0	0	0.5	0	0	0	0	0	0	0	0	0	-0.042	0.0077	0.6852	0.6894
F5	0.75	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6826	0.6368
F6	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0.5	0	0	0.7242	0.6884
F7	0	0	0	0.75	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7548	0.7406
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4458	0.4716
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.669	0.6645
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6655	0.6432
F11	0	0	0	0	0	0.25	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6823	0.6903
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.76	0.7358
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6439	0.7426
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1997	0.7261
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5174	0.4877
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5623	0.5832
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6526	0.5994
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5584	0.5906
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6345	0.5916
F20	0.75	0.75	0	0.75	0.75	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6516	0.6832
F21	0	0	0	0	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6426	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6594
F23	0	0	0	0	0	0	0	0	0	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0.6335
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3352	0

Figure 13 Final FCM in matrix form

6.5 Summary

This chapter provided a thorough and detailed account of the development of the FCM model. The development was described in three major phases. The first phase described the construction of individual FCMs based on the empirical data gathered from the fully structured interviews. The construction of each FCM consisted of four consecutive steps. In steps 1, 2 and 3, the analysis of data from the fully structured interviews led to the construction of the individual FCMs. In the fourth step the derived FCM was converted into a numeric model which could be presented in matrix form. The first phase was considered completed when FCMs in matrix form had been achieved for all participants. This led to the second phase which was concerned with the aggregation of the individual FCMs to form one main FCM model.

In describing the second phase the chapter firstly highlighted the issues that had been raised in chapter 3 with regards to credibility weightings, a critical variable in the FCM aggregation process. In order to address this concern, the chapter presented criteria developed for determining the credibility weightings of the participants within the context of this study. Based on these criteria and from the information provided in chapter 5, credibility weightings were assigned to the participants. Subsequently the individual FCMs were aggregated which resulted in the combined FCM model and its matrix representation.

The chapter then explained the third and final phase of the FCM development. It discussed that the analysis of the data collated from the semi-structured interviews led to the identification of further relationships between factors in the model. It provided examples of the empirical evidence based on which the relationships were identified and provided additional narrative to explain the assertions made by the empirical evidence. It presented a framework, developed within the context of this study, by which it would be possible to assign strength values i.e. weightings to these identified relationships. The existing model was refined by incorporating the newly identified and weighted relationships and the chapter presented the final version of the FCM model. The next chapter discusses the simulation, validation and application of this model.

Chapter 7: Discussion of the FCM model

7.1 Introduction

This chapter discusses the analysis, simulation, validation and application of the FCM model which was constructed and presented in chapter 6. The first section provides a brief analysis of the static FCM model. In doing so it shows that a static analysis is inadequate for examining the overall effects and ascertaining a final outcome within the model, given a change in one or more of the causal concepts/factors, and that a dynamic analysis is considered more appropriate. The chapter then describes the dynamic process adopted to simulate the FCM model. It addresses the concern raised from the static analysis, by simulating the FCM model and considering the simulation results. The chapter highlights the potential of a dynamic FCM analysis in comparison to a static analysis.

The following section considers the validation of the FCM model: first it discuses the validation of the model by experts in the field; second it describes the validation of the FCM model, based on a real life study i.e. the ACOT project (Sandholtz, Ringstaff, Dwyer, 1997), in which the FCM model is simulated by using initial input data replicating the initial stages of the ACOT project; third to validate the FCM model the FCM simulation results are compared to the final stages of the ACOT project; finally, the chapter considers the application of the developed FCM model and draws attention to the purpose of this study and of the FCM model. Given the FCM's ability to explore 'what-if' possibilities, the section presents scenarios generated from practical issues; simulates the FCM model based on these scenarios and discusses the respective simulation results. In doing so the section demonstrates the application potential of the FCM model.

7.2 Static analysis of FCM model

This section briefly discusses the statistic analysis of the FCM model. The static analysis is considered important for this study for two reasons. Firstly, it provides an opportunity to examine the recently developed model. It looks at causal relationships that exist between concepts focusing in particular on the cycles that are formed as a result of direct and indirect relationships. For example, when concept A affects other concepts which in turn affect concept A, this gives rise to a cycle. Such an analysis gives an indication of the concepts/factors which are self-sustaining and of the knock-on effect that can arise within this model because of such cycles. Secondly, by conducting the static analysis it is possible to show the limitation of such an analysis, which consequently provides further justification for pursuing a dynamic FCM analysis.

The static analysis of the model is conducted using graph theory techniques, following Tsardiras, Kouskouvelis and Margaritis (2001) in the analysis of their FCM, modelling the FYROM (Former Yugoslavian Republic of Macedonia) crisis. Cycles within the model are identified and are allocated a positive or negative sign. A positive or negative sign associated with each cycle is determined by multiplying the signs of the arcs present in each cycle (Tsardiras, Kouskouvelis and Margaritis, 2001). The main cycles of the FCM model, for this static analysis, were identified by referring to the FCM model presented in Figure 12, (see chapter 6), and Table 31. Table 31 provides a list of the factors in the FCM model, the factors they directly affect and those that they are affected by. As part of the static analysis the main cycles identified and their associated signs are presented in Table 32.

The cycles seen in Table 32 mainly exhibit behaviour of positive cycles i.e. those which amplify any initial change, therefore if an increase is introduced in the system this will lead to a constant increase. For example looking at cycle 3 from Table 32: F2-> F6-> F20 ->F2, an increase in F2 the 'availability of non-outdated IT equipment' such as laptops for teachers leads to an increase in F6 'level of teachers' ICT skills' which leads to an increase in F20 'ICT culture in school' which fuels further 'availability of non-outdated IT equipment' i.e. an increase in F2. Hence through this cycle for example, F6 'level of teachers' ICT skills' will constantly increase.

A negative cycle counteracts any initial change, i.e. leads to a decrease if an increase is introduced in the cycle. For example looking at cycle 18 from Table 32: F2->F4->F21->F6->F20->F2, an increase in F2 the 'availability of non-outdated IT equipment' such as laptops for teachers' leads to an increase in F4 the 'amount of ICT usage in school' this leads to a decrease in F21 'teachers' usage of ICT outside of school' which will lead to a decrease in F6 'level of teachers' ICT skills' which will lead to a decrease in F20 'ICT culture in school' which leads to a decrease in F2 the 'availability of non-outdated IT equipment'. Hence through cycle 18, F6 'ICT skills of teachers' will constantly decrease.

Therefore from the examples discussed above, the two cycles 3 and 18 are seen to lead to two opposing outcomes/effects, despite the initial increase in factor 2 'availability of non-outdated IT equipment' in both cases. It is difficult to determine which cycle i.e. 3 or 18 is likely to prevail from the study and analysis of the static FCM model. Given the numerous cycles in the FCM model identified as part of the static FCM analysis, and the difficulty in making predictions because of negative and positive feedback cycles, it is therefore important to consider the analysis of the dynamic FCM model.

7.3 Consideration of independent and dependent factors

However there are two important points to take into account prior to the discussion of the simulation process and consideration of the dynamic FCM model: firstly, by drawing on Table 31 the following deduction can be made that there are some factors within the model which are independent i.e. not affected directly or indirectly by other factors in the model. These are factors 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19. It is important to note that these independent factors, unless intentionally activated i.e. given an initial stimuli in the form of an increase or decrease in their activity levels (introduced in section 3.2), will not show a change in their activation levels, when any other factor is changed and the FCM model is simulated as a result of this change i.e. the independent factor will remain unaffected by the simulation of the FCM model.

Table 31 Factors in the FCM and factors which they directly affect and are affected by

Factor	Affects Factors	Affected by Factors
1. Availability and access to IT facilities	2, 4, 11, 20, 21, 22, 23, 24	5, 20
2. Availability of non-outdated hardware/IT equipment	3, 4, 6, 7, 11, 21, 23, 24	1, 5, 20
3. Time to prepare lessons using software	23	2
4. Amount of ICT usage in school	7, 11, 21, 22, 23, 24	1, 2, 7, 20
5. Availability of Technical Support Staff	1, 2, 23, 24	20
6. Level of Teachers' ICT skills	11, 20, 23, 24	2, 7, 11, 21
7. Teachers' training in ICT	4, 6, 23, 24	2, 4, 11, 20
8. Guidelines for integrating educational software into school curriculum	23, 24	None
9. Educational software ability to satisfy learning objectives	23, 24	None
10. Educational software meets curriculum requirements	23, 24	None
11. Availability of educational software	6, 7, 23, 24	1, 2, 4, 6, 23
12. Levels in the ease of use of educational software	23, 24	None
13. Interactivity level of educational software	23, 24	None
14. Entertainment value of educational software	23, 24	None
15. Educational software ability to monitor student progress	23, 24	None
16. Educational software ability to remedy the user's misconception	23, 24	None
17. Availability of specialised educational software	23, 24	None
18. Educational software ability to adapt to students needs and preferences	23, 24	None
19. Educational software ability to satisfy learning requirements	23, 24	None
20. ICT culture in school	1, 2, 4, 5, 7, 23, 24	1, 6
21. Teachers' usage of ICT outside of school	6, 23	1, 2, 4
22. Students' usage of ICT outside of school	24	1, 4
23. Teachers' usage of educational software	11, 24	1-21, 24
24. Students' usage of educational software	23	1-2, 4-20, 22, 23

Table 32 Main cycles identified within the FCM model

No.	Main CYCLES	Cycle sign
1	F1-> F20-> F5 ->F1 OR F5->F1->F20->F5	+ (positive)
2	F1-> F20-> F1	+ (positive)
3	F2-> F6-> F20 ->F2	+ (positive)
4	F2-> F6-> F20 -> F5-> F2	+ (positive)
5	F2-> F6-> F20 -> F1-> F2	+ (positive)
6	F2-> F6-> F20 -> F5-> F1-> F2	+ (positive)
7,8,9	F2-> (F7/F11/F21)->F6-> F20 ->F2	+ (positive)
10	F2-> F11-> F7->F6-> F20 ->F2	+ (positive)
11	F2-> F23->F11-> F7->F6-> F20 ->F2	+ (positive)
12	F2-> F23->F11->F6-> F20 ->F2	+ (positive)
13	F2-> F24->F23->F11->F6-> F20 ->F2	+ (positive)
14	F2-> F24->F23->F11->F7-> F6-> F20 ->F2	+ (positive)
15	F2-> F3->F23->F11->F7-> F6-> F20 ->F2	+ (positive)
16	F2-> F3->F23->F11-> F6-> F20 ->F2	+ (positive)
17	F2->F21->F6->F20->F2	+ (positive)
18	F2->F4->F21->F6->F20->F2	- (negative)
19	F2->F4->F7->F6->F20->F2	+ (positive)
20	F3->F23->F11->F7->F4->F21->F6->F20->F2->F3	- (negative)
21	F4->F7->F4	+ (positive)
22	F4->F6->F20->F4	+ (positive)
23,24,25	F4->F6->F20->(F1/F2/F7)->F4	+ (positive)
26,27	F4->F7-> F6->F20->(F1/F2)->F4	+ (positive)
28	F5->F2->F6->F20->F5	+ (positive)
29	F5->F2->F21->F6->F20->F5	+ (positive)
30	F5->F2->F11->F7->F6->F20->F5	+ (positive)

7.4 Consideration of the dynamic FCM model

This section first draws on chapter 3 which originally introduced and discussed the processes involved for simulating FCMs and provides a general description of how the FCM model is generally simulated within this study. The section then addresses the concern raised in section

7.2 regarding the difficulty of ascertaining a certain outcome/prediction using static analysis; it uses FCM simulation to deal with the example discussed in section 7.2 in which an increase in factor 2 'availability of non-outdated IT equipment' based on the static analysis had led to two opposing effects/outcomes.

7.4.1 Description of the FCM simulation process

Chapter 3 explains that the simulation of an FCM model commences when the FCM is subjected to a stimulus in the form of a state vector (discussed in section 3.2.1) in which the activation level of one or more of the concepts i.e. factors have been intentionally changed. The simulation process is based on the following equation, (introduced in section 3.2.1 chapter 3):

$A(t+1) = S\,[A(t).\,F]$ **Equation 1**

Where $A(t)$ = the state vector $(1 \times n)$ of concepts at some time step t

F= the FCM connection matrix $(n \times n)$.

S= the threshold or non-linear transformation function

In this study, all factors in the FCM model are originally set at activation levels of value 0. In order to initiate simulation of the FCM model, depending on the scenario or situation to be explored a factor or factors, would be selected and activated. Accordingly this would mean that their present 0 activation levels/values would be changed. Table 33 provides general guidelines as in how to determine activation levels for each factor within the context of this study and/or to interpret the activation levels resulting from a simulation run. The measures i.e. range of activation levels considered for each of the factors seen within Table 33 have been based on their descriptions, (listed in Table 5 section 4.4.4.1), as gathered from the literature and in relation to practical situations.

The activation levels of the factors purposely activated and the unchanged activation levels of other factors in the model together would represent the state vector A(0) i.e. at $t = 0$. This state vector, according to equation (1) above, would then be multiplied by the FCM matrix presented in Figure 13 section 6.4.1.

For the threshold function S required in equation (1), the logistic function equation (7) described in section 3.2.1.1, was chosen and used within this study, given that it would provide true fuzzy conceptual node states (Mohr, 1997a). Furthermore given that at larger values of c this threshold function approached discrete values, c was taken as value 1 to allow for a greater degree of fuzzification:

$$S_i(x_i) = \frac{1}{1+e^{-cxi}}$$ **Equation 7**

Where x_i = summation of the inputs prior to normalisation i.e. x_i = [A (k). F]

c = constant (critical in determining the degree of fuzzification of the function)

Hence by substituting the state vector A (0) i.e. at t = 0, the FCM matrix and the logistic function into equation (1), the calculations would result in the state vector A (1). This would represent the state of the FCM model at time step t = 1, in terms of the activation levels reached by concepts i.e. factors in the model, as a consequence of an initial stimuli. The state vector A (1) would then be substituted back into equation (1) and the simulation process repeated for each time step t= 2, 3… so on until the point of equilibrium (described in section 3.2.2). The point of equilibrium was determined by comparing two consecutive state vectors i.e. at time step (t) and (t+1), if the state vectors were the same then it was considered that the FCM model had reached equilibrium.

In order to conduct the above mathematical calculations, the study considered the use of Matlab®, a mathematical programming language. This is because it would allow for the automation of the calculations involved in the FCM simulation process. Given the need to carryout operations involving a large (24 by 24) FCM matrix and deal with iterative steps, these calculations would otherwise be long, tedious and prone to error if conducted manually. In addition Matlab® as a programming language was considered appropriate as it allows for work with matrices and their operations quickly and easily (MathWorks Inc., 2004).

A simple program was written in Matlab®, consisting of m-files (These are available in Appendix H.) which allowed for the mathematical calculations described within this section i.e. the FCM matrix and state vector multiplication and the application of the thresholding function. It also allowed for the comparison between two consecutive vectors confirming when the vectors were not the same and if they were the same that equilibrium had been reached. In addition and importantly it allowed for the ability to the clamp[5] down on node activation levels as required, depending on the scenario being simulated. For example, in the case of truly independent factors (described in section 7.3) which are not originally initiated, it would be

[5] This is when the activation level of the node is kept at a constant value, so even if it changes as a result of a mathematical calculation, it is changed back to its original value (Kosko, 1992; 1994)

possible to keep their node activation levels at a constant 0 value. Hence for the state vector A(*t*) at time step *t*, prior to the mathematical calculation described in equation (1), showing 0 activation levels for such independent factors, if A(*t*) is affected during the course of the mathematical calculation in terms of the activation levels of such factors being boosted to values besides 0, then these boosted values would be clamped down to 0 and then be shown in the new state vector A(*t*+1). This 'clamping' process would maintain the 0 activation levels of such factors and providing of course equilibrium has not been reached ensure that they do not affect calculations in the next iterative step at (*t*+2). Another example of clamping node activation levels is when the activation levels of specific factors whether independent or dependent need to be kept at a constant level in order to explore a specific scenario or 'what-if' situation.

These simulation results were recorded in tabular form. Although the FCM simulation results were obtained as single row vector at each time step *t*, a table recording simulation results would list the simulation results for each time step *t* (until equilibrium) as a single column vector. Therefore is so a snapshot view of the FCM model in terms of its factors' activation levels at any time *t* could be obtained by looking down the column of the table. While a view of each factor's activation level, at each of the different time steps could be obtained by looking across the table rows. Simulation results were also presented as graphs. Both tables and graphs were then examined. In this way it was possible to examine the effects on the overall FCM model, due to initial changes in any one or more of its' factors.

The initial changes, in a factor's activation level, can be considered to arise because of changes in policy, reform or investment. While the results of the simulation leading up to and including the final FCM model at equilibrium can be seen as the effects and final outcome as a consequence of those changes in policy, reform or investment. Therefore a dynamic FCM analysis can allow for the examination of the effects of alternative policies, investments or initiatives in the domain.

The processes for conducting the FCM simulation and recording its results, described within this section, are used next in section 7.4.2 to address the issue raised in section 7.2. Section 7.2 had highlighted the difficulty in ascertaining a certain outcome/prediction using static analysis. It presented an example which showed that an increase in factor 2 'availability of non-outdated IT equipment' based on a static analysis led to two opposing effects/outcomes. Section 7.4.2 with regard to this specific example, shows the advantage of a dynamic FCM analysis in comparison to a static analysis.

Table 33 Description of the fuzzy measures i.e. activation levels of factors in the FCM model within the context of this study

Factor	**General Guidelines: for allocating a numeric fuzzy measure i.e. activation level for each of the factors in the FCM model and/or for interpreting activation levels resulting from a simulation run.** (Please note: The range for activation levels is {0, 1}. The linguistic terms associated with the numeric quartile activation levels within the range {0, 1} are presented in Table 34 below and are based on the same principles as the conversion measures used for the relationship weightings seen in Table 19, section 6.2.)
1. Availability and access to IT facilities	This factor is measured in terms of the maximum number of students and staff (i.e. 1 student/1 staff, small group, 1 classroom, 1 year group, whole school) who can have access to and use computing facilities at any one time. Activation levels range from 0 i.e. 'none have access' to 1 i.e. 'whole school has access'.
2. Availability of non-outdated hardware/IT equipment	This factor is measured in terms of the maximum number of students and staff (i.e. 1 student/1 staff, small group, 1 classroom, 1 year group, whole school) who are able to access and use non-outdated hardware/IT equipment at any one time. Activation levels range from 0 i.e. 'none have access' to 1 i.e. 'whole school has access'.
3. Time to prepare lessons using software	This factor is measured in terms of the extent of the time given to teachers to prepare for a lesson incorporating the use of ICT. Activation levels range from 0 i.e. 'time allocated does not allow for the preparation of a lesson using ICT' to 1 i.e. 'amount of time allocated allows for preparing a lesson incorporating ICT comfortably'.

Factor	General Guidelines: for allocating a numeric fuzzy measure i.e. activation level for each of the factors in the FCM model and/or for interpreting activation levels resulting from a simulation run.
4. Amount of ICT usage in school	A measure of this factor takes into account the number of students and staff (i.e. one student/staff, small group, one class, one year group, whole school) who use ICT in curriculum subjects; the number of the curriculum subjects (i.e. in one subject, in few subjects, in most subjects, in all subjects) in which ICT is used; the frequency of such lessons (i.e. once a month, once a week, for all lessons in the week). For example, within a school: a total of 1 student using ICT in 1 curriculum subject such as maths, once a month, indicates that 'amount of ICT usage' in the school is at activation level 0.1. Whereas the whole school using ICT in all curriculum subjects, for all lessons in the week, indicates that 'amount of ICT usage' in the school is at a maximum activation level of 1. Activation levels range from 0 i.e. 'no usage of ICT in school' to 1 i.e. 'whole school usage as explained above'.
5. Availability of Technical Support Staff	A measure of this factor considers the extent of technical support availability that can ensure trouble free access to facilities and equipment in school. Activation levels range from 0 i.e. 'no availability of technical support' to 1 'availability of technical support ensures 100% trouble free access to facilities and equipment in school'
6. Level of Teachers' ICT skills	A measure of this factor would take into account the level of skills (i.e. from just being able to use the computer at a basic level to being able to use ICT pedagogically in the classroom within the teaching practice at the highest level) and the number of teachers (i.e. one teacher, small group of teachers, majority of teachers, all teachers) within the school who posses such skills. For example, only 1 teacher with basic ICT skills indicates that the 'level of teachers' ICT skills' within the school is at a activation level of 0.1. Whereas all teachers with the highest level of ICT skills, indicates that the 'level of teachers' ICT skills' within the school is at a maximum activation level of 1. Activation levels range from 0 i.e. 'no ICT skills are held by the teachers in school' to 1 i.e. 'all teachers have highest level of skills as explained above'.

Factor	General Guidelines: for allocating a numeric fuzzy measure i.e. activation level for each of the factors in the FCM model and/or for interpreting activation levels resulting from a simulation run.
7. Teachers' training in ICT	A measure of this factor would take into account the level of training provided (i.e. from basic training in the general use of IT equipment and generic software to training in how to use ICT and educational software in a pedagogically effective manner at the highest level) and the number of teachers receiving training (i.e. one teacher, small group of teachers, majority of teachers, all teachers) within the school. For example, only 1 teacher being trained/having received basic ICT training indicates that 'teachers' training in ICT' is at an activation level of 0.1. Whereas all teachers in the school being training/having received training at the highest level, indicates that 'teachers' training in ICT' is at a maximum activation level of 1. Activation levels range from 0 i.e. 'no teachers are trained in ICT' to 1 i.e. 'all teachers train at the highest level as explained above'.
8. Guidelines for integrating software into school curriculum	Activation levels range from 0 i.e. 'no guidelines are offered' to 1 i.e. 'in-depth and detailed guidelines of how to incorporate the software into the lesson plan and conduct the lesson within a classroom environment'.
9. Educational software ability to satisfy learning objectives	A measure of this factor takes into account the number of educational software packages used in school (i.e. one package, few, a lot, all packages) and the number of learning objectives satisfied (i.e. few, some, a lot, all). For example, a total of one educational software package satisfying only a few learning objectives indicates that 'educational software ability to satisfy learning objectives' is at an activation level of 0.1. Whereas all of the educational software packages having the ability to satisfy all of the leaning objectives indicates that 'educational software ability to satisfy learning objectives' is at a maximum activation level of 1. Activation levels range from 0 i.e. 'no learning objective are satisfied' to 1 i.e. 'all educational software satisfies all learning objectives as explained above'.

Factor	General Guidelines: for allocating a numeric fuzzy measure i.e. activation level for each of the factors in the FCM model and/or for interpreting activation levels resulting from a simulation run.
10. Educational software meets curriculum req.	A measure of this factor takes into account the number of educational software packages used in school (i.e. one package, few, a lot, all packages) and the number of National Curriculum (NC) requirements (i.e. few, some, a lot, all). For example, a total of one educational software package satisfying only a few NC requirements indicates that 'educational software meets curriculum requirements' is at an activation level of 0.1. Whereas all of the educational software packages having the ability to satisfy all of the requirements of the national curriculum indicates that 'educational software meets curriculum requirements' is at a maximum activation level of 1. Activation levels range from 0 i.e. 'no curriculum reqs. are met' to 1 i.e. 'all educational software meets all curriculum reqs, as explained above'.
11. Availability of educational software	A measure of the factor takes into account the number of topics (i.e. one, many, all) and the number of subjects (one, many, all) for which the available educational software can be used. For example if the availability of the educational software allows for the use of this software in the teaching and learning of one particular topic within one particular curriculum subject then this indicates that 'availability of educational software' is at an activation level of 0.1. Whereas if the availability of the educational software allows for the use of software in the teaching and learning of all topics within all curriculum subjects then this indicates that 'availability of educational software' is at a maximum activation level of 1. Activation levels range from 0 i.e. 'no educational software is available' to 1 i.e. 'educational software for all topics within all subjects is available, as explained above'.
12. Levels in the ease of use of educational software	A measure of this factor takes into account the number of educational software packages used in school (i.e. one package, few, a lot, all packages) and the levels in the ease of use (i.e. none, small, moderate, high and very high). Activation levels range from 0 i.e. 'all educational software being very difficult to use' to 1 i.e. 'all educational software being very easy to use'

Factor	General Guidelines: for allocating a numeric fuzzy measure i.e. activation level for each of the factors in the FCM model and/or for interpreting activation levels resulting from a simulation run.
13. Interactivity level of educational software	A measure of this factor takes into account the number of educational software packages used in school (i.e. one package, few, a lot, all packages) and the extent to which educational software is interactive and user friendly (i.e. none, small, moderate, high and very high). Activation levels range from 0 i.e. 'educational software is not interactive nor user friendly' to 1 i.e. 'all educational software is very highly interactive and user friendly'.
14. Entertainment value of educational software	A measure of this factor takes into account the number of educational software packages used in school (i.e. one package, few, a lot, all packages) and the extent to which educational software is entertaining (i.e. none, small, moderate, high and very high). Activation levels range from 0 i.e. 'educational software is not entertaining' to 1 i.e. 'all educational software is very highly entertaining'.
15. Educational software ability to monitor student progress	A measure of this factor takes into account the number of educational software packages used in school (i.e. one package, few, a lot, all packages) and the extent to which the educational software can monitor the student's progress (i.e. none, small, moderate, high and very high). Activation levels range from 0 i.e. 'educational software cannot monitor student progresses to 1 i.e. 'all educational software is very highly capable of monitoring student progress'.
16. Educational soft. ability to remedy the user's misconception	A measure of this factor takes into account the number of educational software packages used in school (i.e. one package, few, a lot, all packages) and the extent to which the educational software can remedy the user's misconception (i.e. none, small, moderate, high and very high). Activation levels range from 0 i.e. 'educational software cannot remedy the user's misconception' to 1 i.e. 'all educational software is very highly capable of remedying the user's misconceptions'.

Factor	General Guidelines: for allocating a numeric fuzzy measure i.e. activation level for each of the factors in the FCM model and/or for interpreting activation levels resulting from a simulation run.
17. Availability of specialised educational software	A measure of the factor takes into account the number of topics (i.e. one, many, all) and the number of specialised subjects (one, few, many, all) for which the available educational software can be used. For example, if the availability of the educational software allows for the use of this software in the teaching and learning of one particular topic within one particular specialised subject then this indicates that the 'availability of specialised educational software' is at an activation level of 0.1. Whereas if the availability of the educational software allows for the use of software in the teaching and learning of all topics within all specialised subjects then this indicates that the 'availability of specialised educational software' is at a maximum activation level of 1. Activation levels range from 0 i.e. 'no specialised educational software is available' to 1 i.e. 'specialised educational software for all topics within all subjects is available, as explained above'.
18. Educational soft. ability to adapt to students needs and preferences	A measure of this factor takes into account the number of educational software packages used in school (i.e. one package, few, a lot, all packages) and the extent to which the educational software can adapt to students needs and preferences (i.e. none, small, moderate, high and very high). Activation levels range from 0 i.e. 'educational software cannot adapt to students' needs and preferences' to 1 i.e. 'all educational software is very highly capable of adapting to students needs and preferences'.

Factor	General Guidelines: for allocating a numeric fuzzy measure i.e. activation level for each of the factors in the FCM model and/or for interpreting activation levels resulting from a simulation run.
19. Educational software ability to satisfy learning requirements.	A measure of this factor takes into account the number of educational software packages used in school (i.e. one package, few, a lot, all packages) and the number of learning requirements satisfied (i.e. few, some, a lot, all). For example, a total of one educational software package satisfying only a few learning requirements indicates that 'educational software ability to satisfy learning requirements' is at an activation level of 0.1. Whereas all of the educational software packages having the ability to satisfy all of the leaning requirements indicates that educational software ability to satisfy learning requirements is at a maximum activation level of 1. Activation levels range from 0 i.e. 'educational software satisfies no learning requirements' to 1 i.e. 'all educational software satisfies all learning requirements as explained above'.
20. ICT culture in school	Activation levels range from 0 i.e. 'no ICT culture in school' to 1 i.e. 'highly integrated mature ICT culture'.
21. Teachers' usage of ICT outside of school	A measure of this factor takes into account the number of teachers (i.e. one teacher, small group, most teachers, all teachers) and the frequency of ICT use outside of school (i.e. small, moderate, high, very high). For example, one teacher using a small amount of ICT outside the school indicates that 'teachers' usage of ICT outside of school' is at an activation level of 0.1. Whereas all teachers using very high levels of ICT outside the school indicates that 'teachers' usage of ICT outside of school' is at a maximum activation level of 1. Activation levels range from 0 i.e. 'no usage of ICT by teachers outside school' to 1 i.e. 'all teachers using very high levels of ICT outside of school as explained above'.

Factor	**General Guidelines: for allocating a numeric fuzzy measure i.e. activation level for each of the factors in the FCM model and/or for interpreting activation levels resulting from a simulation run.**
22. Students' usage of ICT outside of school	A measure of this factor takes into account the number of students (i.e. one student, small group, one class, one year group, all students) and the frequency of ICT use outside of school (i.e. none, small, moderate, high, very high). For example, one student using a small amount of ICT outside the school indicates that 'students' usage of ICT outside of school' is at an activation level of 0.1. Whereas all students using very high levels of ICT outside the school indicates that 'students' usage of ICT outside of school' is at a maximum activation level of 1. Activation levels range from 0 i.e. 'no usage of ICT by students outside school' to 1 i.e. 'all students using very high levels of ICT outside of school as explained above'.
23. Teachers' usage of educational software	A measure of this factor takes into account the number of teachers (i.e. one teacher, small group, most teachers, all teachers) and the extent to which they use educational software (i.e. small, moderate, high, very high) in school. For example, one teacher using educational software at a small level i.e. once a month indicates that 'teachers' usage of educational software' is at an activation level of 0.1. Whereas all teachers using educational software at very high levels i.e. in all lessons, indicates that 'teachers' usage of educational software' is at a maximum activation level of 1. Activation levels range from 0 i.e. 'no usage of educational software by teachers in school' to 1 i.e. 'all teachers using very high levels of educational software in school as explained above'.

Factor	General Guidelines: for allocating a numeric fuzzy measure i.e. activation level for each of the factors in the FCM model and/or for interpreting activation levels resulting from a simulation run.
24. Students' usage of educational software	A measure of this factor takes into account the number of students (i.e. one student, small group, one class, one year group, all students) and the extent to which they use educational software (i.e. small, moderate, high, very high). For example, one student using educational software at a small level i.e. once a month indicates that 'students' usage of educational software' is at an activation level of 0.1. Whereas all students using educational software at very high levels i.e. in all lessons indicates that 'students' usage of educational software' is at a maximum activation level of 1. Activation levels range from 0 i.e. 'no usage of educational software by students in school' to 1 i.e. 'all students using very high levels of educational software in school as explained above'.

Table 34 shows the fuzzy linguistic terms in relation to node activation levels and their associated fuzzy numerical values (based on the same principles as the conversion measures seen in Table 19 section 6.2) generally used within this study:

Table 34 Fuzzy linguistic and numerical conversion measures for factor activation levels

Fuzzy linguistic term	none	small	moderate	high	Very high
Fuzzy numerical value	0	0.25	0.5	0.75	1

7.4.2 Static analysis issue addressed

The simulation process described in section 7.4.1 is used to address the concerns raised in section 7.2 in which according to the static analysis an increase in factor 2 'availability of non-outdated IT equipment' led to two opposing effects/outcomes. The analysis had shown that through the positive cycle 3 (seen in Table 32) F6 'level of teachers' ICT skills' would constantly increase, whereas through negative cycle 18 (seen in Table 32) F6 'ICT skills of teachers' would constantly decrease, despite the initial increase in factor 2 'availability of non-outdated IT equipment' in both cases. It was difficult to determine which cycle i.e. 3 or 18 would prevail.

The FCM model was simulated by initiating a change in the activation level of factor 2 the 'availability of non-outdated IT equipment'. While all other factors' activation levels were set at 0, the activation of factor 2 was set from 0 to 0.5, therefore indicating an increase in the activation level of factor 2. The value 0.5 (refer to Table 33) for the activation level of factor 2, was chosen to provide an example.

The simulation results are recorded in Table 35. In which **FCM_t** refers to the state of all factors in the FCM model at time step t. **$F_t(n)$** refers to factor n in the FCM model at time step *t*, n= number of factors as listed in Table 33. For example in Table 35, FCM_1 refers to the activation levels i.e. states of all the factors, as listed in the column, at time step *t*=1, and F_1 (2) refers to the activation level of factor 2 at time step *t*=1, which is in this instance 0.5.

By examining the simulation results presented in Table 35 and the graph, seen in Figure 14, it is found that given an initial increase of 0.5 in factor 2 the 'availability of non-outdated IT equipment', there is a constant rise in factor 6 the 'level of teachers' ICT skills'. The values in Table 35 show the activation level of factor 6 at t = 1 is F_1 (6) = 0.593, at t = 2 is F_2 (6) = 0.796, at t = 3 is F_3 (6) = 0.849 and so on, factor 6 stabilises at an activation level of 0.87 at t=11, when the FCM model reaches equilibrium.

Table 35 Simulation results of the FCM given an increase in factor 2

Factor	FCM_0	FCM_1	FCM_2	FCM_3	FCM_4	FCM_5	FCM_6	FCM_7	FCM_8	FCM_9	FCM_{10}	FCM_{11}
1.	0	0.5	0.6792	0.7193	0.7312	0.7342	0.735	0.7352	0.7352	0.7352	0.7352	0.7352
2.	0.5	0.5	0.7311	0.7862	0.7997	0.8032	0.8042	0.8044	0.8044	0.8045	0.8045	0.8045
3.	0	0.5312	0.5312	0.5456	0.549	0.5498	0.55	0.5501	0.5501	0.5501	0.5501	0.5501
4.	0	0.5927	0.8244	0.8919	0.9068	0.9102	0.911	0.9112	0.9113	0.9113	0.9113	0.9113
5.	0	0.5	0.5927	0.6216	0.6305	0.6325	0.6331	0.6332	0.6333	0.6333	0.6333	0.6333
6.	0	0.5927	0.7956	0.8497	0.8664	0.8699	0.8706	0.8708	0.8709	0.8709	0.8709	0.8709
7.	0	0.5622	0.7416	0.8157	0.8334	0.8366	0.8375	0.8377	0.8377	0.8377	0.8378	0.8378
8.	0	0	0	0	0	0	0	0	0	0	0	0
9.	0	0	0	0	0	0	0	0	0	0	0	0
10.	0	0	0	0	0	0	0	0	0	0	0	0
11.	0	0.5622	0.8386	0.9184	0.9275	0.9297	0.9302	0.9303	0.9303	0.9303	0.9303	0.9303
12.	0	0	0	0	0	0	0	0	0	0	0	0
13.	0	0	0	0	0	0	0	0	0	0	0	0
14.	0	0	0	0	0	0	0	0	0	0	0	0
15.	0	0	0	0	0	0	0	0	0	0	0	0
16.	0	0	0	0	0	0	0	0	0	0	0	0
17.	0	0	0	0	0	0	0	0	0	0	0	0
18.	0	0	0	0	0	0	0	0	0	0	0	0
19.	0	0	0	0	0	0	0	0	0	0	0	0
20.	0	0.5	0.6618	0.7124	0.724	0.7274	0.7282	0.7284	0.7285	0.7285	0.7285	0.7285
21.	0	0.5622	0.5579	0.5844	0.5906	0.5921	0.5925	0.5926	0.5926	0.5926	0.5926	0.5926
22.	0	0.5	0.4973	0.4963	0.4961	0.4961	0.4961	0.4961	0.4961	0.4961	0.4961	0.4961
23.	0	0.5736	0.9804	0.994	0.9957	0.996	0.9961	0.9961	0.9961	0.9961	0.9961	0.9961
24.	0	0.5912	0.9767	0.9939	0.9956	0.9959	0.996	0.996	0.996	0.996	0.996	0.996

(Please note FCM_t refers to the FCM model at time step *t*)

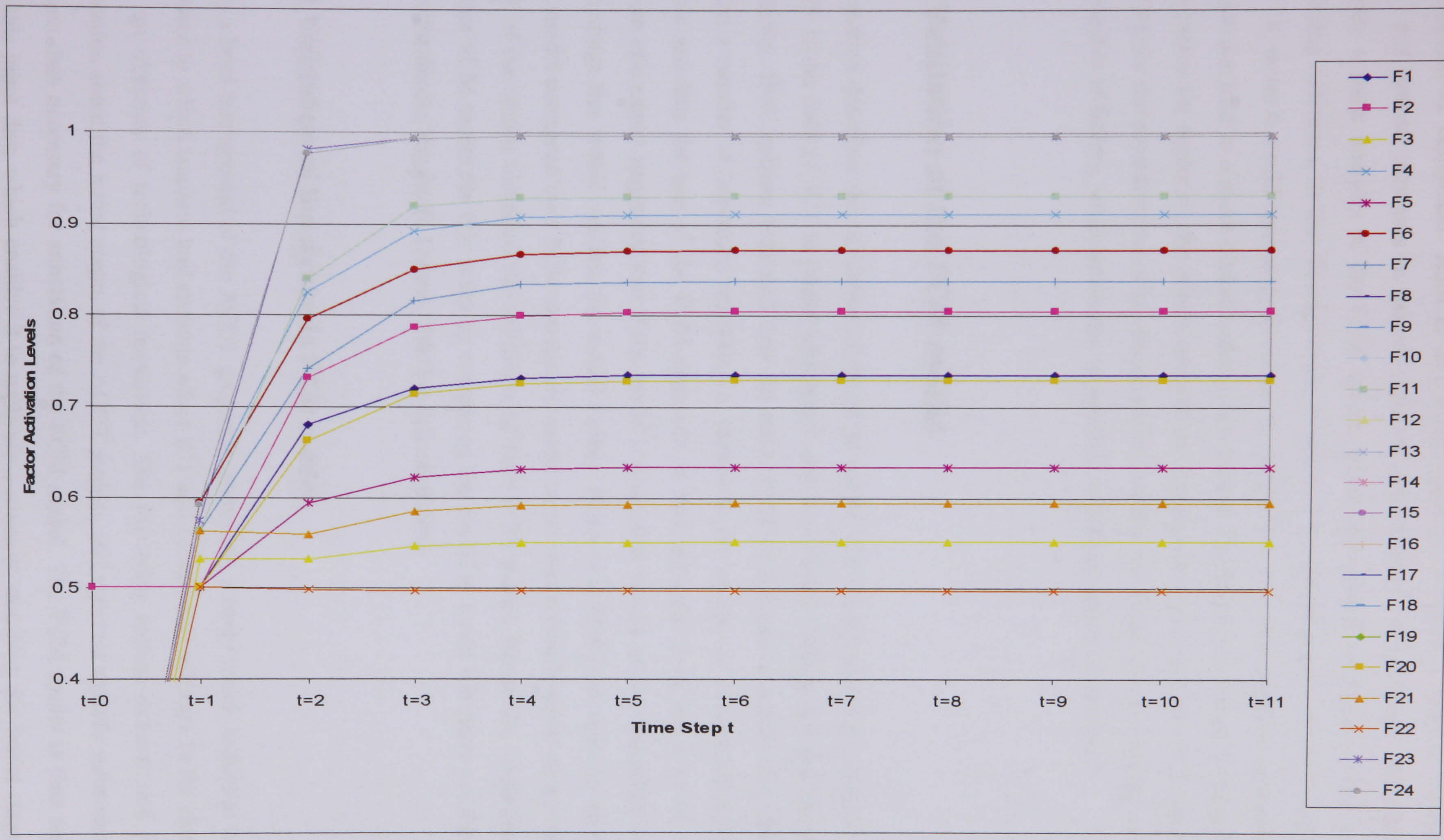


Figure 14 Graph showing FCM simulation results given an initial increase in the activation level of factor 2

From this dynamic analysis it is possible to conclude that an increase in factor 2 'availability of non-outdated IT equipment' leads to an overall increase in factor 6 'level of teachers' ICT skills' and general increases in the activation levels of most of the factors including itself. Whereas a static analysis of the FCM model, given an increase in factor 2, had produced conflicting outcomes, in that through cycle 3, factor 6 would constantly increase and through cycle 18, factor 6 would constantly decrease. In comparison to a static analysis a dynamic FCM analysis can lead to a more certain outcome/prediction. Therefore a dynamic FCM provides a better means for exploring the effects of policies, investments and initiatives in the domain, by allowing for the consideration of an outcome/effect within the model given a change in a factor or a number of factors, which arises due to policies, initiatives and/or investments.

7.5 Validation of the FCM model

This section describes the validation of the FCM model. The model was first validated by two experts in the field of 'ICT in school education', one from Kings College, and one from Brunel University. Both experts indicated that the static FCM model was a sound one taking into account a number of important variables i.e. factors in the up-take of educational software in schools and that the use of the FCM approach in this particular area was a novel idea. In addition one expert suggested that if the model's simulation results were comparable with real life findings this would validate the model further. Khan et al (2001) in order to verify their FCM model compared their FCM simulation results to the results from another study, where the match of the results indicated the validation of their FCM model. Hence the validation of the dynamic FCM model for this study by comparing the model to a real life study i.e. the ACOT study (Sandholtz, Ringstaff, Dwyer, 1997) is discussed next.

7.5.1 Validation of the dynamic FCM model

Firstly a brief background of the ACOT project is presented; a study which looked at how and the extent to which teachers and students adopt ICT and educational software in the classroom, given an injection of technological provisions. The following section extracts and presents information about the initial stages of the ACOT project, and converts specific information into the input data necessary for simulation of the FCM model. The FCM model is then simulated using this input data which enables it to replicate a scenario matching the initial stage of the ACOT project. The simulation results are presented, interpreted and compared to the findings of the ACOT study. The main purpose of this comparison being, that if the simulation results of the FCM model generally match the ACOT study findings, the FCM model can be considered to be validated.

7.5.1.1 The ACOT study background

The Apple Classrooms of Tomorrow (ACOT) project based in the USA (Sandholtz, Ringstaff, Dwyer, 1997) was a study which spanned over 10 years. It investigated the routine use of technology by teachers and students and how this affected teaching and learning. They studied the impact of total computer access on students, teachers and on instructional processes. They initially set about installing and operating computer-saturated classrooms as living laboratories in every grade (k-12) and integrating state-of the art technologies into the instructional fabric of the schooling, equipping project classrooms with computers, printers, CD-ROM drives and variety of software packages.

ACOT started to work in five different schools in five different states, each of these ACOT sites began with one classroom, and this expanded to more classrooms, teachers and students in subsequent years. Initially each participating teacher and student was provided with two computers one for home and one for the classroom. Training was also provided for project teachers on telecommunications, basic troubleshooting and tool software such as spread sheets, databases and graphics programs.

7.5.1.2 Determination of input data for FCM simulation

It is deduced from section 7.5.1.1, that teachers and pupils in each of ACOT project classrooms experienced initial impacts in the following areas: 'availability and access to ICT facilities', 'availability of new IT equipment', and 'availability of educational software' and 'teachers' ICT training'. In relation to the FCM model these mentioned areas are related to factors 1, 2, 7 and 11 respectively. Therefore having identified the initial factors to activate in the FCM model, which will replicate the initial scenario of the ACOT study, the next step is to determine the activation levels that these factors should be set at for initiating the FCM simulation process. Based on the guidelines for factor activation measures set out in Table 33, Tables 36-40, are used in the determination of the activation levels required for initiating the FCM.

The different activation levels of factor 1 the 'availability and access to IT facilities', seen in Table 36 are based on the measures set out in Table 33, and are related to practical situations within a school environment. Similarly Table 37 shows the different activation levels of factor 2 the 'availability of new IT equipment' and Table 38 shows the activation levels for factor 11 the 'availability of educational software'.

Table 36 Activation levels for factor 1

No. of pupils and staff which have access to IT facilities at any one time.	Activation level of factor 1 'Availability and access to IT facilities'
1 pupil/ 1 teacher	0.1
Small group (about 8-10) pupils/ group of teachers	0.25
1 Classroom (about 30 pupils)	0.5
1 year group (about 150-200 pupils)	0.75
Whole school	1

Table 37 Activation levels for factor 2

No. of pupils and staff which have access to non-outdated IT equipment at any one time:	Activation level of factor 2 'Availability of non-outdated IT equipment'
1 pupil/ 1 Teacher	0.1
Small group (about 8-10) pupils/ Small group of teachers	0.25
1 Classroom (about 30 pupils)	0. 5
1 year group (about 150-200 pupils)	0.75
Whole school	1

Table 38 Activation levels for factor 11

Educational software available allows for:	Activation level of factor 11 'Availability of educational software'
Can be used in the teaching /learning of one particular topic in one particular curriculum subject	0.1
Can be used in the teaching /learning of many topics in one particular curriculum subject	0.25
Can be used in the teaching /learning of only one topic in many curriculum subjects	0. 25
Can be used in the teaching /learning of many topics in many curriculum subjects	0.75
Can be used in the teaching /learning of all topics in all of the curriculum subjects	1

To determine the activation level of factor 7 'Teachers' training in ICT', there is a need to consider both the levels of training received and the number of teachers trained in the school, as indicated in Table 33. Table 39 shows the activation levels of factor 7, based on the level of training received by all teachers in the school.

Table 39 Activation levels for factor 7

Levels of training provided for all teachers:	Activation level of factor 7 'Teachers' training in ICT'
1. Basic training in the general use of IT equipment and generic software	0.25
2. Training in how to use non-generic software packages i.e. educational and 1. Above	0.50
3. Training in how to integrate ICT and educational software into a classroom and 1, 2 above.	0.75
4. Training in how to use ICT and educational software in a pedagogically effective manner.	1

Next there is a need to consider the number of teachers trained in the school at each level of training described above, where each activation level in Table 39 above is divided into further activation levels. With specific regard to the ACOT study where basic training was provided, point 1 from Table 39 above is considered, where the activation level 0.25 of factor 7, given that all teachers in the school receive basic training, is divided into different activation levels based on the number of teachers in the school who received the training or for whom the training was provided, as seen in Table 40 next:

Table 40 Activation levels of factor 7 based on number of teachers having a basic level of ICT training

Basic training in the use of IT equipment and generic software for the following number of teachers:	Activation level of factor 7 'Teachers' training in ICT'
1 teacher	0.1
Small group of teachers	0.15
Majority of teachers	0.2
All teachers	0.25

Given the different activation values of factors 1, 2, 7 and 11 in relation to practical situations as described in Tables 36, 37, 38, 39, 40, it is now possible to determine the initial activation levels in order to replicate the ACOT project at the beginning of its study, and initiate the simulation of the FCM model. Since the ACOT project, at the start of its study provided access and equipment for only one classroom within a whole school site, according to Tables 36 and 37, factor 1 ' availability and access to IT facilities' and factor 2 'availability of non-outdated hardware/IT equipment' both need to be activated to 0.5. The ACOT project provided basic training to the teachers participating in the project. Since it is not specified that only one teacher from the newly IT equipped classroom had been trained, it is assumed a small group of teachers in a whole school site were provided with a basic level of training. Therefore according to Table 40 factor 7 'Teachers training in ICT' needs to be activated to 0.15. Given the software initially provided by the ACOT project was described broadly and not in any specific terms, i.e. whether it was generic software or particularly for the teaching of specific curriculum subjects etc, according to Table 38 factor 11 'availability of educational software' needs to be activated to a 0.25 level. In summary Table 41 below lists the activation levels of the factors 1, 2, 7 and 11 that provided the initial input data for initiating the simulation process (as described in section 7.4.1). The results of the simulation are presented in Table 42 and a graph based on the results can be seen in Figure 15.

Table 41 Factors activated and initial activation levels to replicate ACOT study

Factors activated	Factor Activation Levels (Input data for initiating FCM simulation)
Factor 1 ' availability and access to IT facilities'	0.5
Factor 2 'availability of non-outdated hardware/IT equipment'	0.5
Factor 7 'Teachers training in ICT'	0.15
Factor 11 'availability of educational software'	0.25

Table 42 FCM simulation results based on initial ACOT study scenario

Factor	FCM_0	FCM_1	FCM_2	FCM_3	FCM_4	FCM_5	FCM_6	FCM_7	FCM_8	FCM_9	FCM_{10}
1.	0.5	0.5	0.6941	0.7225	0.7319	0.7344	0.735	0.7352	0.7352	0.7352	0.7352
2.	0.5	0.5927	0.7445	0.79	0.8007	0.8035	0.8042	0.8044	0.8045	0.8045	0.8045
3.	0	0.5312	0.537	0.5464	0.5492	0.5499	0.5501	0.5501	0.5501	0.5501	0.5501
4.	0	0.7032	0.8466	0.8967	0.9078	0.9104	0.9111	0.9112	0.9113	0.9113	0.9113
5.	0	0.5	0.6093	0.6224	0.6312	0.6327	0.6331	0.6333	0.6333	0.6333	0.6333
6.	0	0.6341	0.8138	0.8561	0.8673	0.8701	0.8707	0.8708	0.8709	0.8709	0.8709
7.	0.15	0.5927	0.776	0.8202	0.8344	0.8369	0.8375	0.8377	0.8377	0.8378	0.8378
8.	0	0	0	0	0	0	0	0	0	0	0
9.	0	0	0	0	0	0	0	0	0	0	0
10.	0	0	0	0	0	0	0	0	0	0	0
11.	0.25	0.6514	0.8676	0.9215	0.9282	0.9298	0.9302	0.9303	0.9303	0.9303	0.9303
12.	0	0	0	0	0	0	0	0	0	0	0
13.	0	0	0	0	0	0	0	0	0	0	0
14.	0	0	0	0	0	0	0	0	0	0	0
15.	0	0	0	0	0	0	0	0	0	0	0
16.	0	0	0	0	0	0	0	0	0	0	0
17.	0	0	0	0	0	0	0	0	0	0	0
18.	0	0	0	0	0	0	0	0	0	0	0
19.	0	0	0	0	0	0	0	0	0	0	0
20.	0	0.5927	0.6664	0.7166	0.725	0.7276	0.7283	0.7284	0.7285	0.7285	0.7285
21.	0	0.564	0.5681	0.5859	0.591	0.5922	0.5925	0.5926	0.5926	0.5926	0.5926
22.	0	0.4961	0.4975	0.4963	0.4961	0.4961	0.4961	0.4961	0.4961	0.4961	0.4961
23.	0	0.7203	0.9862	0.9947	0.9958	0.9961	0.9961	0.9961	0.9961	0.9961	0.9961
24.	0	0.7395	0.9844	0.9945	0.9957	0.9959	0.996	0.996	0.996	0.996	0.996

(Please note FCM_t refers to the FCM model at time step *t*)

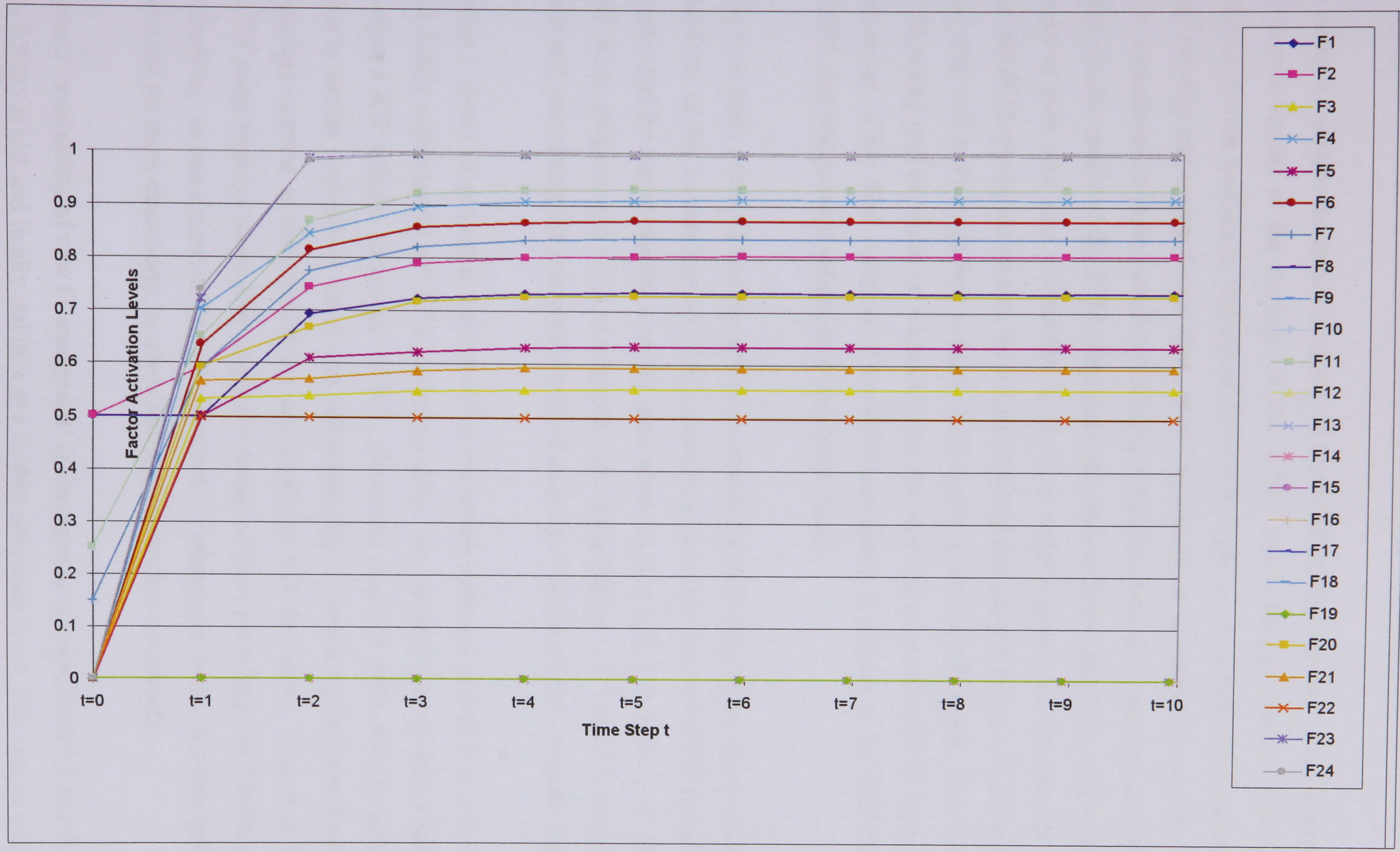


Figure 15 Graph showing FCM simulation results based on initial ACOT study scenario

7.5.1.3 Interpretation and comparison of FCM simulation results to ACOT study findings

In order to validate the dynamic ability of the FCM model this study now compares the FCM simulation results to the findings of the ACOT study. Firstly, however there is a need to mention that the qualitative findings of the ACOT study i.e. the changes and patterns in teaching and learning that emerged over time, were conceptualised as stages of a model. The stages of this instructional evolution consisted of entry, adoption, adaptation, appropriation and invention. However the results of the FCM simulation are given as factor activation levels within the FCM model at each time step *t*. Therefore in order to make comparisons between the ACOT study and the FCM simulation results, the overall findings and general trends will be considered, each time step will not be matched to each of the stages of the ACOT model. The validation of the FCM model will be based on whether given the same inputs as the ACOT study for the FCM simulation, if the final outcome of the FCM simulation is similar to the final findings of the ACOT, this will provide validation of the FCM model.

It is seen from Table 42 that equilibrium is reached as time step 10 i.e. this is where the model stabilizes, so the column headed FCM_{10} provides a snap shot view of the FCM model at t=10. It is seen that the model reaches a steady state where factors 1, 2, 3, 4, 5, 6, 7, 11, 20, 21, 22, 23, and 24 are activated as a result of originally activating factors 1, 2, 7 and 11. Looking across the table and considering the activation levels of each these factors, in turn it can be seen that:

Factor 1 shows an activation level of 0.5 at t=0 which increases to 0.6941 at t=2, 0.7225 at t=3 and finally stabilizes to a 0.7352 activation level. An interpretation of this would be that the energised ICT culture, awareness of ICT, the newly acquired skills and the adoption of ICT leads to further demands in the access and availability of computing facilities therefore causing a gradual increase in the 'availability and access to ICT facilities'. This is in line with the ACOT study findings where they originally started off with providing 'availability and access to IT facilities' to one classroom per site. However in subsequent years, facilities and access were increased for more classrooms, teachers and students within the schools.

Factor 2 'availability of new IT equipment' is also seen to increase from 0.5 at t=0, to 0.5927 at t=1, 0.7445 at t=2 and finally stabilize at a 0.8045 activation level. This can be interpreted as an increase in the availability of IT equipment because of the demand for better, faster IT equipment, given the awareness of schemes and other ICT related state of the art equipment and the need to posses such equipment. The ACOT findings also reflected this. During their adoption phase once teachers and students had started to see and use the equipment, teachers complained about lack of equipment. This led to an increase in equipment leading to an increase in expectations for more, i.e. given one computer and seeing and using it led to a want for more therefore fuelling the demand and subsequently causing a greater 'availability of new IT equipment' in the school.

Although factor 3 was not initially activated it is seen to be activated to 0.5312 at time step t=1 and stabilises to a 0.5501 activation level. The interpretation of this would be that with the increased facilities, support of technical staff, training and skills acquired, teachers can then spend time on preparing lessons incorporating ICT and software. This is similar to the findings of the ACOT study where teachers spent time and needed more time to complete technical work, setting up and arranging equipment. They spent time evaluating and searching for software they could adapt to their established curricular and pedagogical preferences, making it available to use in the classroom.

However as per the simulation results the activation levels of 'time to prepare lessons using software' remains within a moderate level i.e. from 0.5312 to 0.5501 over the 10 time steps, this can be considered reasonable in the sense that initially with the lack of experience and IT skills teachers can spend a considerable amount of time in preparing such lessons, but as their experience and skills increase, given the same amount of time, they may spend a lesser proportion of it on preparing such lessons and maybe inclined to spend a greater proportion of the time on searching and developing new approaches with educational ICTs. Therefore overall the 'amount of time to prepare lessons using software' does not increase by much.

Given increased ICT facilities, equipment, skills and culture, as seen in the column headed FCM_1 from Table 42, factor 4 the 'amount of ICT usage in school' is also seen to be highly energised to an activation level of 0.7032 at t=1, 0.8466 at t=2 and finally stabilises to a 0.9113 activation level. The ACOT study too found a considerable increase in the usage of ICT from the adoption stage onwards through to the invention stage. From teachers incorporating computer-based activities to teach children how to use technology to thoroughly integrating ICT into the traditional classroom practice. Teachers focused on the effects of their teaching and began to utilise technology to their advantage in managing the classroom. They shared ideas with each other, experimented with computers leading to improved techniques for developing assignments and tests. Overall during the period of the ACOT project, students too showed increased initiative by going beyond assignment requirements, and by the adaptation stage they were using word processors, graphic programs and computer-assisted instructional (CAI) packages for approximately 30-40% of the school day. They were highly skilled with the technology and were using it extensively in a number of ways for both assignments and non-assigned work. They spent more time on assignments and projects when working with computers and chose to use computers during free time and after school hours. Therefore altogether the 'amount ICT usage' increased rapidly and to high levels, as also seen in the simulation results.

Factor 5 'availability of technical support staff' is also seen to be activated at t=1 at a 0.5 activation level and reaches a steady state of 0.6333. An interpretation of this result would be that with the increased ICT facilities, equipment, and the 'amount of ICT usage in school' being highly energised there is also now a need to manage and maintain the technical infrastructure and machines, and so 'technical support staff' are employed. As facilities and equipment increase with time there is also a slight increase in the availability of technical staff to maintain the smooth running of the technological infrastructure. The ACOT finding also indicate that, given the number of equipment and frequency of use, there were technical problems, and as a solution they needed to employ on-site computer technicians.

The 'level of teachers' ICT skills' factor 6 is seen to be activated to level 0.6341 at t=1, which increases to 0.8138 at t=2 and stabilizes to a 0.8709 activation level. Hence this can be interpreted as teachers' ICT skills improving rapidly, in line with their training and their increased use of ICT. ACOT findings also indicate this rapid development of teachers' skills from teachers in the entry stages having little or no experience with computer technology to teachers mastering the technology basics, and focusing on instruction. By the adoption stage teachers had skills at troubleshooting and repairing equipment, and by the adaptation stage their familiarity with computer applications and software enabled them to develop strategies for increasing the amount of work they could cover during the day. Teachers in the invention phase were noted to have greater confidence with technology and experimented with new instructional patterns. Although teachers in the study had shown that they were finally comfortable with the changes, compared to how they were at the start of the project, most but not all reached the invention stage.

The activation level for factor 7 'Teachers' training in ICT' initially is 0.15, which is seen to increase to 0.5927 at t=1, 0.776 at t=2 and finally stabilise at a 0.8378 activation level. An interpretation would be that given an energised ICT culture in school there is direction towards providing more ICT related training for teachers. Furthermore with teachers using more ICT and having increased in their technological skills, they are now more likely to consider the effective integration of ICT and software in classrooms for teaching and learning, hence leading to a big increase in teachers acquiring such training. The ACOT findings also indicated this, where at the start of the project teachers had been provided with basic training, by the time they had reached the adoption phase teachers were increasing their knowledge via attending training courses and/or were self-taught in order to enhance their abilities to manage and teach in technology rich classrooms.

Factor 11 'availability of educational software' is activated to 0.25 at t=0, which increases to 0.6514 at t=1, 0.8676 at t=2 and stabilizes at a 0.9303 activation level. This can mean that given the increases in the school's ICT culture, teachers' ICT skills and experiences of both teachers and students in the use of educational software, more educational software is looked at and made available within the school. The ACOT findings too noted that once teachers had mastered the technology basics they focused on instruction, and showed increased concern about how to integrate technology into daily instructional plans. They spent time evaluating and searching for software they could adapt to their established curricular and pedagogical preferences, making it available to use in the classroom as the technology became integrated into the traditional classroom practice.

'ICT culture in school' factor 20, given the recent boost of IT facilities, equipment and newly acquired IT skills by teachers is activated to 0.5927 at t=1. This increases to 0.6664 at t=2, 0.7166 at t=3 and stabilizes at activation level 0.7285 as IT facilities, IT equipment, teachers' skills, training and general usage of ICT increase within the school. A build up of ICT culture is also noted in the findings of the ACOT study. Initially there had been an atmosphere of establishing order in an environment which had been changed radically with the introduction of technology. Over time teachers started to share ideas with each other, experimented with computers leading to improved techniques for developing assignments and tests. Their attitudes changed as their ability to use the technology to their advantage increased i.e. in the beginning there were concerns about technology in the classrooms, but later there were worries about teaching without it. Teachers were noted to have replaced old habits with new ones; there were changes in their beliefs about the usefulness of technology and using the technology in a variety of ways. Overall during the period of the ACOT project, students showed increased initiative by going beyond assignment requirements. They independently experimented with and explored new applications and chose to use computers during free time and after school hours. The whole mood of the sites changed as more teachers reached the invention stage; it was common to see interdisciplinary project based instruction, team teaching and individually based instruction.

Factor 21 'teachers' usage of ICT outside of school' and factor 22 'students' usage of ICT outside school' show activation levels 0.564 and 0.4961 respectively at t=1. This tendency to use ICT at home by both teachers and students can be due to the ICT culture and IT skills picked up at school. The activation level of factor 21 increases slightly and finally settles at 0.5926, as teachers' experiences of using IT equipment and additional training increase they become more aware of the pedagogical benefits of using ICT and move towards creating more innovative ways of using educational ICTs. However there is a slight but noticeable decrease in the use of ICT at home by students from 0.4975 at t=2 to 0.4963 at equilibrium. This maybe because the novelty effect of the highly energised adoption of ICT that students were initially experiencing diminishes or they are making greater use of ICT at school instead, because of the increased facilities and equipment provided there. In the ACOT study although there is mention of 2 computers being provided for each participant, i.e. one for home and one for class, the discussion of their findings generally focuses on the overall ICT usage so the 'usage of ICT at home' specifically is not detailed as such.

'Teachers usage of educational software', factor 23 shows an activation level of 0.7203 at t=1 which increases to 0.9862 at t=2 and stabilizes at activation level 0.9961. 'Students usage of educational software' factor 24 shows activation level 0.7395 at t=1, which increases to 0.9844 at t=2 and stabilizes at 0.996. This can mean that given the increased facilities, availability of software, support of technical staff, training, skills and greater use of ICT, where teachers are spending time looking for appropriate software and preparing lessons incorporating ICT and software, educational software is more readily adopted and used in the classroom. Hence there is a high usage by both teachers and students. The ACOT study found that teachers spent time evaluating and searching for software they could adapt to their established curricular and pedagogical preferences, and make it available to use in the classroom. It was their familiarity with computer applications and software which enabled them to develop strategies for increasing the amount of work they could cover during the day. Students also were found to excel rapidly on their own, mastering the use of software. Therefore generally indicating both teachers' and students' experience of using educational software was high compared to their experiences at the start of the project.

From the above discussion and comparison of the FCM simulation results to the ACOT study findings, it appears that the FCM simulation results are generally found to be in line with the findings of the ACOT study. Therefore given that the final outcome of the FCM simulation is similar to the final findings of the ACOT, the FCM model can be considered to be validated.

7.6 Application of the FCM model

This section demonstrates and discusses how the validated FCM model can be used in a practical situation. However, first it is worth reiterating the main focus of this study and to highlight that this research did not set out to: 1). Study, in any manner, the impact of ICT in education i.e. its impact on the learning process and teaching practices such as pedagogical benefits and benefits it brings about in teaching etc. 2). Conduct studies related to the processes involved in allocating monies and justifying ICT related expenditures based on financial assessments such as costs, pricing, or because ICT impacts education. This research recognises and accepts the importance and relevance of ICT in education based on the available literature, government reports and various studies that have been conducted. Therefore this study is concerned with the uptake of educational ICTs i.e. specifically educational software in the school environment.

In retrospect, this study does in effect have consideration for the above two points 1 and 2 even though they are not the main focus of this study because: 1). Given the impact and benefits of ICT in education as advocated so strongly, it is fundamental to ensure that ICT in education is implemented successfully and adopted readily by the relevant stakeholders. Therefore there is a need to provide an insight into which factors can influence the adoption and utilisation of educational ICTs. After all, the impact of ICT in education can only be realised when it is readily adopted and utilised in the school environment by teachers and students. 2). Assessments conducted, to allocate monies for ICT related expenditures, or strategies developed to direct efforts to ICT related areas, which are based on costs, pricing and/or the impact ICT has on the learning or teaching process, in addition need to take into account the factors which affect adoption and utilisation as perceived by relevant stakeholder groups. Implementing cost effective educational ICTs is only worth while as long as users readily adopt and utilise such ICTs.

Hence the focus of this study has been to determine the factors and the extent to which these factors influence the adoption and use of educational ICTs in the school environment. Importantly the model constructed as a result of this research is based on the perceptions of the relevant stakeholder groups, i.e. the factors and the extent to which these factors, in their opinion, lead to the usage of educational software in the school environment by teachers and students. The purpose of the FCM model can be considered to be twofold: 1). It provides a holistic view of the factors required and the extent of their influence on the adoption of educational software in the school environment. 2). Given that the model can be simulated, it allows 'what-if' possibilities. Therefore scenarios can be created, based on for example policy changes, investments or efforts and can be adapted as factor activation levels in the model. Simulations can be run and the results examined, as to what would be the outcome or effect as a result of such policies, investments or efforts. Such exploitation of FCM models to explore alternatives and to make predictions have been advocated and is evident within the literature (Khan et al., 2001; Kardaras and Karakostas, 1999b; Stach and Kurgan, 2004; Banini and Bearman, 1998, Tsadiras et al., 200, etc), as discussed in chapter 3. The next section looks at scenarios to represent 'what-if' situations which can be explored by using the FCM model dynamically i.e. via simulation. In doing so, the section will demonstrate an example of the FCM's application for a practical situation.

7.6.1 Determining scenarios for FCM simulation based on practical issues

To demonstrate the practical use of the FCM model a brief interview was conducted with an ICT co-ordinator at School A. This was to ascertain whether any practical and relevant issues existed which could be explored by the dynamic FCM model and addressed based on the analysis of the FCM's simulation results. From the interview, the specific extracts, seen below were considered:

> *"Well there are dilemmas. With the last bit of the funds we spent it on wireless laptops. We did however consider between the purchasing of the laptops or refurbishing the old ICT suites. It wasn't that needy, but with lightening and benching etc, it would have slightly increased access. With the laptops we got 240, so that's about £200,000"*
>
> *"The ICT test project won't be receiving anymore funds, whatever we have left is hardly enough to keep us sustainable, we have to look at other means of funding."*

From these extracts it was deduced that the school faced a choice in directing resources between two alternatives i.e. buying laptops or refurbishing computer suites. In this instance an application of the FCM model, would allow the effects of either of these two alternatives on the usage of educational software and other factors in the domain (as seen in the FCM model) to be explored, and allow for a prediction as to which would be the better option. The two alternatives would be represented as two different scenarios based on which the FCM simulation would be initiated. The other issue for consideration, deduced from the extracts above, is that the school in the near future will be facing funding issues. In the event that the school is unable to sustain all of the ICT related areas/factors at their present operational/activation levels, the dynamic FCM model provides the means by which it is possible to explore and ascertain the overall effect on the up-take of educational software if one or more of the factors are not sustained at their present levels. In this instance for example, a scenario for initiating FCM simulation could be based on a situation where the current high level of 'availability and access to IT facilities' cannot be sustained. Table 43 summarises and lists these three scenarios discussed above and the conditions for initiating simulation of the FCM model, in terms of which factors need to be activated and their activation levels.

By examining the FCM as a static model it is seen that for scenario 1: the strength of the causal relationship between factor 2 and factor 23 'usage by teachers' is 0.592. While the strength of the causal relationship between factor 2 and factor 24 'usage by students' is 0.738. For scenario 2: the strength of the causal relationship between factor 1 and factor 23 'usage by teachers' is 0.731 While the strength of the causal relationship between factor 1 and factor 24 'usage by students' is 0.738. Automatically a conclusion may be drawn that an increase of factor 1 will have a greater impact on 'educational software usage' than factor 2.

However what needs to be realised is the extent to which each factor is initially activated and that other factors are either directly or indirectly affected. It is the overall knock-on effect and the resulting impact which is worth considering, i.e. that given an initial boost in either of these areas, which will affect other factors as a consequence and lead to a greater usage of ICT in schools. The results derived from the simulation of the FCM model based on the scenarios and conditions set out in Table 43 are presented in Tables 44, 45 and 46, and their respective graphs are seen in Figure 16, 17, 18, this is followed by a discussion of the results.

Table 43 Scenarios based on practical issues and implications for initiating FCM simulations

Scenario	Conditions for initiating FCM simulation
1. An increase in the 'availability of non-outdated IT equipment' (i.e. the purchase of laptops, in this case).	In the FCM model this means the activation of factor 2. Given roughly 240 persons can have access to the new equipment (i.e. given the procurement of 240 laptops) this is taken to be roughly a whole year group in a school. Therefore factor 2, based on Table 37, is activated to 0.75. This is the initial input data for initiating the simulation process (all other factor activation levels are set at 0 at this stage).
2. An increase in the 'access to computer suites' (i.e. as a result of refurbishing computer suites, in this case).	In the FCM model this means the activation of factor 1. Given that the interviewee mentioned a slight increase in access, based on Table 36, factor 1 is activated to 0.25, in order to provide the initial input data for simulating the FCM. (All other factor activation levels are set at 0 at this stage)
3. A reduction in the current high level of 'availability and access to facilities' (i.e. unable to sustain the current level due to a lack of funds).	According to the FCM model this means that factor 1 presently needs to show a 0.75 activation level (based on Table 36) and the rest of the model must reflect this current situation. The model needs to be simulated by activating factor 1 to 0.75 activation level first, and allowing the model to reach equilibrium. It is at this state, that the model can then be ready to show a disinvestment. Then the activation level of factor 1, only, is changed to 0.5 to show that the factor is operational at a moderate level i.e. due disinvestment. This together with the current activation levels of all the other factors provides the initial input data to initiate FCM simulation.

Table 44 FCM simulation results based on scenario 1

Factor	FCM_0	FCM_1	FCM_2	FCM_3	FCM_4	FCM_5	FCM_6	FCM_7	FCM_8	FCM_9	FCM_{10}	FCM_{11}	FCM_{12}
1.	0	0.5	0.6792	0.72	0.7318	0.7344	0.735	0.7352	0.7352	0.7352	0.7352	0.7352	0.7352
2.	0.75	0.75	0.75	0.7868	0.8003	0.8035	0.8042	0.8044	0.8045	0.8045	0.8045	0.8045	0.8045
3.	0	0.5467	0.5467	0.5467	0.549	0.5499	0.5501	0.5501	0.5501	0.5501	0.5501	0.5501	0.5501
4.	0	0.637	0.8528	0.8956	0.9074	0.9104	0.9111	0.9112	0.9113	0.9113	0.9113	0.9113	0.9113
5.	0	0.5	0.5927	0.6225	0.6311	0.6327	0.6331	0.6333	0.6333	0.6333	0.6333	0.6333	0.6333
6.	0	0.637	0.832	0.8577	0.8671	0.87	0.8707	0.8708	0.8709	0.8709	0.8709	0.8709	0.8709
7.	0	0.5927	0.7695	0.8205	0.8341	0.8368	0.8375	0.8377	0.8377	0.8377	0.8378	0.8378	0.8378
8.	0	0	0	0	0	0	0	0	0	0	0	0	0
9.	0	0	0	0	0	0	0	0	0	0	0	0	0
10.	0	0	0	0	0	0	0	0	0	0	0	0	0
11.	0	0.5927	0.8634	0.9217	0.928	0.9298	0.9302	0.9303	0.9303	0.9303	0.9303	0.9303	0.9303
12.	0	0	0	0	0	0	0	0	0	0	0	0	0
13.	0	0	0	0	0	0	0	0	0	0	0	0	0
14.	0	0	0	0	0	0	0	0	0	0	0	0	0
15.	0	0	0	0	0	0	0	0	0	0	0	0	0
16.	0	0	0	0	0	0	0	0	0	0	0	0	0
17.	0	0	0	0	0	0	0	0	0	0	0	0	0
18.	0	0	0	0	0	0	0	0	0	0	0	0	0
19.	0	0	0	0	0	0	0	0	0	0	0	0	0
20.	0	0.5	0.6668	0.7161	0.7249	0.7276	0.7283	0.7284	0.7285	0.7285	0.7285	0.7285	0.7285
21.	0	0.5927	0.588	0.5864	0.5906	0.5922	0.5925	0.5926	0.5926	0.5926	0.5926	0.5926	0.5926
22.	0	0.5	0.4974	0.4964	0.4961	0.4961	0.4961	0.4961	0.4961	0.4961	0.4961	0.4961	0.4961
23.	0	0.6094	0.9854	0.9947	0.9958	0.9961	0.9961	0.9961	0.9961	0.9961	0.9961	0.9961	0.9961
24.	0	0.635	0.9828	0.9945	0.9957	0.9959	0.996	0.996	0.996	0.996	0.996	0.996	0.996

(Please note FCM_t refers to the FCM model at time step *t*)

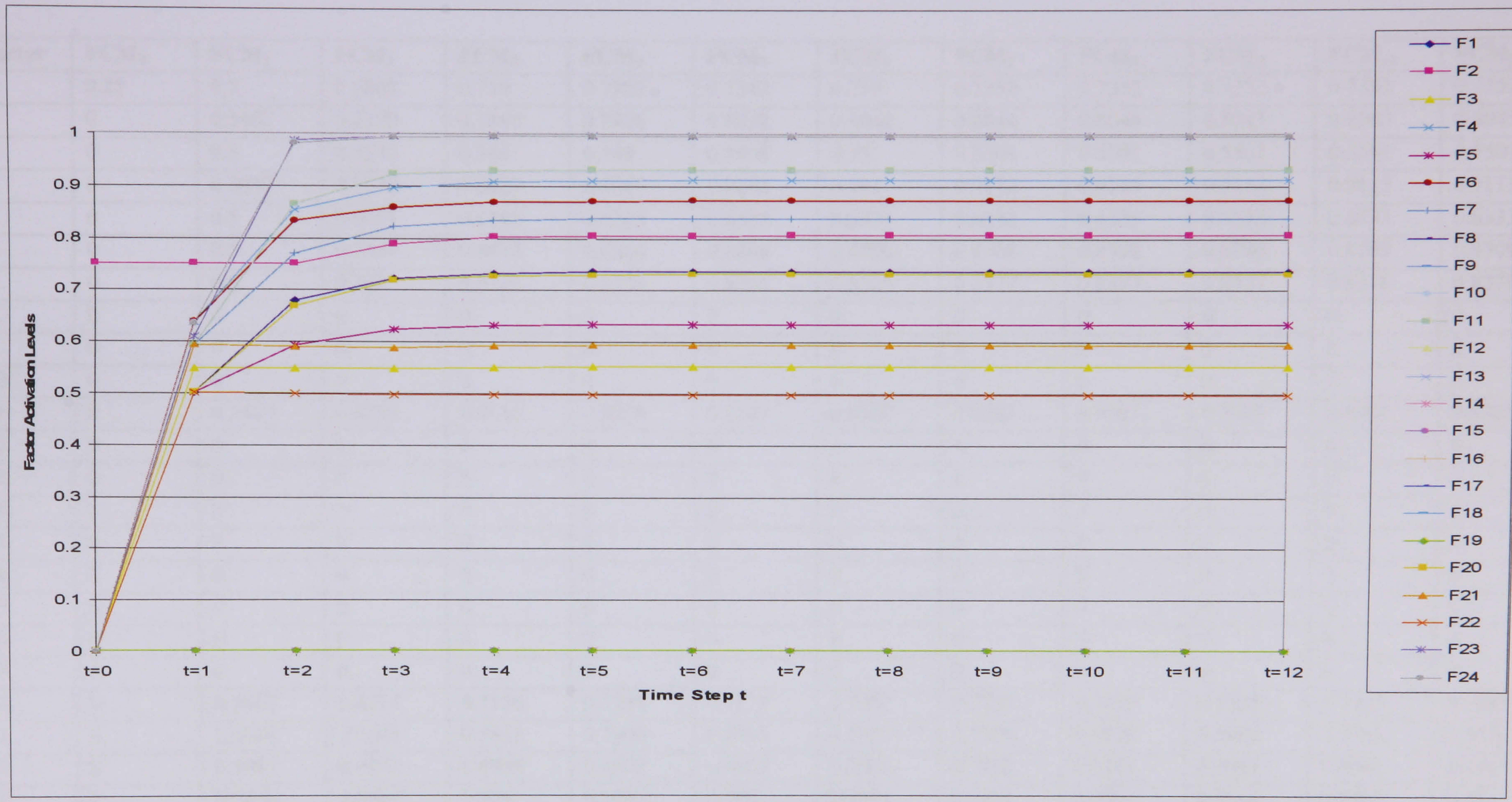


Figure 16 Graph showing FCM simulation results based on scenario 1

Table 45 FCM simulation results based on scenario 2

Factor	FCM_0	FCM_1	FCM_2	FCM_3	FCM_4	FCM_5	FCM_6	FCM_7	FCM_8	FCM_9	FCM_{10}	FCM_{11}
1.	0.25	0.5	0.6868	0.719	0.7309	0.7342	0.735	0.7352	0.7352	0.7352	0.7352	0.7352
2.	0	0.5467	0.7379	0.7865	0.7996	0.8032	0.8042	0.8044	0.8044	0.8045	0.8045	0.8045
3.	0	0.5	0.5341	0.546	0.549	0.5498	0.55	0.5501	0.5501	0.5501	0.5501	0.5501
4.	0	0.5467	0.8278	0.8927	0.9067	0.9102	0.911	0.9112	0.9113	0.9113	0.9113	0.9113
5.	0	0.5	0.6011	0.6198	0.6305	0.6325	0.6331	0.6332	0.6333	0.6333	0.6333	0.6333
6.	0	0.5	0.7854	0.8514	0.8664	0.8698	0.8706	0.8708	0.8709	0.8709	0.8709	0.8709
7.	0	0.5	0.749	0.8144	0.8334	0.8366	0.8375	0.8377	0.8377	0.8377	0.8378	0.8378
8.	0	0	0	0	0	0	0	0	0	0	0	0
9.	0	0	0	0	0	0	0	0	0	0	0	0
10.	0	0	0	0	0	0	0	0	0	0	0	0
11.	0	0.5467	0.8293	0.9186	0.9276	0.9297	0.9302	0.9303	0.9303	0.9303	0.9303	0.9303
12.	0	0	0	0	0	0	0	0	0	0	0	0
13.	0	0	0	0	0	0	0	0	0	0	0	0
14.	0	0	0	0	0	0	0	0	0	0	0	0
15.	0	0	0	0	0	0	0	0	0	0	0	0
16.	0	0	0	0	0	0	0	0	0	0	0	0
17.	0	0	0	0	0	0	0	0	0	0	0	0
18.	0	0	0	0	0	0	0	0	0	0	0	0
19.	0	0	0	0	0	0	0	0	0	0	0	0
20.	0	0.5467	0.6514	0.7126	0.7241	0.7274	0.7282	0.7284	0.7285	0.7285	0.7285	0.7285
21.	0	0.5009	0.5641	0.5853	0.5906	0.5921	0.5925	0.5926	0.5926	0.5926	0.5926	0.5926
22.	0	0.4981	0.4972	0.4963	0.4962	0.4961	0.4961	0.4961	0.4961	0.4961	0.4961	0.4961
23.	0	0.5456	0.9767	0.994	0.9957	0.996	0.9961	0.9961	0.9961	0.9961	0.9961	0.9961
24.	0	0.5487	0.9741	0.9939	0.9956	0.9959	0.996	0.996	0.996	0.996	0.996	0.996

(Please note FCM_t refers to the FCM model at time step *t*)

Figure 17 Graph showing FCM simulation results based on scenario 2

Table 46 FCM simulation results based on scenario 3

Factor No.	FCM_0	FCM_1	FCM_2	FCM_3	FCM_4	FCM_5	FCM_6	FCM_7
1.	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2.	0.8065	0.8065	0.7755	0.7705	0.7699	0.7698	0.7698	0.7698
3.	0.5502	0.5502	0.5502	0.5483	0.548	0.548	0.548	0.548
4.	0.9125	0.9125	0.8963	0.8913	0.8904	0.8903	0.8903	0.8903
5.	0.6337	0.6337	0.6337	0.627	0.627	0.6269	0.6269	0.6269
6.	0.8711	0.8711	0.8711	0.8681	0.8666	0.8664	0.8664	0.8664
7.	0.8382	0.8382	0.8382	0.8306	0.83	0.8298	0.8298	0.8298
8.	0	0	0	0	0	0	0	0
9.	0	0	0	0	0	0	0	0
10.	0	0	0	0	0	0	0	0
11.	0.9312	0.9312	0.9181	0.9163	0.9158	0.9157	0.9156	0.9156
12.	0	0	0	0	0	0	0	0
13.	0	0	0	0	0	0	0	0
14.	0	0	0	0	0	0	0	0
15.	0	0	0	0	0	0	0	0
16.	0	0	0	0	0	0	0	0
17.	0	0	0	0	0	0	0	0
18.	0	0	0	0	0	0	0	0
19.	0	0	0	0	0	0	0	0
20.	0.7307	0.7307	0.6922	0.6922	0.6919	0.6918	0.6917	0.6917
21.	0.5929	0.5929	0.592	0.5884	0.5879	0.5878	0.5878	0.5878
22.	0.4959	0.4959	0.4979	0.4979	0.4978	0.4978	0.4978	0.4978
23.	0.9962	0.9962	0.9954	0.9951	0.995	0.995	0.995	0.995
24.	0.9961	0.9961	0.9952	0.9949	0.9948	0.9948	0.9948	0.9948

(Please note FCM_t refers to the FCM model at time step t)

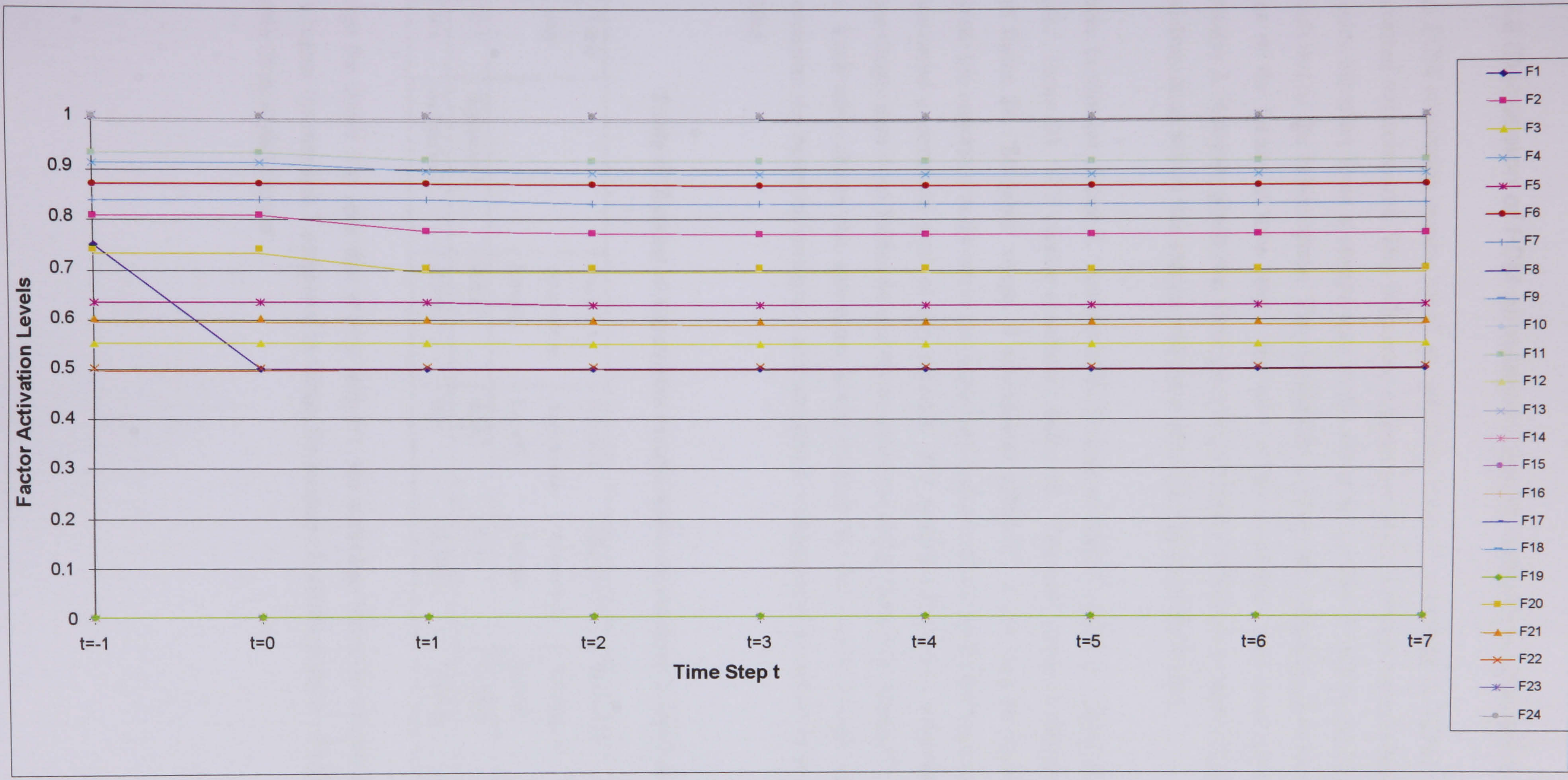


Figure 18 Graph showing FCM simulation results based on scenario 3

7.6.2 Discussion of FCM simulation results based on scenarios 1, 2, 3

The FCM simulation results based on scenarios 1 and 2, presented in Tables 44 and 45 are examined and compared. This is because scenarios 1 and 2 represent two alternative investment options therefore from a comparison of the simulation results it will be possible to ascertain which one is the better option. The comparison is made by comparing the activation levels of each of the factors at time step *t*, for both of the simulation runs based on scenario 1 and scenario 2. However given that there are a large number of factors to consider, the comparison and discussion within this section will focus on a specific set of the factors.

These factors are: factor 4. 'Amount of ICT usage in school', factor 6. 'Level of Teachers' ICT skills', factor 20. 'ICT culture in school', factor 23. 'Teachers' usage of educational software' and factor 24. 'Students' usage of educational software'. It can also be assumed that these factors are important in the sense that achieving high activation levels for these factors would be considered a desirable goal of any schools' ICT related initiative or investment. Therefore accordingly data from Tables 44 and 45 are extracted and presented in Tables 47, 48, 49, 50 and 51. Each table shows the activation levels reached by the factors at time step *t*, for each simulation run based on scenario 1 and scenario 2. Comparisons are made by drawing on these tables.

Table 47 Extract of simulation results based on scenario 1 and 2 at t=1

Time step		Factor 4 Activation Levels	Factor 6 Activation Levels	Factor 20 Activation Levels	Factor 23 Activation Levels	Factor 24 Activation Levels
t=1	Scenario 1	0.637	0.637	0.5	0.6094	0.635
t=1	Scenario 2	0.5467	0.5	0.5467	0.5456	0.5487

From the above it is seen that at time step t=1, the activation levels for factors 4, 6, 23 and 24 are higher for scenario 1 compared to values for scenario 2, although the level of ICT culture i.e. factor 20 is slightly lower.

Table 48 Extract of simulation results based on scenario 1 and 2 at t=2

Time step		Factor 4 Activation Levels	Factor 6 Activation Levels	Factor 20 Activation Levels	Factor 23 Activation Levels	Factor 24 Activation Levels
t=2	Scenario 1	0.8528	0.832	0.6668	0.9854	0.9828
t=2	Scenario 2	0.8278	0.7854	0.6514	0.9767	0.9741

Again it is seen from the above that at time step t=2, the activation levels for factors 4, 6, 23 and 24 are higher for scenario 1 compared to values for scenario 2, this time the level of ICT culture i.e. factor 20 is also slightly higher.

Table 49 Extract of simulation results based on scenario 1 and 2 at t=3

Time step		Factor 4 Activation Levels	Factor 6 Activation Levels	Factor 20 Activation Levels	Factor 23 Activation Levels	Factor 24 Activation Levels
t=3	Scenario 1	0.8956	0.8577	0.7161	0.9947	0.9945
t=3	Scenario 2	0.8927	0.8514	0.7126	0.994	0.9939

Table 50 Extract of simulation results based on scenario 1 and 2 at t=4

Time step		Factor 4 Activation Levels	Factor 6 Activation Levels	Factor 20 Activation Levels	Factor 23 Activation Levels	Factor 24 Activation Levels
t=4	Scenario 1	0.9074	0.8671	0.7249	0.9958	0.9957
t=4	Scenario 2	0.9067	0.8664	0.7241	0.9957	0.9956

Table 51 Extract of simulation results based on scenario 1 and 2 at t=5

Time step		Factor 4 Activation Levels	Factor 6 Activation Levels	Factor 20 Activation Levels	Factor 23 Activation Levels	Factor 24 Activation Levels
t=5	Scenario 1	0.9104	0.87	0.7276	0.9961	0.9959
t=5	Scenario 2	0.9102	0.8698	0.7274	0.996	0.9959

Generally the activation levels are slightly higher for scenario 1, as seen in Tables 47 and 48. However the values become very similar for both scenarios 1 and 2, at time steps 3, 4 and 5 as seen in Tables 49 50 and 51. Although both scenarios 1 and 2, in the long run lead to similar equilibrium results, in scenario 1 the initial boost in factor 2 the 'availability of non-outdated IT equipment' leads to higher activation levels in some of the important factors 4, 6, 20, 23 and 24, during the earlier time steps i.e. the benefits and/or desired levels in these factors are experienced earlier on. Therefore from the examination and discussion above of the simulation results it can be concluded that scenario 1 is a better option in comparison to scenario 2.

The FCM simulation results based on scenario 3 are also examined in the similar manner discussed above. The activation levels of the factors seen in Table 52 are compared at each time step.

Table 52 Extract of simulation results based on scenario 3 at time step *t*

Time step	Factor 4 Activation Levels	Factor 6 Activation Levels	Factor 20 Activation Levels	Factor 23 Activation Levels	Factor 24 Activation Levels
t=0	0.9125	0.8711	0.7307	0.9962	0.9961
t=1	0.9125	0.8711	0.7307	0.9962	0.9961
t=2	0.8963	0.8711	0.6922	0.9954	0.9952
t=3	0.8913	0.8681	0.6922	0.9951	0.9949
t=4	0.8904	0.8666	0.6919	0.995	0.9948
t=7	0.8903	0.8664	0.6917	0.995	0.9948

From the results in Table 52 it is seen that there is a general decrease in the factors' activation levels as a consequence of reducing the 'availability and access to IT facilities' from high to moderate levels. However the decreases are slight in most cases. This can be explained as follows: Given that the FCM model was initially activated and had reached equilibrium, it had therefore achieved an optimum level of ICT and educational software usage. This means many factors in the model such as teachers' ICT skills, ICT culture etc were well established at this stage. Therefore, although there was a decrease in the 'availability and access to IT facilities' it did not have a great impact on already established skills, IT culture and on other relevant factors in the domain.

Hence the application of the FCM model provided an opportunity to examine the effect of disinvestment within the domain of educational software usage in schools. By studying the effects of a decrease in factors in the FCM model it is possible to determine which factors cause minimum disruption to a well established domain if they are reduced, such that disinvestment can be directed accordingly. The FCM model has also allowed for the exploration of two alternative options, based on a practical/real situation i.e. school A's decision to procure laptops or refurbish computer suites. The FCM allowed for both alternatives to be simulated and from the examination of the simulation results it was possible to suggest that option 1 which was to purchase laptops was the better option in terms of the overall effect it would have in the relevant domain. Therefore accordingly investments and resources need to be allocated to the better option.

The above examples therefore show that the FCM model can be used as a means to facilitate better management of resources in schools, especially given that resources in schools are often limited and choices have to be made for allocating such resources. Furthermore given that the FCM model clearly incorporates two concepts which are distinctly concerned with the usage of educational software by teachers and students i.e. factors 23 and 24, the model is able to show the effects of any actions such as changes in policy and/or investment on the up-take of educational software by teachers and students in the school environment. For example in examining the simulation results of scenarios 1, 2 and 3 above, the activation levels of factors 23 and 24, indicated the level of educational software use by both teachers and students under the three different scenarios being simulated and modelled. In this respect the FCM model can show the levels of educational software usage that can be achieved as a result of directing resources to areas/factors seen within the model. Hence the model in demonstrating its ability to facilitate better resource management can also clearly show the effects such actions will have on the level of educational software use in schools. Therefore the FCM model has the potential to guide planners and decision makers to direct resources to areas which can influence a greater up-take of educational software by teachers and students and which can subsequently lead to the greater utilisation of educational software in schools.

7.7 Summary

This chapter firstly provided a brief analysis of the static FCM model. In doing so it showed that a static analysis, given a change in one or more of the causal concepts i.e. factors, was inadequate for examining the overall effects and ascertaining a final outcome within the model. The chapter then described the dynamic process adopted within this study to simulate the FCM model. It highlighted the potential of a dynamic FCM analysis in comparison to a static analysis and addressed the concerns raised from the static analysis.

The chapter then discussed the validation of the FCM model: the model was validated firstly by two experts in the field of 'ICT in school education' and secondly validated by comparing the dynamic FCM model to the ACOT study (a real life study which looked at how and the extent to which teachers and students adopt ICT and educational software in the classroom, given an injection of technological provisions). The chapter then described how input data, to replicate the initial stages of the ACOT study and initiate the FCM simulation, was determined. The simulation results were presented, interpreted and compared to the findings of the ACOT study. Given that the final outcome of the FCM simulation was similar to the final findings of the ACOT study, the FCM model was considered validated.

This was followed by a discussion as to the purpose of the FCM model constructed. The chapter then, in order to consider the application of the FCM model, in terms of exploring 'what-if' possibilities, generated scenarios from a practical situation. The FCM model was simulated based on these scenarios; the respective simulation results were examined and discussed. In doing so, the chapter finally, demonstrated the use of the FCM model in a practical situation. It highlighted the application potential of the FCM model, especially as a means for facilitating better resource management and as a guide to influencing and achieving the greater up-take of educational software in schools.

Chapter 8: Conclusion and directions for further research

8.1 Introduction

The aim of this research has been to provide the means by which to facilitate better management of resources by schools such that they can achieve greater utilisation of educational software within their environment. To this end, the study based on the perceptions of relevant stakeholder groups, has developed a fuzzy cognitive map, modelling the factors which impact the up-take of educational software by teachers and students. The practical application of this model in terms of its potential to facilitate resource management to achieve a greater up-take of educational software within a schools adoption of ICTs has been demonstrated. This chapter firstly reviews the ways in which each chapter has contributed to the study. The following section discusses how the objectives stated within chapter 1 of this thesis have been met. The chapter then presents the research contributions made by this study. The chapter concludes with the limitations of this study and provides directions for future research.

8.2 Overview of the research

This study began with an overview of the issues surrounding the adoption of educational software in secondary education, the motivation for this research and its objectives in **chapter 1**. The literature indicates that the adoption of educational ICTs can bring about many benefits to the teaching and learning practices. Driven by this and the global IT movement in education and industry, the UK government has invested substantial monies and efforts for the integration of ICTs in education.

Over the last 20 years, UK schools have been furnished with IT equipment and equipped with a level of ICT infrastructure. The National Curriculum includes ICT as one of the core taught subjects in the school curriculum and furthermore stipulates that ICTs be used within all subjects across the curriculum. Although there have been advances in technology, in the provision of IT facilities and in the IT skills held by teachers and students, the evidence suggests that the adoption of ICT in schools is unsatisfactory. In particular the adoption and use of educational software, across subjects in the curriculum, has been limited and inefficient. Over the years various OFSTED (Office for Standards in Education) reports and many studies have drawn attention to the problems or barriers to this adoption (McKinsey & Co., 1997; OFSTED, 1996; Siemer, 1998; Stammers, 1997; Gulliver, 1999; Guest and Alimi, 2000; Ward, 1999; Weikart and Marrapodi, 1999; Hossain et al,. 2000; Hossain et al. 2003). Despite further investments and efforts to address these issues, many of these problems appear again and again as reasons for the unsatisfactory adoption of educational ICTs in schools.

Given that the government has highlighted the importance of developing software content (OFSTED, 2002), and the potential of using educational software as emphasised by its advocates, this study deemed it important to shed light on the factors and the extent to which they play a part in the adoption and utilization of educational software in schools. Chapter 1 stated the aim of this thesis, which was to provide the means by which to facilitate better management of resources by schools, such that they can achieve greater utilisation of educational software within their environment. It presented the objectives required to achieve the aim of this study.

The chapter then discussed the scope of this study, and in doing so drew upon information systems literature. The study in looking at the adoption of educational software recognised the need to take into account the broader context of ICT adoption in schools. In addition, the study recognised the importance of the role of relevant stakeholder groups in the development and adoption of information technologies. From the many possible stakeholders groups pertaining to the domain of study, the chapter identified students, teachers, department heads, ICT-coordinators and ICT support staff, as key stakeholder groups. These key stakeholder groups were considered fundamental to this study. This is because the model to be constructed, was to be based on the key stakeholders' opinions and perceptions on the up-take of educational software in schools. The chapter also presented an introduction to the modelling approach and the methodology adopted in this study. It finally concluded with an overview of the thesis structure.

Chapter 2 provided an insight into the diverse field of research that has taken place and continues to take place in relation to ICTs in school education. It gave an overview of research that has taken place with respect to ICTs in schools; provided examples of studies which have drawn upon theories from organisational IT/IS implementation research and looked at studies concerned with the implementation/integration of ICT in schools. In light of the objectives of this study concerned with factors and modelling the up-take of educational software, the chapter in particular highlighted studies concerned with the identification of factors which affect and/or the examination of their effects on the adoption and use of computers or computer related applications. It presented a number of factors and issues, considered to be significant, which have arisen from such studies and the literature in general. These factors were later drawn upon in chapter 4, in the design of the questionnaire to be used in the fully structured interviews; one of the vehicles for data collection, devised for conducting the empirical research of this study.

The chapter then discussed, as examples, two studies which have developed models. It discussed the methods used by these studies, and emphasized that the statistical methods used for identifying factors and developing models as seen in these examples was common in the literature. The study, by drawing on the two examples, highlighted potential areas of concern in using such statistical techniques. It drew attention to ways in which the strengths of relationships between factors had been determined in these studies, and contended that they were not suitable for what this study wanted to achieve i.e. to model relationships between factors which can exhibit the strength of the relationship in terms of the extent of the influence of the causal factor on the effect factor. The chapter then discussed the use of fuzzy logic within educational research. It finally discussed and concluded that statistical modelling techniques commonly used would be unsuitable to address the aims and objectives of this study. Furthermore given evidence of the use of fuzzy logic in education the study considered exploring Fuzzy Cognitive Maps as a potential modelling approach in chapter 3.

Chapter 3 introduced the theory of FCMs by providing descriptions of its diagrammatic form and mathematical matrix representation. It presented the underlying vector-matrix operations of a FCMs dynamic process and the different states that can be reached as result of a stimulus. The chapter provided examples of FCM applications to show the variety of domains and studies which have applied the FCM approach. It discussed the purposes of some of these studies, and drew parallels to those studies whose purposes were similar to those of this thesis. It examined why some studies adopted the FCM approach instead of traditional approaches and modelling techniques. It presented the concerns of this thesis in relation to traditional modelling methods. The dynamic ability of FCMs which posed an attractive and useful feature of the FCM approach by many studies was also discussed. It was contended that this was a feature also desirable for this study.

The chapter provided an overall summary of the benefits and drawbacks that have been advocated and realised from the use of FCMs as indicated in the literature. It also focused on the advantages and concerns surrounding the FCM methodology, in doing so, it also provided a brief overview of the FCM methodology. The chapter concluded by providing justification for considering FCMs as an appropriate modelling approach within the context of this study. It drew on the advantages, and on earlier discussions in the chapter and suggested that there were a number of FCM features which were particularly suitable to the requirements of this study. Although the chapter had highlighted the determination of credibility weightings of participants as one of the concerns within the FCM literature, the study contended that this concern posed a challenge which would need to be addressed within the context of this study. This is because there are very strong arguments for adopting the FCM modelling approach for this particular study given that FCMs offer a modelling approach which is particularly suitable for achieving the aims and objectives of this study.

Chapter 4 presented and reviewed the epistemological and ontological stances of positivist, interpretive and pragmatic research paradigms and highlighted the differences between them. It listed quantitative, qualitative and mixed methods approaches as research approaches which use the philosophical assumptions associated with these paradigms, and presented the strategies of inquiry and methods typically employed by these research approaches. The chapter provided justification for selecting the mixed methods research approach for this study. This was followed by a detailed description of the methods used to conduct the empirical study for this thesis. The chapter discussed the reasons for selecting the particular sample, and for drawing the particular sample from a range of three different schools. It gave reasons for the sample size and for the number of field sites chosen for this study.

The chapter then provided reasons for selecting interviews as the main source of data collection. It gave a general description of what this entailed i.e. a semi-structured interviews based on a topic guide and a fully structured interview based on a questionnaire. Issues related to access to educational settings were also discussed in order to explain why group interviews, instead of individual interviews with student participants, were considered more appropriate. The chapter then described the topic guide used within the semi-structured interviews and the design of the questionnaire used in the fully structured interviews. It also highlighted and explained the differences which existed in the topic guide and questionnaire, for student participants and staff participants. The chapter presented the documentary coding method and content analysis as the methods selected for the analysis of the empirical data, which would be appropriate to elicit specific information required for the construction of the FCM model, the main goal of this thesis. Finally the chapter provided details of the simulation process that was chosen to conduct the simulation of the FCM model. The outcome of implementing the strategies of enquiry and adopting the methods of data collection and analysis are discussed in chapters 5 and 6.

Chapter 5 provided an insight into and an understanding of the domains, in which the empirical research, for this study was conducted. It presented the backgrounds of schools A, B and C, which included an overview of their current level of ICT infrastructure and ICT capabilities. It compared schools A, B and C, with each other, with average schools in their respective boroughs and with average schools in England, by drawing on statistical information provided by the government and background information. The chapter established that the three schools from which participants had been drawn for this study, were representative of typical secondary schools in England, they were neither special nor failing schools. Although differences were noted between the schools in regard to ICT infrastructure and capabilities, this was considered beneficial for this study. This is because schools in England are at different levels of ICT implementation/integration, therefore the three schools as a cluster would be representative of such typical schools. In addition this study would be able to provide a richer and wider insight into the adoption and use of educational technologies in schools by drawing on the views of participants who have differing experiences of ICT because of their different environments in relation to different levels of ICT infrastructure and ICT capabilities.

The chapter then described the research conducted at schools A, B and C, from the stages of initial contact through to the overall processes involved to gain access to the participants and to the conducting of the interviews. It presented a statistical summary description of the sample followed by a brief discussion to highlight the general characteristics of the sample. It then presented tables which described each of the participants in the study. It emphasised the importance of the information within this chapter, given that the presented material would be drawn upon in the determination of participants' credibility weightings, in chapter 6.

Chapter 6 provided a thorough and detailed account of the development of the FCM model, which was described in three major phases. The first phase described the construction of individual FCMs based on the empirical data gathered from the fully structured interviews. The construction of each FCM consisted of four consecutive steps. In steps 1, 2 and 3, the analysis of data from the fully structured interviews led to the construction of the individual FCMs. In the 4th step the derived FCM was converted into a numeric model which could be presented in matrix form. The first phase was considered completed when FCMs in matrix form had been achieved for all participants. This led to the second phase which was concerned with the aggregation of the individual FCMs to form one main FCM model.

To describe the second phase the chapter first highlighted the issues that had been raised in chapter 3 with regard to participant credibility weightings, a critical variable in the FCM aggregation process. In order to address this concern, the chapter presented criteria, developed for determining the credibility weightings of the participants within the context of this study. These criteria and the information presented in chapter 5 enabled the study to allocate credibility weightings to the participants. It subsequently conducted the aggregation of the individual FCMs, which resulted in the combined FCM model and its matrix representation.

The chapter then described the third phase of the FCM development. It discussed that the analysis of the data collated from the semi-structured interviews led to the identification of further relationships between factors in the model. It provided examples of the empirical evidence based on which the relationships were identified and provided additional narrative to explain the assertions made by the empirical evidence. It presented a framework, which was developed within the context of this study, by which it would be possible to assign strength values i.e. weightings to these identified relationships. The existing model was refined by incorporating the newly identified and weighted relationships and the chapter presented the final version of the FCM model.

Chapter 7 discussed the analysis, validation and application of the final FCM model. It firstly provided a brief analysis of the static FCM model and in doing so showed that a static analysis, given a change in one or more of the causal concepts i.e. factors, was inadequate for examining the overall effects and ascertaining a final outcome within the model. The chapter then described the dynamic process adopted within this study to simulate the FCM model. It highlighted the potential of a dynamic FCM analysis in comparison to a static analysis and addressed the concerns raised from the static analysis.

The chapter then discussed the validation of the FCM model: It discussed that the model was initially validated by two experts in the field of 'ICT in school education'. The model was then validated by comparing the dynamic FCM model to a real study i.e. the ACOT project (Sandholtz, Ringstaff, Dwyer, 1997), which looked at how and the extent to which teachers and students adopt ICT and educational software in the classroom, given an injection of technological provisions. In order to validate the dynamic FCM model, the chapter first discussed the determination of input data to replicate the findings at the initial stages of the ACOT study and initiate simulation of the FCM model. The FCM model was simulated using the determined input data and the chapter presented the simulation results. The results were interpreted and compared to the findings of the ACOT study. The chapter concluded that the final outcome, in terms of the evolved FCM model as gathered from the simulation results, was similar to the ACOT study findings at the end of its project, therefore the FCM model was considered validated.

This was followed by a discussion as to the purpose of the FCM model constructed. In considering the application potential of the FCM model, the chapter then discussed and generated scenarios based on a practical situation so that 'what-if' possibilities could be explored, from which the practical application of the FCM model could be demonstrated. The FCM model was simulated based on these scenarios; the respective simulation results were examined and discussed. In doing so, the chapter demonstrated the practical use of the FCM model. It highlighted the potential of the FCM model, as a means to facilitate better resource management and as a guide to influencing and achieving the greater up-take of educational software in schools.

8.3 Achievement of the study objectives

This section presents the objectives which had been stated in chapter 1, and indicates the chapters within this thesis in which the accomplishment of these objectives are evident:

- Objective to 'explore the issues surrounding the unsatisfactory adoption of educational software and general ICTs in schools from past and current findings' has been accomplished as is evident within the review of the literature and discussions that have been presented in **chapters 1 and 2** (described in section 8.2).

- The objective to 'model complex chains of causal relationships, which allow for the measure of such relationships to be determined and where many stakeholder perceptions can be incorporated' was partly achieved in **chapter 3** and partly achieved in **chapter 6**. The findings in chapter 3 allowed for the study to draw upon and use a modelling approach which would allow for the modelling of causal relationships, where importantly a measure could be associated with each relationship and which allowed for many stakeholder views to be taken into account. Details of chapter 3 have been discussed in the previous section. Chapter 6 provides evidence of accomplishing the above mentioned objective in that the chapter presented the FCM model which had been developed from the combined knowledge of a number of stakeholders and which modelled the causal weighted relationships between factors in the adoption of educational software in schools.

- The study objective to 'devise means of targeting and collating relevant stakeholders' perceptions on the adoption of educational software and general ICTs in schools' has been partly addressed and accomplished by **chapter 4** and partly addressed by **chapter**

1. Chapter 1 contributed to this objective in establishing which stakeholders are relevant to this study and should therefore be targeted. Chapter 4 (as described in section 8.2) detailed the means devised for collating relevant stakeholder perceptions i.e. in terms of the participants, field sites and the modes of data collection selected for this study.

- The objective to 'elicit specific knowledge from relevant stakeholders, needed for modelling the adoption of educational software in schools' is seen to be achieved partly in **chapter 4** and partly in **chapter 6**. Chapter 4 described the means for eliciting specific details required for the construction of the FCM through the vehicles designed for data collection and the methods chosen for the data analysis. Chapter 6, in constructing the FCM, provided a step by step analysis of the empirical data gathered from the relevant stakeholders, which showed the elicitation of specific data required for the construction of the FCM model.

- The objective to 'construct models of the adoption of educational software in schools, based on relevant stakeholder perceptions, which show the various combinations of factors and the extent to which each factor influences the adoption of educational software by students and teachers' has been accomplished as is evident in **chapter 6**. Chapter 6, as discussed in the previous section, provided details of the FCM construction, from constructing individual models based on the perceptions of each participant to the final combined and refined FCM model developed for this study.

- Objective to 'employ the developed model to ascertain and examine the outcomes or the overall effects when certain factors within the model are enabled/activated i.e. consider scenarios in which an initial policy or investment change means enabling a factor or factors in the model and where the evolved model, as a result of the change in the factors, is seen as the final outcome or the overall effects of such policy/investment change' has also been accomplished as is evident in **chapter 7**. Chapter 7, (discussed in section 8.2) in order to demonstrate the application potential of the FCM model employed the model in regard to exploring 'what-if' possibilities arising from practical issues i.e. different investment options. Factors within the model were changed based on scenarios reflecting these options, the results of the simulated model were examined. From which the chapter discussed the benefits of choosing one course of action i.e. one investment option instead of another given the overall effects seen in the evolved model.

8.4 Research Contributions

This research contributes to three different research domains: ICTs in education research, information systems research and in the area of fuzzy cognitive mapping. Figure 19 gives an overview of the multi-dimensional research area that this study contributes to.

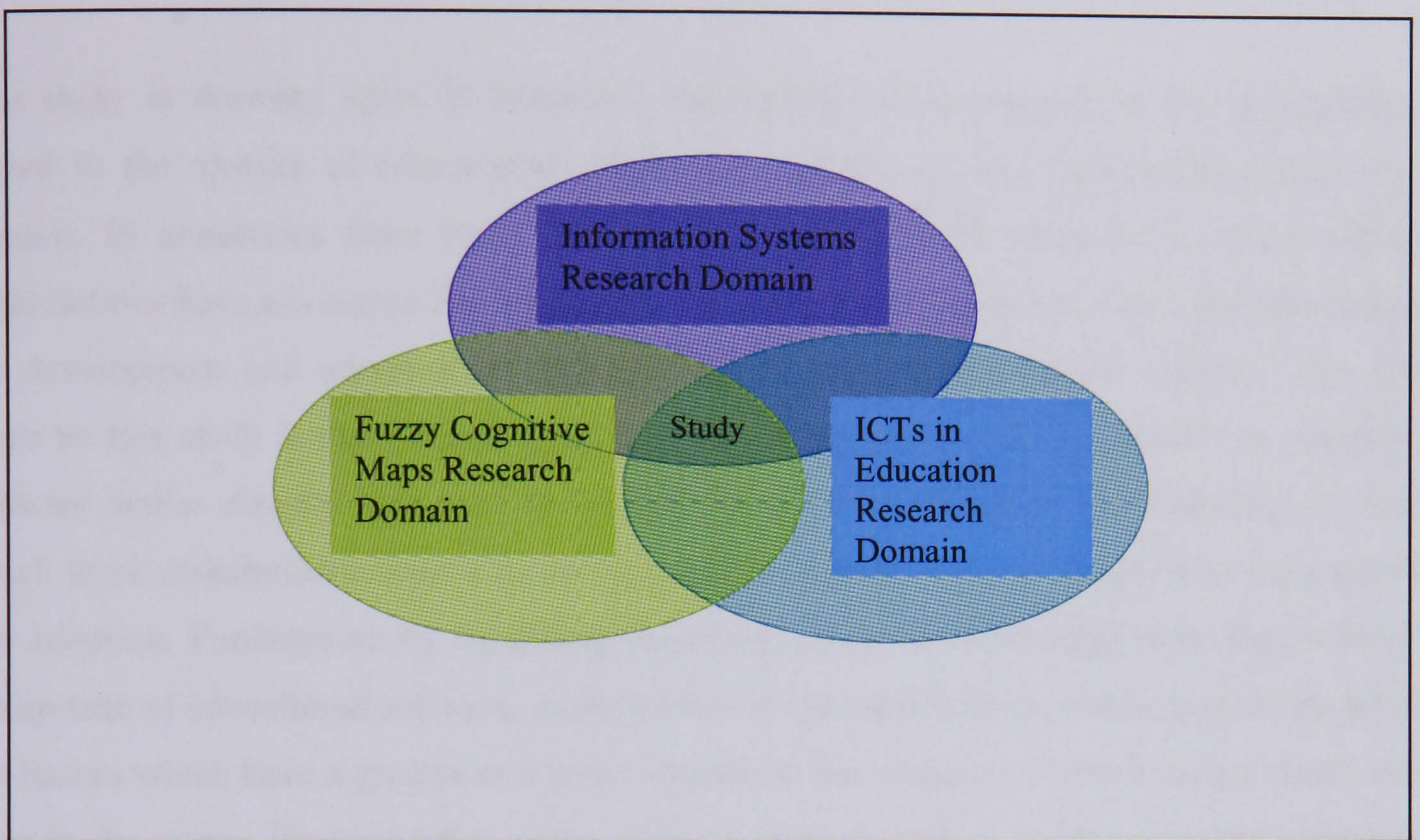


Figure 19 Contribution to multi research dimensions

8.4.1 ICTs in education research domain

The literature, reviewed within this study, indicated that the adoption and utilisation of educational software in schools is limited and inefficient. The potential of using educational software in the teaching and learning practices; the governments' recognition and emphasis on developing software content; the concern of schools that scare resources are wasted on ICTs that are not being used appropriately or at all, provided the motivation for this study.

The empirically developed fuzzy cognitive map modelling the adoption of educational software in schools is the main and practical contribution of this study. The FCM model offers a visual medium providing insight into the necessary factors required in the up-take of educational software as perceived by relevant stakeholders. As a holistic model it provides insights and understanding of the context of educational software adoption in schools. As a dynamic model it allows for the opportunity to explore 'what-if' possibilities and scenarios relating to different policy and investments options, from which it is possible to ascertain the effects if such an option is implemented. Ultimately the model provides the means by which planners and decision makers in schools can direct resources ensuring maximum utilisation of educational software within the teaching and learning practices. In doing so the model can help to bridge the gap between the government's policies and persons adopting educational software at the operational level. In addition the model acts as a useful guide for software developers in their development of educational software for school use.

This study in drawing upon IS literature, highlighted the importance of the perceptions, in regard to the up-take of educational software in schools, of key stakeholder groups in the domain. IS academics from their study of problematic IT/IS adoptions in many different organisations have advocated the importance of stakeholders' opinions, views and knowledge in the development and adoption of information technologies/information systems. The stance taken by this study is that ultimately it is the key stakeholders who adopt and use educational software and/or directly influence its adoption in schools. Therefore by modelling the factors which these stakeholders believe to be important would provide an insight into the context of this adoption. Furthermore by modelling the extent of the influence that these factors have on the up-take of educational software, as perceived by the stakeholders, would provide insight into the factors which have a greater or a lesser impact on the adoption. Overall such a model would provide the means for facilitating better resource management in terms of enabling schools to direct scarce resources to areas/factors which have a greater impact on the up-take of educational software.

However the statistical modelling techniques commonly used in the ICTs in education research domain, as indicated in the literature, were found to be inadequate for addressing the modelling requirements of this study. This study required a modelling approach which could incorporate the knowledge of a number of stakeholders, and importantly allow for the strengths of causal relationships to be determined i.e. the extent of the influence a causal factor has on the effect factor. In this respect, the study drew upon, explored and used fuzzy cognitive mapping as a modelling approach. The result is an FCM model which can be utilised both statically and dynamically.

In the education domain there has been much research to explore the issues surrounding the adoption of educational ICTs in schools. This thesis contributes to this body of knowledge through addressing the problem of the unsatisfactory uptake of educational software in schools, by drawing on IS knowledge, which highlights the importance of stakeholder perceptions and by using FCM theory to model such perceptions (as discussed within this section). In doing so, this study gives rise to a different and novel approach and perspective in addressing the problematic adoption of educational ICTs, and which can lead to the development of appropriate strategies and policies for greater utilisation of educational software in schools. Therefore the use of fuzzy cognitive mapping based on stakeholder perceptions, to model the factors in the up-take of educational software in schools, is an important theoretical contribution to the adoption of ICTs in education research domain.

8.4.2 Information Systems research domain

Although the use of FCMs in Information Systems literature has been acknowledged, the review of literature indicates that the FCMs developed have been based on expert perceptions and knowledge. This study has highlighted the potential of considering all relevant stakeholders in examining or understanding the domain of study, particularly in developing a fuzzy cognitive map modelling the problem domain. Ultimately a FCM modelling the adoption of educational software in schools has been developed based on key stakeholder persons in the school domain, in this study. Furthermore there are noted differences in the way in which the empirical FCM model was developed for this study, (discussed next in section 8.4.3) compared to the ones reviewed in the literature. Therefore the unique empirical development of the FCM model, based on the perceptions of relevant stakeholders, modelling the adoption of a specific educational technology within an educational environment, in this study, constitutes a theoretical contribution to Information Systems research.

8.4.3 Fuzzy Cognitive Mapping research domain

The literature indicates that FCMs have been used for many different purposes and in many different domains. This thesis contributes to the FCM body of research in that this study has used FCMs in an educational context, to model a domain showing the adoption of educational software in schools, based on the perceptions of relevant stakeholder groups. Furthermore this study in the methods it has chosen to develop and address concerns of the FCM methodology, has contributed both theoretically and methodologically to the FCM research domain, as is discussed below.

The manner in which the FCM for this study was constructed can be considered to be one of the contributions of this thesis. Commonly, as indicated in the literature, FCMs are developed based on the knowledge of persons who are considered experts of the particular domain or the problem area which needs to be modelled. This thesis, by drawing on Information Systems literature, was concerned not only with the perceptions of experts but fundamentally in the perceptions of all relevant stakeholder groups, i.e. those who are directly affected by the adoption of educational software or can affect its adoption in school. Therefore the FCM model arising from this study, based on relevant stakeholder perceptions constitutes a theoretical contribution to the domain of FCM research.

Secondly there were three phases in the development of the FCM model. The first phase could be considered typical of how FCMs are generally constructed, where a questionnaire conducted within a fully structured interview, elicited specific data for the construction of the FCMs for all individual participants. However in the second phase of the FCM development, which was concerned with the aggregation of the individual FCMs, the study identified a gap in the existing FCM literature as in how to determine credibility weights of the participants. This is an important coefficient in the mathematical aggregation of individual FCMs.

Many studies which have constructed FCMs have often assigned experts equal credibility weightings, which is understandable where the experts in the field are similar. In this study however the participants did not have similar experience and knowledge and this needed to be taken into account and reflected in the final FCM model. Other studies have derived credibility weightings based on complex mathematical steps and even then this has been based on the credibility of the knowledge held by their participants rather than the credibility weighting of the person i.e. experts were ranked based on if they provided the right answers to questions related to the domain to be modelled. In this study there were no right or wrong answers, the empirically developed FCM was based on the perceptions of stakeholders and their opinions as to which factors they felt influenced the adoption of software in school, and arguably therefore a better FCM in context was developed. Hence within this study, criteria was developed, so that it was possible to determine the credibility of each participant, this too constitutes one of the contributions of this study.

The last phase of the FCM development was a further enrichment stage of the existing FCM model. Qualitative data was analysed using content analysis and the documentary coding method, which led to the identification of further interrelationships between factors within the FCM model. However at this stage participants did not assign weights to the identified relationships, as is commonly seen in FCM literature, instead a framework was developed by which such weights could be determined, based on the researchers judgment i.e. based on his/her knowledge and experience of the study domain, and by taking into account the assertions made by the study participants. This too forms another contribution of this study.

Ultimately the three stages leading to the development of the FCM model is a contribution in that both quantitative and qualitative data have been used to develop a richer FCM model in this study, which is not common in the literature. Narayanan and Liao, (2005) contend that despite many who advocate the use of fuzzy causal logic for the analysis of causal maps, empirically developed FCM models are rare both in IT and organisation sciences. They suggest that this maybe due to lack of awareness of the technique by empirically minded research community. It is hoped that this study, which contributes, in presenting an empirically developed FCM model, in which the techniques at each stage of the FCM development have been explained explicitly, can prove useful to researchers contemplating developing a FCM model empirically and to the research community at large.

8.5 Limitations

This section discusses the main limitations of this study. In doing so it also highlights some of the approaches/methods or actions which have been adopted or taken in order to address some of the areas of concern which have been encountered during the process of this study.

One of the limitations of this thesis is that this study has focused on FCMs as a way of achieving the aims of this research. This is however only one way of addressing the aims and objectives of this study, there is a need to acknowledge that there are other methods and approaches related to causal mapping which also exist such as the Bayesian network theory where the graphical representation of the expert's knowledge is based on probability theory (Nadkarni and Shenoy, 2001). However given the constraints of time and resources, the exploration of all other such methods to tackle the aims of this study have not been discussed within the context of this thesis.

In discussing the limitations of this study, it is important to acknowledge that there is a wider picture which needs to be considered. There many other external factors which have the power to influence the adoption of educational software and ICTs within schools, such as educational legislation; governmental initiatives and policies related to ICTs within education; the economy of the country and how this can affect the government's funding in schools; the rapid technological advancements and how this can affect hardware, software and access to the internet within the school environment. In addition there are other factors within the schools environments such as limited resources, where resources may be allocated to a leaking roof instead of procuring some laptops; the politics within the school, where a conflict of opinions between key persons may prevent an ICT related innovation from materialising; the environment of the classroom in which the teaching and use of educational software is to take place, where for example a disruptive class may prevent an ICT based lesson from being implemented. Although this study has portrayed core factors in the adoption of educational software in schools as perceived by relevant stakeholder groups it recognises that these wider factors have the potential to influence the up-take of educational software, but due to the constraints of time, have not been explored in detail within the context of this study.

Another limitation that is recognised is in regard to the questionnaire which was conducted within the fully structured interviews with both staff and student participants. The B-type questions/statements (refer to section 4.4.4.1) in the questionnaire had been designed in a manner which would mean in most cases, if the participant considered the factors relevant, positive relationships would arise as a consequence of the responses to the questions and statements. This may be seen as a limitation in that the design of the questionnaire allows for a positive bias. Most respondents given the long list of B-type questions may be inclined to agree more readily to the statements which are already positively biased. In recognising this limitation there is however a need to mention that the design of the B –type statements in the questionnaire were influenced by the rules and principles discussed within FCM literature (refer to section 6.2). More specifically in line with the rule advocated by Kosko (1986) to replace, as far as possible, every negative relationship with a positive one by modifying the concept pertaining to the relationship with its abstract negation or complement.

Kosko (1986) contends that, since causal objects are variable concepts, they can be represented as fuzzy subsets of some concept space, where the change in fuzzy-set membership degree represents concept variation. He defines a concept C_i as the fuzzy union of some fuzzy quantity set Q_i and associated dis-quantity set $\sim Q_i$, where $\sim Q_i$ is considered to be the abstract negation or fuzzy set complement of Q_i. Kosko (1986) further contends that fuzzy causality can be defined in terms of fuzzy set-theoretical relationships among fuzzy concepts. Deductions are made based on a mathematical proof theorem that negative causality can be defined with the same fuzzy quantities and relationships as positive causality i.e. negative causality is eliminable. This observation has led to the general rule of replacement in FCM construction whereby $Ci \xrightarrow[-]{} Cj$ is replaced with $Ci \xrightarrow[+]{} \sim Cj$ (as discussed in more detail in section 6.2).

The study in taking the above into account realised that, if an initial FCM model was constructed with a mixture of negative and positive relationships then at a later stage it would be necessary to replace negative relationships with positively defined relationships (following the rule of replacement described earlier). This may have been more complex to deal with once the model had been initially developed. The study therefore concentrated on designing the questionnaire's B-type questions in such a manner that it would be possible to not only elicit the participants perception about the relationships being positive or in some instances negative but that it would be straight forward to convert the analysed data into the information required for the construction of the FCM which would predominantly consist of the positive relationships advocated by Kosko (1986), within the first instances of construction. Although this course of action was considered reasonable in adhering to the FCM theory, the design of the questionnaire may be seen as a limitation of this study.

The other main limitation recognised is in regard to research within educational settings where empirical results depend heavily on the access that schools allow to the researcher. In addition to this, is the access that the stakeholder i.e. participant, will allow the researcher. The thesis has discussed that necessary formalities can be involved for schools to grant permission for research to be conducted within the school environment, especially with regard to accessing student participants for the study. Even when access is allowed, availability of participants for interview within school environments is also an issue for consideration; members of staff are busy within the school day, and time for interviews is limited. In this study the scheduling of interviews had to be managed carefully so as to fit in with the time constraints of the staff participants, especially teaching staff, who even in their non-teaching periods have other duties. In respect to interviewing students the following were issues for consideration: additional procedures involved to gain access to students on an individual basis; the practicality of conducting individual interviews i.e. arranging different interview times, dates and locations (such as rooms in which the interviews could take place subject to availability) within the busy schedule of a school environment; and finally, given the number of students in the sample, the time constraints of this study and of the researcher. In light of such issues, group interviews were considered for student participants instead of one-to one interviews. In the circumstances this was the next best feasible option, in terms of eliciting students' perceptions about the adoption of educational software in schools, for this study.

One of the limitations in the area of fuzzy cognitive maps is the lack of readily available commercial software which can be used to construct FCMs and run simulations. In this study, especially once the FCM model had been developed, it was considered that software which could be used to run FCM simulations would be beneficial in exploring the dynamic potential of the model. Importantly because given the size of the developed FCM matrix it would be a difficult task to manually carry out the mathematical operations involved in the FCM simulations. Advice and consultation with experts from the field of FCM research, led the study to consider Matlab®, a mathematically based programming language. A program was written which consisted of m-files (These are available in Appendix H) which incorporated the steps and mathematical procedures involved in the FCM simulation process, and which could take into account independent and dependent concepts of the model, as a result of which the FCM simulations for this study were conducted effectively and accurately.

Finally in regard to the FCM model which has been constructed based on the empirical data gathered from participants drawn from three different UK schools there is a need to recognise and acknowledge the following: The three participating schools are considered typical of average schools in England based only on their academic records i.e. achievements, as documented in governmental reports. Furthermore all three schools have been drawn from schools based in London, where the cultures, ethos, backgrounds of the schools, backgrounds of the students, the IT cultural influences, the type of funding available, the economical status of the schools, will be different to schools all over England and of course to schools internationally. Although the FCM model has been validated by a study conducted in the USA, such western schools have resources, standards and cultures which are similar to some degree to the schools within this study. However where there are significant differences in cultures, resources and standards, for example such as in schools in Chile, the model maybe limited in applicability. Although this poses as a limitation of this study it also presents a potential area for further research as will be discussed in the next section.

8.6 Areas for further research

This research has importantly contributed to providing the means to facilitate better management of resources in schools such that they can achieve greater utilisation of educational software in their environment and in providing an understanding of the context of educational software adoption in schools. This context is particularly interesting due to the importance of developing strategies for the effective up-take and utilisation of educational technologies at local and national levels.

Given that this study has looked at the adoption of educational software in secondary level education, further research could investigate the perceptions of relevant stakeholders in the adoption of educational software in primary schools and/or in higher education. The comparison of these results will be interesting as to the differences and similarities among the different educational environments. This will provide useful information in the consideration of possibilities and limitations in the adoption of common procedures or the establishment of good practice guidelines for the development and adoption of software within educational settings.

In addition further research could also include the exploration of the perceptions of relevant stakeholders from the wider environment i.e. local education authorities, governmental agencies, software developers etc. They can provide an insight as to the factors they believe influence the up-take of educational software in the school domain, which may be useful in terms of incorporating further factors or relationships to the FCM model. This would mean expanding the scope of the study which has taken place within the context of this thesis, as another direction for further research.

Given that the validation of the dynamic FCM model in this study was conducted by comparing the simulation results of the FCM model to the results of a study conducted in USA, this indicates that although the model is based on the perceptions of stakeholders in UK secondary schools it is seen to be applicable to schools pertaining to another environment, in this instance, the USA. Although schools in the west can be considered similar in some respects such as in terms of resources, standards etc and there maybe common generic factors in the adoption of ICTs, there are however differences in school systems and cultures. It can therefore be useful to see how the FCM model works in terms of exploring 'what-if' possibilities and scenarios in such other contexts.

More directions for further research, which can benefit from the study within this thesis, include:

- The adoption of other educational technologies in schools where the adoption has been slow or unsuccessful and/or to offer the means by which scarce resources can be directed to prime areas which will increase the use of this technology.
- The adoption of other educational technologies at different educational levels such as at primary school or at university levels, such as the adoption of distance learning technologies at university level.
- The introduction of a new innovation in schools in order to ascertain and model the factors which stakeholders consider will be important in influencing them to adopt the new technology, for example in the adoption of management information systems in schools which allow for electronic registration etc.
- The adoption of educational software and ICTs in other countries, where the adoption of ICTs such as educational software is slow and limited.
- The adoption of educational or non-educational software (i.e. training software, business related software) in organisations such as in businesses, in hospitals etc, where the adoption has been slow or unsuccessful and/or to offer the means by which to facilitate better resource management.

- The adoption of other technologies in organisations such as in businesses, in hospitals etc, where the adoption has been slow or unsuccessful and/or to offer the means by which to facilitate better resource management.
- The introduction of a new innovation in organisations in order to ascertain and model the factors which stakeholders consider will be important in influencing them to adopt the new technology.

Finally with specific regard to the FCM research domain, there is a lack of commercially available FCM software/applications. This constitutes an area for further research and work, in that there is a need to develop applications/software which can be used to construct FCM models and run simulations i.e. allow for the visual representation of FCMs, the aggregation of individual FCMs to form one main model which takes into account assigned credibility weightings, the calculations involved in the simulation process and the ability to address truly independent concept in such calculations etc.

8.7 Concluding Remarks

This study, in order to address the problem of the unsatisfactory uptake of educational software in UK secondary schools, aimed to facilitate better management of resources by schools in order that they can achieve greater utilisation of educational software within their environment. It aimed to provide a holistic view of the combination of the various factors which are required in the adoption and usage of educational software and the means by which it is possible to determine where resources should be directed so that factors which either alone or in combination with other factors are enabled and can influence the up-take of educational software by teachers and students. With respect to these aims, this study resulted in an empirically developed fuzzy cognitive map, modelling the adoption of educational software in schools, based on the perceptions of relevant stakeholder groups from UK secondary education.

This study contributes to three different areas of research: ICTs adoption in education, information systems and the fuzzy cognitive mapping domain. The contributions made by this study can be taken further within and beyond the current educational software adoption research agenda. It is hoped that this thesis will prove useful for improving the understanding of a problematic adoption of technology within the social and cultural context of an educational environment.

Finally and importantly the FCM model provides the means by which resources can be directed to areas which influence and ensure the up-take of educational software by teachers and students. In doing so, the model can help to bridge the gap between the government's policies and persons adopting educational software at the operational level. Furthermore by providing the means to achieve greater utilisation of educational software in schools this can potentially lead to the attainment of many of the pedagogical benefits associated with the use of educational software. Therefore the FCM model as a practical tool can be useful to software developers, planners and decisions makers both at local and national levels.

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APPENDICES

Appendix A: Topic agenda for semi-structured interviews

(Personal notes in italics)

1. Background of interviewee (applicable for staff participants only)

(Gender and Age)

- What is your position/normal role? *(i.e. teacher, head teacher, technical assistant etc)*

(Dual Role)

- What does this normally involve? *(i.e. teaching, managing, technical support)*
- What are your areas of expertise? *(subject specialty i.e. history, IT, school admin)*
- How many years have you worked in this field?

2. Regarding the general adoption of ICTs in schools

- According to your perception what does the term ICT adoption in schools mean?
  -What does ICT include?
  -What do you envisage when you consider the use of ICT in the teaching and learning processes? *(I.e. is it the use of Power point for presentations, use of Microsoft word applications. Or educational software usage in the curriculum)*
- What kind of role does educational software play within the broad term of ICT adoption in schools? *(i.e. Govt. emphasis of ICT usage across the curriculum)*
- In your view how important is it for teachers and students to use ICT- educational software in the curriculum?

3. Regarding the use of ICTs in the participant's school

- Do teachers and students in your school use educational software? (Including yourself.)

- To what extent is educational software used? (low/ moderate/ sufficient/ high/ very high level?) ***(Leading question)***

If "high or very high"

- Then how do you ensure or encourage this practice?
- Which factors play a part in this? *(i.e. is it because you have good facilities, trained staff, strong IT culture etc) (Identify factors/Agree with identified factors)*

If "low or moderate or sufficient *(given benefits should not just be sufficient)*"

- Why is the current practice of educational software low/ moderate or just sufficient?
- What are the obstacles? *(i.e. lack of facilities, lack of trained staff etc)*
- Which factors are important or need to be addressed to ensure good practice- ICT, educational software usage in the teaching and learning processes? *(Identify factors/Agree with identified factors)*

- Do you feel the adoption of educational software in schools has met the expectations and aspirations so far:
  - Students
  - Teachers
  - Head teachers
  - Technical staff
  - Department Heads

4. Regarding the process of change- i.e. ICT adoption in schools

25. To what extent has this process of change been

-Technology-led?

-Pedagogically/education-led?

-IT globalization-led?

26. What has been the role of users i.e. teachers and students?

-When and how have they been involved?

5. What is your key message with regard to general ICT and educational software adoption in schools?

Appendix B: Questionnaire used in fully structured interviews with staff participants

Section A: Background Information

Please tick where applicable

Gender:

Male	
Female	

Age:

20-29	
30-39	
40-49	
50-59	
60-up	

What is your current position/normal role? (i.e. teacher, technical assistant, department head etc)

What does this normally involve? (i.e.teaching, managing school ICT, technical support etc)

How many years have you personally worked in this field?

What are your areas of relevant expertise? (subject speciality, IT, school admin etc)

If you teach please indicate your specific teaching area(s):
Please tick where applicable

Art
Citizenship
Design and Technology
English
Georgraphy
History
Humanities
Information technology
Mathematics
Modern Foreign languages
Music
Physical Education
Religious Education
Science
Other (please specify)

Have you had the expeience of achieving ICT competencies that now form part of the QT award?

Yes		No	

If you have indicated 'NO' please specify why...............

Have you received any computer-related training as part of the NOF scheme?

Yes		No	

If you have indicated 'NO' please specify why...............

If so, have you completed your NOF training?

Yes		No	

If you have indicated 'NO' please specify why...............

Have you received any other computer-related training? (past education/courses outside school/in school)

Yes		No	

Do you have computer access at:

Home	Yes		No	
Work	Yes		No	

Section B: Looks at educational software adoption and usage by teachers and students in school.

There has been much emphasis over recent years by the government to introduce ICT into the school education system.

This research looks at the adoption and usage of educational software in the teaching and learning processs i.e. across the curriculum by key stakeholder groups, teachers and students i.e. the main users.

The following are a list of statements indicating a relationship between certain factors or conditions which may need to be in place in order for teachers and students to use educational software in school, **specifically in the teaching and learning processes.**

IMPORTANT: Please circle one of the choices, *given in italics and underlined*, in each of the statements below :

1. Availability and access to IT facilites

A. There needs to be *no/small/moderate/high/very high* level of IT facilities available and access to these facilities for any kind of educational software usage by teachers.

A. There needs to be *no/small/moderate/high/very high* level of basic IT facilities available and access to these facilities for any kind of educational software usage by students.

B. An increase in IT facilities and greater access will increase educational software usage by teachers: *Agree* *Disagree*

B. An increase in IT facilities and greater access will increase educational software usage by students: *Agree* *Disagree*

C. A change in the availabilty of IT facilities (eg. more computer rooms) and change in the amount of access to these facilities will have *no/small/moderate/big/very big* effect on teachers' usage of educational software.

C. A change in the availabilty of IT facilities (eg. more computer rooms) and change in the amount of access to these facilities will have *no/small/moderate/big/very big* effect on students' usage of educational software.

2. Availability of non-outdated hardware/IT equipment

A. There needs to be *no/small/moderate/high/very high* level of IT equipment available for any kind of educational software usage by teachers.

A. There needs to be *no/small/moderate/high/very high* level of IT equipment available for any kind of educational software usage by students.

B. An increase in IT equipment will increase educational software usage by teachers.
Agree *Disagree*

B. An increase in IT equipment will increase educational software usage by students
Agree *Disagree*

C. A change in the availabilty of IT equipment (eg. more updated equipment) will have *no/small/moderate/big/very big* effect on teachers' usage of educational software.

C. A change in the availabilty of IT equipment (eg. more updated equipment) will have *no/small/moderate/big/very big* effect on students' usage of educational software.

3. Time to prepare lessons using software

A. There needs to be *no/small/moderate/high/very high* level of extra time available to evaluate software and plan the lessons accordingly before teachers can use educational software in their teaching.

B. If teachers are allowed more preparation time to plan lessons using educational software this will increase their use of educational software in classroom teaching.
Agree *Disagree*

C. A change in the amount of time allowed for teachers to prepare lessons with software will *have no/small/moderate/big/very big* effect on teachers' usage of educational software.

4. Amount of time spent on ICT in School
A. There needs to be *no/small/moderate/high/very high* amount of time allocated for ICT usage in lessons in order for teachers to use educational software.

A. There needs to be *no/small/moderate/high/very high* amount of time allocated for ICT usage in lessons in order for students to use educational software.

B. An increase in the amount of time spent on ICT will increase educational software usage by teachers. *Agree* *Disagree*

B. An increase in the amount of time spent on ICT will increase educational software usage by students. *Agree* *Disagree*

C. A change in the amount of time allocated to ICT will have *no/small/moderate/big/very big* effect on teachers' usage of educational software.

C. A change in the amount of time spent on ICT will have *no/small/moderate/big/very big* effect on students' usage of educational software.

5. Technical Support Staff
A. There needs to be *no/small/moderate/high/very high* level of technical support staffing available in order for teachers to be able to use basic educational software.

A. There needs to be *no/small/moderate/high/very high* level of technical support staffing available in order for students to be able to use basic educational software.

B. An increase in the number of technical support staff will increase educational software usage by teachers. *Agree* *Disagree*

B. An increase in the number of technical support staff will increase educational software usage by students. *Agree* *Disagree*

C. A change in the number of technical support staff will have *no/small/moderate/big/very big* effect on teachers' usage of educational software.

C. A change in the number of technical support staff will have *no/small/moderate/big/very big* effect on students' usage of educational software.

6. Teachers' ICT skills
A. Teachers need to have *no/small/moderate/high/very high* level of ICT skills in order for them to use basic educational software.

A. Teachers need to have *no/small/moderate/high/very high* level of ICT skills in order for students to use basic educational software.

B. An increase in teachers ICT skills will increase teachers' usage of educational software.
Agree *Disagree*

B. An increase in teachers' ICT skill will cause students to use more educational software.
Agree *Disagree*

C. A change in the level of teachers' ICT skills will have no/small/moderate/big/very big effect on teachers' usage of educational software.

C. A change in the level of teachers' ICT skills will have no/small/moderate/big/very big effect on students' usage of educational software.

7. Teachers' training in ICT
A. Teachers need to have *no/small/moderate/high/very high* level of training in ICT in order for them to use educational software.

A. Teachers need to have *no/small/moderate/high/very high* level of training in ICT in order for students to use educational software.

B. An increase in teachers' training in ICT will cause teachers to use more educational software.
Agree *Disagree*

B. An increase in teachers ICT training will lead to an increase in the use of educational software by students. *Agree* *Disagree*

C. A change in the level of teachers' ICT training will have *no/small/moderate/big/very big* effect teachers' usage of educational software.

C. A change in the amount of teachers' ICT training will have *no/small/moderate/big/very big* effect on students' usage of educational software.

8. Guidelines/Instructions for integrating software into the curriculum
A. There needs to be *no/small/moderate/high/very high* level of guidelines available for integrating software into the curriculum in order for teachers to use educational software.

A. There needs to be *no/small/moderate/high/very high* level of guidelines available for integrating software into the curriculum in order for students to use educational software.

B. More guidelines about how to integrate software into the curriculum will cause teachers to use more educational software. *Agree* *Disagree*

B. More guidelines about how to integrate software into the curriculum will lead to students using more educational software. *Agree* *Disagree*

C. A change in the availabilty of guidelines/instructions for integrating software into the curriculum will have *no/small/moderate/big/very big* effect on teachers' usage of educational software.

C. A change in the availabilty of guidelines/instructions for integrating software into the curriculum will have *no/small/moderate/big/very big* effect on students' usage of educational software.

9. Software ability to satisfy learning objectives
A. Educational software must have *no/small/moderate/high/very high* ability to satisfy learning objectives, in order for teachers to use such software.

A. Educational software must have *no/small/moderate/high/very high* ability to satisfy learning objectives, in order for students to use such software.

B. The higher the ability of the software to satisfy learning objectives, greater the usage of educational software by teachers. *Agree* *Disagree*

B. The higher the ability of the software to satisfy learning objectives, greater the usage of educational software by students. *Agree* *Disagree*

C. A change in the ability of the software to satisfy learning objectives will have *no/small/moderate/big/very big* effect on teachers' overall usage of educational software.

C. A change in the ability of the software to satisfy learning objectives will have <u>no/small/moderate/big/very big</u> effect on students' overall usage of educational software.

10. Software up-to-date with curriculum requirements

A. Educational software must meet <u>no/small/moderate/high/very high</u> level of the curriculum requirements in order for teachers to use educational software.

A. Educational software must meet <u>no/small/moderate/high/very high</u> level of the curriculum requirements in order for students to use educational software.

B. The greater the level of curriculum requirements met by educational software, the greater the usage of educational software by teachers. <u>Agree</u> <u>Disagree</u>

B. The greater the level of curriculum requirements met by educational software, the greater the usage of educational software by students. <u>Agree</u> <u>Disagree</u>

C. A change in the ability of the software to meet curriculum requirements will have <u>no/small/moderate/big/very big</u> effect on teachers' overall usage of educational software.

C. A change in the ability of the software to meet curriculum requirements will have <u>no/small/moderate/big/very big</u> effect on students' overall usage of educational software.

11. Availabity of educational software

A. There needs to be <u>no/small/moderate/high/very high</u> level of educational software available in order for teachers to use educational software.

A. There needs to be <u>no/small/moderate/high/very high</u> level of educational software available in order for students to use educational software.

B. An increase in the availability of educational software will increase educational software usage by teachers. <u>Agree</u> <u>Disagree</u>

B. An increase in the availability of educational software will increase educational software usage by students. <u>Agree</u> <u>Disagree</u>

C. A change in the availabilty of educational software will have <u>no/small/moderate/big/very big</u> effect on teachers' usage of educational software.

C. A change in the availabilty of educational software will have <u>no/small/moderate/big/very big</u> effect on students' usage of educational software.

12. Levels in the ease of use of educational software

A. Educational software must be <u>very difficult/difficult/moderately easy/ easy/very easy</u> to use in order for teachers to use educational software.

A. Educational software must be <u>very difficult/difficult/moderately easy/ easy/very easy</u> to use in order for students to use educational software.

B. The more difficult it is to use educational software, will cause an increase in the usage of educational software by teachers. <u>Agree</u> <u>Disagree</u>

B. The more difficult it is to use educational software, will cause an increase in the usage of educational software by students. <u>Agree</u> <u>Disagree</u>

C. A change in the levels of ease of use of educational software will have <u>no/small/moderate/big/very big</u> effect on teachers' usage of educational software.

C. A change in the levels of ease of use of educational software will have <u>no/small/moderate/big/very big</u> effect on students' usage of educational software.

13. Interactive software
A. Educational software must have *no/small/moderate/high/very high* level of interactivity in order for teachers to be able to use educational software.

A. Educational software must have *no/small/moderate/high/very high* level of interactivity in order for students to be able to use educational software.

B. An increase in the level of educational software interactivity will cause a decrease in teachers' usage of educational software. *Agree* *Disagree*

B. An increase in the level of educational software interactivity will cause a decrease in students' usage of educational software. *Agree* *Disagree*

C. A change in the level of interactivity in educational software will have *no/small/moderate/big/very big* effect on teachers' overall usage of educational software.

C. A change in the level of interactivity in educational software will have *no/small/moderate/big/very big* effect on students' overall usage of educational software.

14. Entertainment value of educational software
A. Educational software must have *no/small/moderate/high/very high* entertainment value in order for teachers to use educational software.

A. Educational software must have *no/small/moderate/high/very high* entertainment value in order for students to use basic educational software.

B. An increase in the entertainment value of educational software will increase educational software usage by teachers. *Agree* *Disagree*

B. An increase in the entertainment value of educational software will decrease educational software usage by students. *Agree* *Disagree*

C. A change in the entertainment value of educational software will have *no/small/moderate/big/very big* effect on teachers' overall usage of educational software.

C. A change in the entertainment value of educational software will have *no/small/moderate/big/very big* effect on students' overall usage of educational software.

15. Software ability to monitor student progress
A. Educational software must have *no/small/moderate/high/very high* ability to monitor student progress in order for teachers to use educational software.

A. Educational software must have *no/small/moderate/high/very high* ability to monitor student progress in order for students to use basic educational software.

B. An increase in the software ability to monitor student progress will increase educational software usage by teachers. *Agree* *Disagree*

B. An increase in the software ability to monitor student progress will increase educational software usage by students. *Agree* *Disagree*

C. A change in the software ability to monitor student progress will have *no/small/moderate/big/very big* effect on teachers' overall usage of educational software.

C. A change in the software ability to monitor student progress will have *no/small/moderate/big/very big* effect on students' overall usage of educational software.

16. Software ability to remedy the user's misconception
A. Educational software must have *no/small/moderate/high/very high* ability to provide

an explanation or correct any misconception/mistake, in order for teachers to use educational software.

A. Educational software must have _no/small/moderate/high/very high_ ability to provide an explanation or correct any misconception/mistake, in order for students to use educational software.

B. An increase in the ability of software to remedy a misconception will increase educational software usage by teachers. _Agree_ _Disagree_

B. An increase in the ability of software to remedy a misconception will increase educational software usage by students. _Agree_ _Disagree_

C. A change in the ability of educational software to remedy a misconception will have _no/small/moderate/big/very big_ effect on teachers' overall usage of educational software.

C. A change in the ability of educational software to remedy a misconception will have _no/small/moderate/big/very big_ effect on students' overall usage of educational software.

17. Availabilty of specialised software for specific subjects
A. There needs to be _no/small/moderate/high/very high_ level of specialised educational software available for specific subjects in order for teachers to use educational software.

A. There needs to be _no/small/moderate/high/very high_ level of specialised educational software available for specific subjects in order for students to use educational software.

B. An increase in the availabilty of specialised educational software wll increase educational software usage by teachers. _Agree_ _Disagree_

B. An increase in the availabilty of specialised educational software wll increase educational software usage by students. _Agree_ _Disagree_

C. A change in the availabilty of specialised software for specific subjects will have _no/small/moderate/big/very big_ effect on teachers' overall usage of educational software.

C. A change in the availabilty of specialised software for specific subjects will have _no/small/moderate/big/very big_ effect on students' overall usage of educational software.

18. Software ability to adapt to students needs and preferences
A. Educational software must have _no/small/moderate/high/very high_ ability to adapt to students needs and preferences, in order for teachers to use educational software.

A. Educational software must have _no/small/moderate/high/very high_ ability to adapt to students needs and preferences, in order for students to use educational software.

B. An increase in the ability of software to adapt to students' needs and preferences will increase educational software usage by teachers. _Agree_ _Disagree_

B. An increase in the ability of software to adapt to students' needs and preferences will increase educational software usage by students. _Agree_ _Disagree_

C. A change in the ability of educational software to adapt to students needs and preferences will have _no/small/moderate/big/very big_ effect on teachers' overall usage of educational software.

C. A change in the ability of educational software to adapt to students needs and preferences will have _no/small/moderate/big/very big_ effect on teachers' overall usage of educational software.

19. Software abilty to satisfy learninig requirements
A. Educational software must have _no/small/moderate/high/very high_ ability to satisfy learning requirements, in order for teachers to use educational software.

A. Educational software must have _no/small/moderate/high/very high_ ability to satisfy learning requirements, in order for students to use educational software.

B. An increase in the ability of software to satisfy learning requiremnets will increase educational software usage by teachers. _Agree_ _Disagree_

B. An increase in the ability of software to satisfy learning requiremnets will increase educational software usage by students. _Agree_ _Disagree_

C. A change in the ability of educational software to satisfy learning requirements will have _no/small/moderate/big/very big_ effect on teachers' overall usage of educational software.

C. A change in the ability of educational software to satisfy learning requirements will have _no/small/moderate/big/very big_ effect on students' overall usage of educational software.

20. IT culture in school

A. There needs to be _no/small/moderate/high/very high_ level of IT culture in school, in order for teachers to use educational software.

A. There needs to be _no/small/moderate/high/very high_ level of IT culture in school, in order for students to use educational software.

B. An increase in the level of IT culture in school will lead to more educational software usage by teachers. _Agree_ _Disagree_

B. An increase in the level of IT culture in school will lead to more educational software usage by students. _Agree_ _Disagree_

C. A change in the richness/level of IT culture will have _no/small/moderate/big/very big_ effect on teachers' overall usage of educational software.

C. A change in the richness/level of IT culture will have _no/small/moderate/big/very big_ effect on students' overall usage of educational software.

21. ICT usage outside of school hours and environment

A. There needs to be _no/small/moderate/high/very high_ level ICT usage outside of school, for example at home, in order for teachers to be able to use educational software.

A. There needs to be _no/small/moderate/high/very high_ level ICT usage outside of school, . for example at home, in order for students to be able to use educational software

B. An increase in ICT usage outside of school, for example at home, will increase teachers' use of educational software. _Agree_ _Disagree_

B. An increase in ICT usage outside of school, for example at home, will increase students' use of educational software. _Agree_ _Disagree_

C. A change in the amount of ICT usage outside of school, for example at home, will have _no/small/moderate/big/very big_ effect on teachers' overall usage of educational software.

C. A change in the amount of ICT usage outside of school, for example at home, will have _no/small/moderate/big/very big_ effect on students' overall usage of educational software.

21.1 B. An increase in the availabilty of IT facilities at school, with greater access, will decrease teachers' need to use of ICT at home i.e outside of school. _Agree_ _Disagree_

21.1 B. An increase in the availabilty of IT facilities at school, with greater access, will decrease students' need to use of ICT at home i.e. outside of school. _Agree_ _Disagree_

21.1.C. A change in the availabilty and access to IT facilities at school will have *no/small/moderate/big/very big* effect on teachers' overall need to use ICT outside of school.

21.1.C. A change in the availabilty and access to IT facilities at school will have *no/small/moderate/big/very big* effect on students' overall need to use ICT outside of school.

21.4.B. An increase in the amount of time spent on ICT at school will lead to a decrease in teachers' need to use of ICT outside of school. *Agree* *Disagree*

21.4.B An increase in the amount of time spent on ICT at school will lead to a decrease in students' need to use of ICT outside of school. *Agree* *Disagree*

21.4.C. A change in the amount of time spent on ICT at school will have *no/small/moderate/big/very big* effect on teachers' overall need to use ICT outside of school.

21.4.C. A change in the amount of time spent on ICT at school will have *no/small/moderate/big/very big* effect on students' overall need to use ICT outside of school.

22. Teacher usage of educational software

A. Teachers need to use *no/small/moderate/high/very high* level of educational software in order for students to use educational software.

B. An increase in teachers usage of educational software will lead to an increase in students' usage of educational software. *Agree* *Disagree*

C. A change in the amount of educational software usage by teachers will have *no/small/moderate/big/very big* effect on students' usage of educational software.

23. Student usage of educational software

A. Students need to be able use *no/small/moderate/high/very high* level of educational software in order for teachers to use educational software.

B. An increase in students usage of educational software will lead to an increase in teachers' usage of educational software. *Agree* *Disagree*

C. A change in the amount of educational software usage by students will have *no/small/moderate/big/very big* effect on teachers' usage of educational software.

24. What do you think would happen if students adopted and used more educational software than their teachers?

Would increase teacher usage of educational software in order to keep up with students/ Would decrease teacher usage of educational software because of the educational software usage skills gap between teacher and student. / Other reasons (please specify)...........

25. Are there any other factors that you think we should have taken into account? Or if there are any other comments you would like to make?

Appendix C: Questionnaire used in fully structured interviews with student participants

Section A: Background Information

Please tick where applicable

Gender:

Male	
Female	

Year group in school:

Do you have access to a computer at:

Home	Yes		No	
School	Yes		No	

Please tick where applicable:

Subjects	You are currently taught in School	Have used educational software in this subject
Art		
Citizenship		
Design and Technology		
English		
Georgraphy		
History		
Humanities		
Information technology		
Mathematics		
Modern Foreign languages		
Music		
Physical Education		
Religious Education		
Science		
Other (please specify)		

Do you use ICT including software packages at home or outside of school?
For example the internet, games packages.

Yes		No	

Do you use educational software at home or outside of school? For example a maths software package to help with maths revision.

Yes		No	

Section B: Looks at educational software adoption and usage by teachers and students in school.

There has been much emphasis over recent years by the government to introduce ICT into the school education system.

This research looks at the adoption and usage of educational software in the teaching and learning processs i.e. across the curriculum by key stakeholder groups, teachers and students i.e. the main users.

The following are a list of statements indicating a relationship between certain factors or conditions which may need to be in place in order for teachers and students to use educational software in school, **specifically in the teaching and learning processes.**

IMPORTANT: Please circle one of the choices, *given in italics and underlined*, in each of the statements below :

1. Availability and access to IT facilites

A. There needs to be *no/small/moderate/high/very high* level of IT facilities available and access to these facilities for any kind of educational software usage by teachers.

A. There needs to be *no/small/moderate/high/very high* level of basic IT facilities available and access to these facilities for any kind of educational software usage by students.

B. A change in the availabilty of IT facilities (eg. more computer rooms) and change in the amount of access to these facilities will have *no/small/moderate/big/very big* effect on teachers' usage of educational software.

B. A change in the availabilty of IT facilities (eg. more computer rooms) and change in the amount of access to these facilities will have *no/small/moderate/big/very big* effect on students' usage of educational software.

2. Availability of non-outdated hardware/IT equipment

A. There needs to be *no/small/moderate/high/very high* level of IT equipment available for any kind of educational software usage by teachers.

A. There needs to be *no/small/moderate/high/very high* level of IT equipment available for any kind of educational software usage by students.

B. A change in the availabilty of IT equipment (eg. more updated equipment) will have *no/small/moderate/big/very big* effect on teachers' usage of educational software.

B. A change in the availabilty of IT equipment (eg. more updated equipment) will have *no/small/moderate/big/very big* effect on students' usage of educational software.

3. Time to prepare lessons using software
A. There needs to be *no/small/moderate/high/very high* level of extra time available to evaluate software and plan the lessons accordingly before teachers can use educational software in their teaching.

B. A change in the amount of time allowed for teachers to prepare lessons with software will *have no/small/moderate/big/very big* effect on teachers' usage of educational software.

4. Amount of time spent on ICT in School
A. There needs to be *no/small/moderate/high/very high* amount of time allocated for ICT usage in lessons in order for teachers to use educational software.

A. There needs to be *no/small/moderate/high/very high* amount of time allocated for ICT usage in lessons in order for students to use educational software.

B. A change in the amount of time allocated to ICT will have *no/small/moderate/big/very big* effect on teachers' usage of educational software.

B. A change in the amount of time spent on ICT will have *no/small/moderate/big/very big* effect on students' usage of educational software.

5. Technical Support Staff
A. There needs to be *no/small/moderate/high/very high* level of technical support staffing available in order for teachers to be able to use basic educational software.

A. There needs to be *no/small/moderate/high/very high* level of technical support staffing available in order for students to be able to use basic educational software.

B. A change in the number of technical support staff will have *no/small/moderate/big/very big* effect on teachers' usage of educational software.

B. A change in the number of technical support staff will have *no/small/moderate/big/very big* effect on students' usage of educational software.

6. Teachers' ICT skills
A. Teachers need to have *no/small/moderate/high/very high* level of ICT skills in order for them to use basic educational software.

A. Teachers need to have *no/small/moderate/high/very high* level of ICT skills in order for students to use basic educational software.

B. A change in the level of teachers' ICT skills will have no/small/moderate/big/very big effect on teachers' usage of educational software.

B. A change in the level of teachers' ICT skills will have no/small/moderate/big/very big effect on students' usage of educational software.

♦———————————————♦

7. Teachers' training in ICT

A. Teachers need to have _no/small/moderate/high/very high_ level of training in ICT in order for them to use educational software.

A. Teachers need to have _no/small/moderate/high/very high_ level of training in ICT in order for students to use educational software.

B. A change in the level of teachers' ICT training will have _no/small/moderate/big/very big_ effect teachers' usage of educational software.

B. A change in the amount of teachers' ICT training will have _no/small/moderate/big/very big_ effect on students' usage of educational software.

♦———————————————♦

8. Guidelines/Instructions for integrating software into the curriculum

A. There needs to be _no/small/moderate/high/very high_ level of guidelines available for integrating software into the curriculum in order for teachers to use educational software.

A. There needs to be _no/small/moderate/high/very high_ level of guidelines available for integrating software into the curriculum in order for students to use educational software.

B. A change in the availabilty of guidelines/instructions for integrating software into the curriculum will have _no/small/moderate/big/very big_ effect on teachers' usage of educational software.

B. A change in the availabilty of guidelines/instructions for integrating software into the curriculum will have _no/small/moderate/big/very big_ effect on students' usage of educational software.

♦———————————————♦

9. Software ability to satisfy learning objectives

A. Educational software must have _no/small/moderate/high/very high_ ability to satisfy learning objectives, in order for teachers to use such software.

A. Educational software must have _no/small/moderate/high/very high_ ability to satisfy learning objectives, in order for students to use such software.

B. A change in the ability of the software to satisfy learning objectives will have _no/small/moderate/big/very big_ effect on teachers' overall usage of educational software.

B. A change in the ability of the software to satisfy learning objectives will have _no/small/moderate/big/very big_ effect on students' overall usage of educational software.

10. Software up-to-date with curriculum requirements

A. Educational software must meet *no/small/moderate/high/very high* level of the curriculum requirements in order for teachers to use educational software.

A. Educational software must meet *no/small/moderate/high/very high* level of the curriculum requirements in order for students to use educational software.

B. A change in the ability of the software to meet curriculum requirements will have *no/small/moderate/big/very big* effect on teachers' overall usage of educational software.

B. A change in the ability of the software to meet curriculum requirements will have *no/small/moderate/big/very big* effect on students' overall usage of educational software.

11. Availabity of educational software

A. There needs to be *no/small/moderate/high/very high* level of educational software available in order for teachers to use educational software.

A. There needs to be *no/small/moderate/high/very high* level of educational software available in order for students to use educational software.

B. A change in the availabilty of educational software will have *no/small/moderate/big/very big* effect on teachers' usage of educational software.

B. A change in the availabilty of educational software will have *no/small/moderate/big/very big* effect on students' usage of educational software.

12. Levels in the ease of use of educational software

A. Educational software must be *very difficult/difficult/moderately easy/ easy/very easy* to use in order for teachers to use educational software.

A. Educational software must be *very difficult/difficult/moderately easy/ easy/very easy* to use in order for students to use educational software.

B. A change in the levels of ease of use of educational software will have *no/small/moderate/big/very big* effect on teachers' usage of educational software.

B. A change in the levels of ease of use of educational software will have *no/small/moderate/big/very big* effect on students' usage of educational software.

13. Interactive software

A. Educational software must have *no/small/moderate/high/very high* level of interactivity in order for teachers to be able to use educational software.

A. Educational software must have *no/small/moderate/high/very high* level of interactivity in order for students to be able to use educational software.

B. A change in the level of interactivity in educational software will have *no/small/moderate/big/very big* effect on teachers' overall usage of educational software.

B. A change in the level of interactivity in educational software will have *no/small/moderate/big/very big* effect on students' overall usage of educational software.

♦————————♦

14. Entertainment value of educational software

A. Educational software must have *no/small/moderate/high/very high* entertainment value in order for teachers to use educational software.

A. Educational software must have *no/small/moderate/high/very high* entertainment value in order for students to use basic educational software.

B. A change in the entertainment value of educational software will have *no/small/moderate/big/very big* effect on teachers' overall usage of educational software.

B. A change in the entertainment value of educational software will have *no/small/moderate/big/very big* effect on students' overall usage of educational software.

♦————————♦

15. Software ability to monitor student progress

A. Educational software must have *no/small/moderate/high/very high* ability to monitor student progress in order for teachers to use educational software.

A. Educational software must have *no/small/moderate/high/very high* ability to monitor student progress in order for students to use basic educational software.

B. A change in the software ability to monitor student progress will have *no/small/moderate/big/very big* effect on teachers' overall usage of educational software.

B. A change in the software ability to monitor student progress will have *no/small/moderate/big/very big* effect on students' overall usage of educational software.

♦————————♦

16. Software ability to remedy the user's misconception

A. Educational software must have *no/small/moderate/high/very high* ability to provide an explanation or correct any misconception/mistake, in order for teachers to use educational software.

A. Educational software must have *no/small/moderate/high/very high* ability to provide an explanation or correct any misconception/mistake, in order for students to use educational software.

B. A change in the ability of educational software to remedy a misconception will have *no/small/moderate/big/very big* effect on teachers' overall usage of educational software.

B. A change in the ability of educational software to remedy a misconception will have *no/small/moderate/big/very big* effect on students' overall usage of educational software.

17. Availabilty of specialised software for specific subjects
A. There needs to be *no/small/moderate/high/very high* level of specialised educational software available for specific subjects in order for teachers to use educational software.

A. There needs to be *no/small/moderate/high/very high* level of specialised educational software available for specific subjects in order for students to use educational software.

B. A change in the availabilty of specialised software for specific subjects will have *no/small/moderate/big/very big* effect on teachers' overall usage of educational software.

B. A change in the availabilty of specialised software for specific subjects will have *no/small/moderate/big/very big* effect on students' overall usage of educational software.

18. Software ability to adapt to students needs and preferences
A. Educational software must have *no/small/moderate/high/very high* ability to adapt to students needs and preferences, in order for teachers to use educational software.

A. Educational software must have *no/small/moderate/high/very high* ability to adapt to students needs and preferences, in order for students to use educational software.

B. A change in the ability of educational software to adapt to students needs and preferences will have *no/small/moderate/big/very big* effect on teachers' overall usage of educational software.

B. A change in the ability of educational software to adapt to students needs and preferences will have *no/small/moderate/big/very big* effect on teachers' overall usage of educational software.

19. Software abilty to satisfy learninig requirements
A. Educational software must have *no/small/moderate/high/very high* ability to satisfy learning requirements, in order for teachers to use educational software.

A. Educational software must have *no/small/moderate/high/very high* ability to satisfy learning requirements, in order for students to use educational software.

B. A change in the ability of educational software to satisfy learning requirements will have *no/small/moderate/big/very big* effect on teachers' overall usage of educational software.

B. A change in the ability of educational software to satisfy learning requirements will have *no/small/moderate/big/very big* effect on students' overall usage of educational software.

♦————————♦

20. IT culture in school

A. There needs to be *no/small/moderate/high/very high* level of IT culture in school, in order for teachers to use educational software.

A. There needs to be *no/small/moderate/high/very high* level of IT culture in school, in order for students to use educational software.

B. A change in the richness/level of IT culture will have *no/small/moderate/big/very big* effect on teachers' overall usage of educational software.

B. A change in the richness/level of IT culture will have *no/small/moderate/big/very big* effect on students' overall usage of educational software.

♦————————♦

21. ICT usage outside of school hours and environment

A. There needs to be *no/small/moderate/high/very high* level ICT usage outside of school, for example at home, in order for teachers to be able to use educational software.

A. There needs to be *no/small/moderate/high/very high* level ICT usage outside of school, . for example at home, in order for students to be able to use educational software

B. A change in the amount of ICT usage outside of school, for example at home, will have *no/small/moderate/big/very big* effect on teachers' overall usage of educational software.

B. A change in the amount of ICT usage outside of school, for example at home, will have *no/small/moderate/big/very big* effect on students' overall usage of educational software.

♦————————♦

21.1 B. An increase in the availabilty of IT facilities at school, with greater access, will decrease teachers' need to use of ICT at home i.e outside of school. *Agree* *Disagree*

21.1 B. An increase in the availabilty of IT facilities at school, with greater access, will decrease students' need to use of ICT at home i.e. outside of school. *Agree* *Disagree*

21.1.C. A change in the availabilty and access to IT facilities at school will have *no/small/moderate/big/very big* effect on teachers' overall need to use ICT outside of school.

21.1.C. A change in the availabilty and access to IT facilities at school will have *no/small/moderate/big/very big* effect on students' overall need to use ICT outside of school.

♦————————♦

21.4.B. An increase in the amount of time spent on ICT at school will lead to a decrease in teachers' need to use of ICT outside of school. *Agree* *Disagree*

21.4.B An increase in the amount of time spent on ICT at school will lead to a decrease in students' need to use of ICT outside of school. _Agree_ _Disagree_

21.4.C. A change in the amount of time spent on ICT at school will have _no/small/moderate/big/very big_ effect on teachers' overall need to use ICT outside of school.

21.4.C. A change in the amount of time spent on ICT at school will have _no/small/moderate/big/very big_ effect on students' overall need to use ICT outside of school.

22. Teacher usage of educational software

A. Teachers need to use _no/small/moderate/high/very high_ level of educational software in order for students to use educational software.

B. An increase in teachers usage of educational software will lead to an increase in students' usage of educational software. _Agree_ _Disagree_

C. A change in the amount of educational software usage by teachers will have _no/small/moderate/big/very big_ effect on students' usage of educational software.

23. Student usage of educational software

A. Students need to be able use _no/small/moderate/high/very high_ level of educational software in order for teachers to use educational software.

B. An increase in students usage of educational software will lead to an increase in teachers' usage of educational software. _Agree_ _Disagree_

C. A change in the amount of educational software usage by students will have _no/small/moderate/big/very big_ effect on teachers' usage of educational software.

24. What do you think would happen if students adopted and used more educational software than their teachers?

Would increase teacher usage of educational software in order to keep up with students/ Would decrease teacher usage of educational software because of the educational software usage skills gap between teacher and student. / Other reasons (please specify)...........

25. Are there any other factors that you think we should have taken into account. Or if there are any other comments you would like to make (please do so in the space provided below).

Thank you very much for your time and effort.

Appendix D: Preliminary Study

D.1 Introduction

ICT adoption in schools has been driven primarily by political and pedagogical agendas, the school as an organisation, has not been adequately addressed. This study argues that in addition to considering pedagogical issues in the adoption of ICT in schools it is imperative to consider the broader technical, organisational and social issues that make up the adoption context as well. This study gathers qualitative data, in order to provide both insight and an understanding of the problems encountered in the current practice of educational software adoption in UK secondary schools.

D.2 Emphasis on the user

This study focuses on students' views. Firstly, because students are identified as key a stakeholder group and main beneficiaries of educational ICT adoption (Hossain, 2000). Secondly and importantly students are identified as the main users of educational software in schools. Users play an important role in determining the success of a system development or adoption, their involvement, participation and influence are considered to be beneficial to the success of a system (Laudon and Laudon, 1998; Lin and Shao, 2000). For example participation is encouraged to ensure that user requirements are met, to gain user commitment and to avoid user resistance, in addition the incorporation of users' knowledge and expertise can lead to better solutions (Laudon and Laudon, 1998). Given the significance of users' roles, their knowledge and views, this paper explores the perceptions of users in the adoption and usage of educational software in schools.

D.3 Research Methodology

This research adopts an Interpretive/Constructivist paradigm (Mertons, 1998). Educational software adoption and usage in schools presents a complex social and cultural context. Therefore a qualitative research approach has been undertaken.

D.3.1 Data collection and analysis

Data collection methods for this study included a series of semi-structured and structured interviews, and questionnaires. The main questions driving the empirical research were

1) *What are students 'perceptions of educational software adoption and usage in secondary education in the UK?*
2) *What do students perceive to be the reasons for the slow adoption and limited usage of educational software in schools?*

Data collection techniques included:

- Survey: The questionnaire was designed to include closed and open-ended questions. 120 students participated in the survey. The participants had just completed school exams, left secondary school or Sixth Form College and had enrolled as undergraduates for IT related courses at University. This was an apt sample for the study because these students had to some extent an interest in IT in their school life. Therefore they would have been more susceptible to ICT related issues or practices, which were existent or being implemented within their educational environment and this sample included persons who would have more likely to have had previous experience in using educational software packages.
- Interviews: Fully structured interviews were conducted with 20 of the students, who had also participated in the survey.
- The following is a sample of the types of questions asked in the interviews and questionnaires: What are your opinions of the use of educational software in the curriculum, e.g. extent of software use in non-IT subjects? What do you perceive as the reasons for the successful or limited usage of educational software in your school? What are your opinions of educational software that you have used i.e. the benefits of using the software etc?

Miles and Huberman (1994) steps, for qualitative data analysis, were used to analyze the empirical data collected, in which:

(1) codes were given to the first set of notes drawn from initial literature reviews

(2) materials were sorted to identify similar phases, themes, and common sequences

(3) patterns identified were kept in mind in the next set of data collection

(4) sets of generalizations that cover consistencies in the data (i.e. identification of the factors affecting in educational software adoption) were elaborated;

(5) generalizations were examined in light of a formalized body of knowledge in the form of constructs.

D.4 Empirical Findings

Based on users' perceptions, this study identifies factors, which affect the adoption and usage of educational software in schools. For example factors such as insufficient computing facilities and teachers' inadequate IT skills have often resulted in teachers relying on traditional teaching methods. Table D presents: the empirical evidence gathered from students; the identified factors which can effect the adoption and usage of educational software in schools based on the empirical evidence and the categorisation of the identified factors into organisational, technical, pedagogical, social and cultural elements.

Table D: Empirical evidence, the associated identified factors and their categorisation

Empirical Evidence	**Identified factors which affect the adoption and usage of educational software in schools**	**Categorisation of the identified factors**
"our school had been equipped with a small number of PCs with Internet aces... there were so few of these machines, students would have to book in advance. This was a problem, as it did not encourage us to use them."(student)	Availability and access to IT facilities	Organisational
• *"... software used on the school network was very difficult to use and had not been changed for over a decade. This was mainly due to a lack of funding as the school was run on a strict budget and could not allocate money to expensive IT equipment without letting other areas suffer. My knowledge of computers did suffer as a result..."(student)* • *"technological equipment was limited amongst the students, thus leading to minimal use of the software packages."(student)*	Availability of non-outdated hardware/IT equipment	Organisational
• *"little time was allocated to the subject of IT, resulting in students not having a solid foundation of the subject..."(student)* • *"During this course we would have a one-hour lesson in IT every two weeks. I feel that this was very insufficient amount compared to what we should have had."(student)*	Amount of time spent on ICT in school	Organisational
• *"...The undersized technical team at the school was incapable of managing the network efficiently...."(student)*	Technical Support Staff	Organisational

Empirical Evidence	**Identified factors which affect the adoption and usage of educational software in schools**	**Categorisation of the identified factors**
• *".. apart from the Business studies and IT staff, all other teachers had very little experience and training in computer skills. This meant that students only ever used computers during IT and Business Studies lessons or during lunch breaks."(students)* • *" Many (i.e. teachers) have minimal IT skills." (student)*	Teachers' ICT skills	Organisational
• *"The main problems encountered with IT in education are teaching staff not being well trained enough to teach students how to fully utilise the software available to them...."(student)*	Teachers' training in ICT	Organisational
• *"Indeed there is such software available on the market however it is not always incorporated within school/college teaching patterns."(student)* • *".. the facilities were provided quite successfully, however, they were inadequately integrated into the education system. The technology was almost exclusively used by IT students, and rarely used for the other subjects that could have benefited from the services that the technology has to offer."(student)*	Guidelines/Instructions for integrating software into the curriculum	Pedagogical
• *"..the software we used seemed to be either too advanced or too basic. The applications created by companies for educational use were not as contributive as they could have been to a pupil. This is due to irrelevant questions being asked in some circumstances. Reason being they did not match that, the criteria for the exam board, which we were sitting." (student)*	Software ability to satisfy learning objectives	Pedagogical

Empirical Evidence	**Identified factors which affect the adoption and usage of educational software in schools**	**Categorisation of the identified factors**
• *"... curriculum guidelines regularly changed and no software was really up to date thus students did not really use them (i.e. software)." (student)*	Software up to date with curriculum requirements	Pedagogical
• *"Too often in my experience the software has been difficult to use to begin with. Complications arise, such as errors occurring meaning extra time is wasted in learning...." (student)*	Levels of difficulty in the use of software	Technical
• *".. it (i.e. software) became very boring as it was the same every time and also the interface was not very user friendly." (student)* • *".. I was allowed to use the software for learning languages that were extremely helpful. The learning applications for languages provided by the school were user friendly and easy to use." (student)* • *".. majority of this software was not user friendly and required additional help before I could use it effectively."(student)*	Interactive/User friendly software	Technical
• *".. using software that tried to incorporate learning of scientific or mathematical concepts into games. However there was a problem of balancing entertainment with the educational values of these games."(student)*	Entertainment value of educational software	Technical

Empirical Evidence	**Identified factors which affect the adoption and usage of educational software in schools**	**Categorisation of the identified factors**
• *"..there were certain flaws in it and one of them was that the applications did not provide any means to monitor my progress." (student)* • *"The package provided vast amounts of information on some of the GCSE subjects such as sciences, maths and German but the problem was that there was no way to test yourself using the software and monitor your progress." (student)*	Software ability to monitor student progress	Technical
• *"..software.. could not provide an explanation for the invalid quadratics or input values that the user may try to implement." (student)*	Software ability to remedy a misconception	Technical
• *"The majority of schools have access to integrated suites but hardly have any specialised software for specific subjects."(student)*	Availability of specialised software for specific subjects	Technical

Empirical Evidence	**Identified factors which affect the adoption and usage of educational software in schools**	**Categorisation of the identified factors**
• *"Educational Software suffers from the impatience of children. (Children lack the patience to read through all the steps. They have a click button at the end of each page and basically this is what they use to rush through to the end.)" (student)* • *"... software helped me to meet my own needs as it helped me to gain a better understanding of what I had learnt in the lessons." (student)* • *"The main problem with these applications is that they only cover one 'level' of learning. I wasn't the only member in my class who found these lessons tediously easy...the government should look at covering different levels of learning within an age group so that all the pupils are constantly learning something new and therefore remain stimulated." (student)* • *"Although I had learnt the fundamentals of IT via classes, I felt there was a lack of challenge because the material or tasks given for us was merely the basics. I feel that my learning experience could have been enhanced by a more interactive approach to learning such as more group work and greater independence."(student)*	Software ability to adapt to students needs and preferences	Technical
• *".. there is an opportunity to make the learning experience more pleasurable with the use of graphics, moving images and sounds."(student)*	Software ability to satisfy learning objectives	Technical

Empirical Evidence	**Identified factors which affect the adoption and usage of educational software in schools**	**Categorisation of the identified factors**
• *"The teaching of IT as a compulsory subject within the school curriculum, was not emphasised, and had little weighting in comparison to core subjects, such as Mathematics, Science and English."(student)* • *"IT has been given less priority then other more familiar methods of teaching and studying. Teachers have usually left it to individual choice, on whether one chooses to make use of the IT software's." (student)* • *"we were introduced to IT software packages such as word, works and excel but not with the same teaching standards, as found in other compulsory subjects. Consequentially the lessons were very informal and not considered as important or as necessary as the others."(student)*	IT culture in schools i.e. motivation to use ICT	Cultural/Social

Empirical Evidence	Identified factors which affect the adoption and usage of educational software in schools	Categorisation of the identified factors
• *"IT was hardly taught at school. The basic IT skills which I had gained were from personal use of home computers.." (student)* • *"When I approached teachers for help, I received the minimum amount of teacher input and was often told that the 'solution' was in the book. Due to lack of sufficient training given to teachers – my knowledge about manipulating the features to produce the desired result originated from my own research." (student)* • *".. teachers were not given specialised computer training but were asked to run classes. This resulted in us being taught very little and only really understanding computers due to having home PCs."(student)* • *"This software was profitable for the school since pupils could purchase copies on CD-ROM's to take home, which could be used once installed. This not only meant we could do revision from home but we could be taught to use an increasing variety of equipment and applications confidently and purposefully alone. The only problem encountered with this, were that those pupils without home computers could not benefit."(student)*	IT usage outside of school hours and environment	Cultural/Social

“Availability and access to IT facilities” and the “availability of non-outdated hardware/IT equipment” (cf. Table D) are fundamental factors in the adoption and usage of educational software in schools. There are indications from students to suggest that the underlying reasons for their slow adoption of educational software are the lack of/limited facilities and/or lack of/limited up to date equipment.

19% of students indicated they had minimal access to computing facilities at school because of a lack of computing facilities, 50% blamed the lack of facilities and equipment for their non use of software. Therefore the availability and the access to facilities and equipment is a fundamental organisational factor, because it makes it impossible to use ICT, even when the potential of ICT in the learning experience is recognised.

Although there is investment in professional development and access to technical expertise, there is a lack of teacher's confidence and pedagogy in using educational software in teaching (OFSTED, 2001; 2002), which is confirmed by this empirical investigation as well. 'Lack of training and knowledge' was quoted as a major reason for teachers' lack of educational software use in a pedagogical manner or for non use of educational software. The findings revealed that 45% of students felt their teachers had the necessary ICT skills however 50% of students felt their teachers were not well trained or equipped with ICT skills. The students comments also indicate that they feel teachers need more training (c.f. Table D). To alleviate this problem and ensure that confidence in technology is cultivated teachers' training needs to be a continual activity. In this way, teachers will be able to take advantage of up to date technology and implement it in their own teaching practice.

Another aspect that emerged in the study is the role of IT culture in education, and the way culture influences the success of educational software adoption in schools as can be gathered through the comments of students (c.f. Table D). Educational computing needs to consider the cultural context within which technology is being used (Latzer, 1995; Niemi, 2002).

D.5 Conclusion and directions for future research

The findings provide evidence to suggest that, from users’ perspectives, the implementation of educational software in schools needs to address a broad spectrum of issues for the adoption to be considered a success. Some of these issues include technological, organisational, social, cultural, teacher training, resistance and economical factors (e.g., Schofield 1995; Ward, 1999; Weikart and Marrapodi, 1999; Selwyn, 2000; Siemer, 1998). Along this line the findings presented in Table D have been categorized into technological, organisational, cultural and pedagogical elements. In this respect, the study proposes the need for a socio-technical approach i.e. an integrated approach, which will recognise the complexity and interrelations of the organisational, technical, social, cultural, issues in the implementation of educational software in schools. This is similar to Lim’s (2002) understanding, that ICT in education cannot be studied alone; it has to be studied in the learning environment and in its broader context (Lim and Hang, 2003).

It is also necessary to increase and encourage user involvement in educational software development and implementation. Users' opinions, requirements, involvement and influence are important in the design, development and implementation of education systems, and therefore user participation should be encouraged (Lin and Shao, 2000).

The above discussion indicates, many barriers, have to be overcome before a school can provide a rich ICT environment for students and teachers. A holistic view of all such factors based on users perceptions, can provide both insight and act as a guide for policy-makers and decision makers in the adoption of educational ICTs in schools. In this respect a construction of such a model can be beneficial to the educational field.

Appendix E: Summary details of research conducted with participants

E.1: Participants at School A

Participant Id.	Position	Why chosen	Initial Contact	Date and place of interview for empirical research purposes	Brief description of the interview conducted
StaffA1	ICT coordinator/ICT teacher	Matched criteria of research agenda to gather the perceptions of an ICT co-ordinator	Made via correspondence. Followed by telephone calls to confirm meeting times. And finally two subsequent meetings as detailed above.	3rd of March 2004, in ICT co-ordinators office, School A.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 1-11/2 hours.
StaffA2	Department Head/Assistant Head Teacher/Teacher of Mathematics	Matched criteria of research agenda to gather the perceptions of a subject specialist teacher i.e. Mathematics teacher. In addition holds a position.	Made via liaising with ICT Co-ordinator (contact) at the school, as explained above.	29th of January 2004, in ICT co-ordinators office, School A.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 1 hour.
StaffA3	Head of key stage 3 French/Teacher of Modern Foreign Languages French and German	Matched criteria of research agenda to gather the perceptions of a subject specialist teacher i.e. Modern languages teacher. In addition holds a position.	Made via liaising with ICT Co-ordinator (contact) at the school, as explained above.	29th of January 2004, in ICT co-ordinators office, School A.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 1 hour.

Participant Id.	Position	Why chosen	Initial Contact	Date and place of interview for empirical research purposes	Brief description of the interview conducted
StaffA4	Teacher of Mathematics	Matched criteria of research agenda to gather the perceptions of a subject specialist teacher i.e. Mathematics teacher.	Made via liaising with ICT Co-ordinator (contact) at the school, as explained above.	29th of January 2004, in ICT co-ordinators office, School A.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 40 –50mins.
StaffA5	Teacher of ICT	Matched criteria of research agenda to gather the perceptions of a subject specialist teacher i.e. ICT teacher.	Made via liaising with ICT Co-ordinator (contact) at the school, as explained above.	3rd of March 2004, in ICT co-ordinators office, School A.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 1 hour.
StaffA6	ICT Technician	Matched criteria of research agenda to gather the perceptions of an ICT Technician	Made via liaising with ICT Co-ordinator (contact) at the school, as explained above.	29th of January 2004, in ICT co-ordinators office, School A.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 40mins.
StuA(1,2, 3 and 4)	Students from Year Groups 7-8	Matched criteria of research agenda to gather the perceptions of an male and female students	Made via liaising with head teacher (contact) at the lower school, as explained above.	30th of January 2004, at lower school, School A.	Semi-structured group interview conducted followed by a fully structured interview. Total duration of about 1 hour.
StuA(5, 6, 7,8, 9,10)	Students from Year Groups 9-11	Matched criteria of research agenda to gather the perceptions of an male and female students	Made via liaising with ICT Co-ordinator (contact) at the school, as explained above.	30th of January 2004, at upper school, School A.	Semi-structured group interview conducted followed by a fully structured interview. Total duration of about 1 hour.

E.2: Participants at School B

Participant Id.	Position	Why chosen	Initial Contact	Date and place of interview for empirical research purposes	Brief description of the interview conducted
StaffB1	Head of Business and ICT Department /ICT coordinator/ Teacher	Matched criteria of research agenda to gather the perceptions of an ICT co-ordinator	Made via liaising with contact at the school, as explained above.	11th of March 2004, in designated meeting room, upper school, School B.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 1 hour.
StaffB2	Head of Year 10/Teacher of Mathematics and ICT	Matched criteria of research agenda to gather the perceptions of a subject specialist teacher i.e. Mathematics and ICT teacher. In addition holds a position.	Made via liaising with contact at the school, as explained above.	11th of March 2004, in designated meeting room, upper school, School B.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 1 hour.
StaffB3	Head of key stage 3 Science/Teacher of Science	Matched criteria of research agenda to gather the perceptions of a subject specialist teacher i.e. Science teacher. In addition holds a position.	Made via liaising with contact at the school, as explained above.	11th of March 2004, in designated meeting room, upper school, School B.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 1 hour.

Participant Id.	Position	Why chosen	Initial Contact	Date and place of interview for empirical research purposes	Brief description of the interview conducted
StaffB4	Head of Design and Technology Department /Teacher of Design and Technology	Matched criteria of research agenda to gather the perceptions of a subject specialist teacher i.e. Design and Technology teacher.	Made via liaising with contact at the school.	11th of March 2004, in designated meeting room, upper school, School B.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 40 –50mins.
StaffB5	ICT Technician	Matched criteria of research agenda to gather the perceptions of an ICT Technician	Made via liaising with contact at the school.	11th of March 2004, in designated meeting room, upper school, School B.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 40mins.
StuB(1,2, 3,4,5, and 6)	Students from Year Groups 7-9	Matched criteria of research agenda to gather the perceptions of an male and female students	Made via liaising with contact at the school.	20th of March 2004, in designated meeting room, lower school, School B.	Semi-structured group interview conducted followed by a fully structured interview. Total duration of about 1 hour.
StuB(7,8, 9,10)	Students from Year Groups 10-11	Matched criteria of research agenda to gather the perceptions of an male and female students	Made via liaising with contact at the school.	11th of March 2004, in designated meeting room, upper school, School B.	Semi-structured group interview conducted followed by a fully structured interview. Total duration of about 1 hour.

E.3: Participants at School C

Participant Id	Position	Why chosen	Initial Contact	Date and place of interview for empirical research purposes	Brief description of the interview conducted
StaffC1	ICT Director/ICT coordinator/ ICT Teacher	Matched criteria of research agenda to gather the perceptions of an ICT co-ordinator	Subsequent to liaising with contact at the school, approached directly as explained above.	16^{th} of June 2004, in ICT support office room, School C.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 1 hour.
StaffC2	Teacher of Sociology, Psychology and Media	Matched criteria of research agenda to gather the perceptions of a subject specialist teacher i.e. Social Sciences teacher.	Subsequent to liaising with contact at the school, approached directly as explained above.	26^{th} of May 2004, in staff common room, School C.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 40-50 minutes.
StaffC3	Teacher of History	Matched criteria of research agenda to gather the perceptions of a subject specialist teacher i.e. History teacher.	Subsequent to liaising with contact at the school, approached directly as explained above.	25^{th} of June 2004, in History Dept office room, School C.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 1 and half hours.

Participant Id	Position	Why chosen	Initial Contact	Date and place of interview for empirical research purposes	Brief description of the interview conducted
StaffC4	Teacher of Art	Matched criteria of research agenda to gather the perceptions of a subject specialist teacher i.e. Art teacher.	Subsequent to liaising with contact at the school, approached directly as explained above.	16th of June 2004, in Art classroom, School C.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 40 –50mins.
StaffC5	ICT Technician	Matched criteria of research agenda to gather the perceptions of an ICT Technician	Subsequent to liaising with contact at the school, approached directly as explained above.	9th of June 2004, in ICT support office room, School C.	Semi-structured interview conducted followed by a fully structured interview. Total duration of about 1 and half hours.
StuC(1,2,3,4,5,6,7,8,9, 10)	Students from Year Groups 7-11	Matched criteria of research agenda to gather the perceptions of an male and female students	Made via liaising with contact at the school.	12th of May 2004, in designated meeting room, School C.	Semi-structured group interview conducted followed by a fully structured interview. Total duration of about 1 hour.

Appendix F: Complete set of individual FCMs from first phase of main FCM development

FCM matrix representation for participant StuA1

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	-1	0.5	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	-1	0.75	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	1
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	1
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FCM matrix representation for participant StuA2

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75	0.75	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	0.5	0.75	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0

FCM matrix representation for participant StuA3

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75	0.75	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75	0.5	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0

FCM matrix representation for participant StuA4

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75	0.75	1
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	1	1
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0

FCM matrix representation for participant StuA5

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.25	0.5
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25	0.25	0.25
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.25
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.25
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.25
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FCM matrix representation for participant StuA6

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	-1	0.75	1
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	-1	1	0
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	1
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	1
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	0

FCM matrix representation for participant StuA7

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5	1	1
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	1	1
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FCM matrix representation for participant StuA8

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75	0	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	-0.75	0.75	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	1
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0

FCM matrix representation for participant StuA9

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.75	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.5	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.25
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0

FCM matrix representation for participant StuA10

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.25
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FCM matrix representation for participant StuB1

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.25	-0.5	0.75	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	-0.75	0.5	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FCM matrix representation for participant StuB2

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25	0.25	0.25
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.25	0.5	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.25
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0

FCM matrix representation for participant StuB3

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	0.75	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	0.75	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0

FCM matrix representation for participant StuB4

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	-1	1	1
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	0.75	1	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0

FCM matrix representation for participant StuB5

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.75	1
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	-1	0.75	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0

FCM matrix representation for participant StuB6

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	0.75	1	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	-0.75	0.5	1
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.5
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0

FCM matrix representation for participant StuB7

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	0.75	0.75	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	-0.75	0.75	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0

FCM matrix representation for participant StuB8

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	0.5	0.75	0.5
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75	0.75	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	0

FCM matrix representation for participant StuB9

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.25	0.25	0.5
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.25	0.25	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.25
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0

FCM matrix representation for participant StuB10

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	-0.25	0.5	0.5
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	-0.5	0.5	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0

FCM matrix representation for participant StuC1

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-0.5	1	1
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	1	1
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FCM matrix representation for participant StuC2

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	1	0.5	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	0.75	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

FCM matrix representation for participant StuC3

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	0.5	0.75	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	0.25	0.75	1
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	1
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0

FCM matrix representation for participant StuC4

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	-0.75	0.5	1
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	-0.75	0.5	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0

FCM matrix representation for participant StuC5

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	0.25	0.5
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.5
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.5
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.25
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.25
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0

FCM matrix representation for participant StuC6

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	-0.5	0.25	0.5
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	0.75	0.25	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0

FCM matrix representation for participant StuC7

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.25	0.25	0.5	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.25	0.75	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.25
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0

FCM matrix representation for participant StuC8

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	1
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.25
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FCM matrix representation for participant StuC9

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	-0.5	0.5	0.5
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.5	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	1
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	0

FCM matrix representation for participant StuC10

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75	0.75	0.5
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25	0.75	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	1
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0

FCM matrix representation for participant StaffA1

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.75	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.25	0.25	0.5	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.25	0.25
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FCM matrix representation for participant StaffA2

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25	1	1
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	1	1
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FCM matrix representation for participant StaffA3

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	-0.75	0.75	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	-0.75	0.75	1
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.25	0

FCM matrix representation for participant StaffA4

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.25	1	1
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.75	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.25
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	0.5
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0

FCM matrix representation for participant StaffA5

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	-0.5	1	1
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	-0.5	0.75	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0

FCM matrix representation for participant StaffA6

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	1	1
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	1	1
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	0.5
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

FCM matrix representation for participant StaffB1

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	0.5	0.5
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	-0.75	0.75	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	0.5
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0

FCM matrix representation for participant StaffB2

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	-0.5	0.75	1
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	-0.5	0.75	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0

FCM matrix representation for participant StaffB3

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	-0.5	0.75	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	-0.5	0.5	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.25	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0

FCM matrix representation for participant StaffB4

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	-0.5	0.75	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.5	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0

FCM matrix representation for participant StaffB5

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25	0.5	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25	0.5	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.25
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.25
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.25
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FCM matrix representation for participant StaffC1

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	1	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.75	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0

FCM matrix representation for participant StaffC2

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	-0.5	0.75	0.75
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.5	0.5	0.5	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	1
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.25	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0

FCM matrix representation for participant StaffC3

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	-0.75	1	1
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.75	0.75
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	1
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0

FCM matrix representation for participant StaffC4

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.5	0.5
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5	0.5	0.5
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.25
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.25	0

FCM matrix representation for participant StaffC5

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5	0.75	1
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5	0.75	1
F5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	1
F8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.5
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.75
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.25	0.5
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0.75
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.75
F21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
F23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix G: Empirical data related to third phase of FCM development.

1. Factor 1: Availability and access to facilities ***affects*** Factor 2. Availability of equipment

- *"...we are constrained by brick walls that we can only put kit* [referring to computers, computing equipment] *into rooms where we can have them. And this causes incredibly tightened space. There are certain times in the school week when there are no rooms available to use. So our constraints at the moment on access is not to do with kit, but more with classrooms available to put the kit in. As more buildings being done it releases just a little bit more. "(StaffA1- credibility weight 22.5)*

- *"we have 60 wireless laptops.....Well it does work, it's just physically moving them because there is quite a few stairs in this school its not on the same level, so its difficult to physically to move the trolleys along the corridors where you have to go up and down stairs. (Me: this is an issue as well) Yes it needs to be addressed really before people go ahead. "(StaffC5- credibility weight 8)*

- *" we have laptops but then you have problems again, are they in the right place, they tend to live in one of the other buildings, the technology block so you have got to get them across here, use the lift to get them up to where ever you are teaching, so there are issues with that, its not that simple as it should be. "(StaffB2 - credibility weight 18.5)*

2. Factor 1: Availability and access to facilities ***affects*** Factor 4. Amount of ICT usage in School

- *"..the impression I get every time I try to book an ICT suite is it is booked up either by ICT lessons which obviously they need or by another teacher who has managed to get in there before you. So I get the impression yes it is or maybe there is a lack of them, I don't know. .... I haven't yet used ICT here with any of my classes. No, every time I have tried to book it, it has always been booked up. So I guess sometimes that makes it difficult to put into practice. ... I don't have a computer in my room and I don't have an interactive white board. Unless I've often used for example different websites where they've got some interactive lessons that you can do with your classes, I've often printed off those sheets and used them, so I guess in a sense they are originally designed to be used on a computer, practiced in a classroom. " (StaffC3- credibility weight 8)*

- *"I still think there is a significant number in this school that don't use IT very much, I'm not talking about in the lessons and classes, I think it's almost impossible for the teachers mainly because there aren't the facilities but even you know producing set lists and things like that there are a lot aren't happy about doing it. " (StaffB3- credibility weight 16.5)*

- *"... a lot of teachers were very very willing to use more ICT in their teaching but because of the lack of accessibility made it all very difficult. "(StaffA3-- credibility weight 9.5)*

- *"I think we just need the facilities to do it* [refers to ICT and educational software use] *and the incentives to do it to some extent. I mean a lot of people might think well I get on quite well without it at the moment, but it's so difficult in schools to get to use it that they don't use it. So it's got to be to* *put ICT into lots of classrooms... "(StaffB3- credibility weight 16.5)*

- *"..we still don't have access to classrooms with computers for the kids to use. We have teaching tools now one that we can use to demonstrate but we don't have computers available to take the kids for a lesson on the computers. "(StaffA5- credibility weight 12)*

- *"Sometimes its really busy, until this time of the year when we've got no year 13s and 11s and next week year 10s are off for two weeks for work experience so for that time there will be a lot more subjects getting into the ICT rooms. "(StaffC1- credibility weight 25)*

- *"with RE certainly in years 10s and 11s they have great difficulty getting into the IT rooms because they're backed up against IT, so IT and RE are going on at the same time"(StaffC1- credibility weight 25)*

- *"NO, it's a complete nightmare to be honest you can never, it is really difficult because especially with GCSE media they have 50% coursework and has all got to be done on the computer, its impossible virtually to get room. And you have to book months in advance and if you were to organise yourself properly and if your timetable didn't fit in with a free room then you've got no chance of getting it. However there are laptops in French but it is generally a headache trying to organise IT for a whole, big group its alright for sixth form groups which are smaller and you can sneak in with other groups. But with a group of year elevens you can't just say 'do you mind if we come in' because they're not going to be quiet and you're going to need the whole room"(StaffC2- credibility weight 8)*

- *"but I can honestly say that I haven't yet used ICT here with any of my classes. No, every time I have tried to book it, it has always been booked up. So I guess sometimes that makes it difficult to put into practice. "(StaffC3- credibility weight 8)*

- *"I think people do want to use IT but I think logistically with the room booking it is really difficult, it's a headache." (StaffC2- credibility weight 8)*

- *"... I have a laptop but its my own, I've occasionally done power point presentations on the screen there and borrowed the laptop from the school. If I want the whole class to do something I take them up to the ICT rooms, there are two computers in the one Art class and three in another upstairs and there is hit and miss when they are working, I could occasionally swap classrooms but you can have only two people working in there at a time, so you have to get the whole class to do something else and swap them over. So its not effective if you want to do something for the whole classroom. "(StaffC4- credibility weight 10)*

- *"No not really because we hardly use computers in school apart from ICT lessons"(StuC2- credibility weight 6)*

- *"About once every month or something, not that often...... Because there are other classes using them at the same time. (StuC4- credibility weight 4)*

- *".... if you teach maths you tend to be in a group of thirty so you got get somewhere that will accommodate a whole class. .. It [refers to computing suites] is not so much heavily booked it's the commitment to teach ICT in those rooms because ICT is a very popular subject for students to take in years 10 and 11...... You've got to find a way of getting into those rooms, we have laptops but then you have problems again, are they in the right place, they tend to live in one of the other buildings, the technology block so you have got to get them across here, use the lift to get them up to where ever you are teaching, so there are issues with that, its not that simple as it should be."(StaffB2- credibility weight 18.5)*

- *"you are limited* [refers to ICT usage] *by some disciplines you haven't computers in their rooms, that's one of the reasons for the trolley route so that we can wheel in trolleys and a non ICT classroom could become a computer room for that particular lesson."(StaffC5- credibility weight 8)*

- "*Yes,* [refers to what the additional facilities allow] *mean not just educational software par se but things like the internet and things like staff making their own PowerPoint for presentation and using even just using text worksheets and especially on things like the visualizer, so easy to just throw anything on the visualizer and some of the things you see around are great." (StaffA1- credibility weight 22.5)*

- *"I think now with access to the net and number of sites dedicated to NfL teaching and the kind of activities available there in, I think people are increasingly using that more than actual individual software packages, even though they come along with the course."(StaffA3- credibility weight 9.5)*

- *"Definitely,* [refers to the impact of additional ICT facilities on ICT use] *I think because..... it is easy to use, you walk into a classroom you've got a computer there set up already and you can have access to the internet, and the projectors have been put up..... Well we are also using stuff on the internet as well like 'Maths Net' website, what's the other one 'My maths' that's for teachers that I've started using, they've got sample lessons that you can download and use and get the department to use."(StaffA2- credibility weight 23)*

3. Factor 1: Availability and access to facilities ***affects*** Factor 11. Availability of educational software

- " [Refers to what the additional facilities allow] *As far as subject specific software is, yes, for instance the science department paid £2500 for a piece of software that is the bees knees , that's really nice, its excellent, its all they need for GCSE, and that was subject to beginning to get there. Modern languages use online system so they can download stuff from um. Technology have been using it. Art was upgraded, have got the latest version of Photo Shot and number of licences. So we are looking at each department in turn and making sure they have what they require."(StaffA1- credibility weight 22.5)*

- *"...teachers who have seen a piece of software and got a trial for it and we put it on to the network and if they think it works well then we get the licences and put it on permanently."(StaffC1- credibility weight 22.5)*

- *I think we're well a head of the game for access to the internet i.e. 100 megB um because lots of schools are still now just happy they've got 10 and we've got a 100. Um does enable things to happen......And accessing online materials... um and that works directly off the internet. I think that's the way it goes I think that schools are getting that feeling, software companies are thinking that hold on a minute I don't need to worry about delivering my stuff on CD anymore to them, I can deliver it online and make them pay yearly subscription....."(StaffA1- credibility weight 22.5)*

4. Factor 1: Availability and access to facilities ***affects*** Factor 20. ICT culture in school

- *"It is written in the schemes of work, staff are supposed to do it but there are then the issues of access to machinery and software."(StaffB2- credibility weight 18.5)*

- *"I still think there is a significant number in this school that don't use IT very much, I'm not talking about in the lessons and classes, I think its almost impossible for the teachers mainly because there aren't the facilities but even you know producing set lists and things like that there are a lot that aren't happy about doing it."(StaffB3- credibility weight 16.5)*

5. Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 3. Time to prepare lessons

- *"Absolutely, I think it* [referring to laptops] *makes it more realistic. I think prior to that there was a certain feeling that if you can get on a school computer during the day to either bring up whatever you wanted to do in the lesson the next day or practise or write a letter, and it didn't really go ahead. Now I think people have that advantage they are able to go home and in their own time see what they want to do the next day and bring it in and teach it and I think that has been very successful"(StaffA3- credibility weight 9.5)*

6. Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 4. Amount of ICT usage in School

- *"It's the teaching equipment in the classrooms that makes a difference and also actually the fact they were given a PC each to use at home or a lap top. That's almost kind of, um; even the most reluctant users are still doing bits and pieces on it and beginning to use it for worksheets and PowerPoint presentations". (StaffA1- credibility weight 22.5)*

- *"Yes, It* [refers to IT equipment] *gives the teachers the ability to show you what you could be doing at home, there is at least one computer in every classroom now, so they can go on the internet and show you websites that you can use at home if you've got access to the internet and things like that."(StuA9- credibility weight 6)*

- *"I mean considering now every classroom has now got it ,*[refers to IT equipment] *teachers are having to use the machine, at least in some of their lessons."(StaffA4- credibility weight 12)*

- *"I think its* [refers to the availability of IT equipment] *also has... had an waking up effect, but I think a lot of the staff who were reliant on very old traditional methods, I think they've become to adopt* *themselves more unusual methods involving ICT and there is a tendency to go in that direction."(StaffA3- credibility weight 9.5)*

- *"I work in a department of 13, 14 and we have allocated to us three laptops and we should be using them in a classroom with data logging equipment and all that and it doesn't happen."(StaffB3- credibility weight 16.5)*

- *"Experience of IT is it's a pain in schools, you cannot, very rarely can do a nice, simple IT lesson because either the equipment is not working properly, you haven't got enough equipment, the kids have forgotten passwords, there are lots of factors that can affect an IT lesson that you cannot get round once you have started if you like"(StaffB4- credibility weight 18.5)*

- *"Well in our department we've got a central room where we've got ten computers. .... Well each room has up to 25 pupils, so even for one class there isn't enough computers, so half of the group might be drawing while the other half are on the computers." (StaffB4- credibility weight 18.5)*

- *"...in Art we had to research on all different artists for coursework, there were computers on one side so some people go on while some people do their work... There's not enough for the whole class."(StuA7- credibility weight 6)*

- *"...in my classroom when I need to use something and none of us would have a computer because they would all be booked and it would hard to do my coursework in that lesson, if there was more computers it would be much easier. Then we would all have somewhere to go for a computer. Increasing computers would help." (StuA7- credibility weight 6)*

- *"...we did have a series of CD ROMs that the children were using on an ad hoc basis. I mean they were generally based in the library and now and again we use them in lessons. But again the problem there was that actually the number machines available across the curriculum for us to use, and that was a problem which obviously now, that problem has now been alleviated to a certain" (StaffA3- credibility weight 9.5)*

7. Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 6. Level of teachers' ICT skills

- *"The kits* [referring to computers, computing equipment]*only been in the classroom since November time, so once we get to grips with the kit. And I think most members of the staff are beginning to get to grips with kit completely, and then we can think of looking at what software we need." (StaffA1- credibility weight 22.5)*

- *"I think it's the fact that they've seen the kit in the classroom and realise that they can now do things that they would have never been able to in the past" (StaffA1- credibility weight 22.5)*

- *"It's the teaching equipment in the classrooms that makes a difference and also actually the fact they were given a PC each to use at home or a lap top. That's almost kind of, um; even the most reluctant users are still doing bits and pieces on it and beginning to use it for worksheets and*

PowerPoint presentations". (StaffA1- credibility weight 22.5)

- "[Referring to IT equipment]...*had an waking up effect, but I think a lot of the staff who were reliant on very old traditional methods, I think they've become to adopt themselves more unusual methods involving ICT and there is a tendency to go in that direction. And equally said it's a learning curve as well because we are learning an awful lot."(StaffA3- credibility weight 9.5)*

8. Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 7. Teachers' training in ICT

- *"As far as hardware training is concerned we have to make sure the kit* [refers to computing equipment] *is used properly...... " (StaffA1- credibility weight 22.5)*
- *"There is a workshop..... Everyone has to go to it, so what we are going to do is one of my colleagues is going to demonstrate it* [referring to IT equipment], *and we are going to split up into groups and the more experienced colleague that has really used it will encourage the others." (StaffA2- credibility weight 23)*
- *"...there was also the training of the graphic tablets use and all these things and people got quite bombarded by it and I think as a result certain members of staff in my department focused on one particular area and focused on that well and didn't necessarily attend other sessions on the other areas of technological advancement."(StaffA3- credibility weight 9.5)*

9. Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 11. Availability of educational software

- *".. I think what's enabled them* [refers to the obtaining of educational software by staff] *is not just the funding. I think it's the fact that they've seen the kit in the classroom and realise that they can now do things that they would have never been able to in the past..".(StaffA1- credibility weight 22.5)*
- *"..I think over the next year that's where the main emphasis will be on, now that we've got the kit in place what* [refers to educational and generic software] *are we going to use with it"(StaffA1- credibility weight 22.5)*
- *"I mean a lot of them are using it* [refers to laptops that have been allocated to staff] *very generically I mean they all came with office xp and stuff like that so I think they've been using that side of it a lot more. Some members of staff, maths department have got Maths Alive downloaded onto all their laptops so they can actually use that anywhere they like um and I know other bodies and departments are putting software on them"(StaffA1- credibility weight 22.5)*

10. Factor 2: Availability of non-outdated hardware/IT equipment ***affects*** Factor 21. Teachers' ICT usage outside of school

- *"Absolutely, I think it* [referring to laptops] *makes it more realistic. I think prior to that there was a certain feeling that if you can get on a school computer during the day to either bring up whatever*

you wanted to do in the lesson the next day or practise or write a letter, and it didn't really go ahead. Now I think people have that advantage they are able to go home and in their own time see what they want to do the next day and bring it in and teach it and I think that has been very successful"(StaffA3- credibility weight 9.5)

11. Factor 4: Amount of ICT usage in school ***affects*** Factor 7. Teachers' training in ICT

• *"...have used it* [refers to ICT] *in the classroom and have seen a lot happening by the use of software and therefore I'm going to give myself time out to get to the next section* [refers to training] *as I go a long and I think perhaps a more structured programme would have been slightly better... "(StaffA3- credibility weight 9.5)*

12. Factor 4: Amount of ICT usage in school ***affects*** Factor 11. Availability of educational software

• *"What we see here is that more and more people are using the net for educational support whereas two or three years ago we stuck to sort of CD ROMs and run software from the server. We see more and more now where people access the net and accessing applications directly from the net. "(StaffC5- credibility weight 8)*

13. Factor 5: Availability of Technical Support Staff ***affects*** Factor 1. Availability and access to ICT facilities

• *".. my role* [refers to position as technical support staff] *originally was when I started was just to support the curriculum server and make sure the machines were running..."(StaffB5- credibility weight 6)* • *"A lot of staff struggle because as you say because of the training and we range from a staff who can barely turn on a machine through to those that run training sessions. And its getting a department up to scratch and its having the flexibility within a curriculum and not just to run a training session for staff but also to be available to go and team teach, to have a technician available perhaps if there are any issues with hardware or software"(StaffB2- credibility weight 18.5)* • *"What we* [referring to technical support staff] *do is look after the school network, install software where applicable. I mean half of the different disciplines in the school we're responsible for making sure that the computers work alright, printers work ok, all the hardware works ok. We're responsible for installing new printers and new hardware, responsible for keeping network up to date wherever possible........"They should be aware that they do need to spend money to get trained professional people to make things run smoothly." "(StaffC5- credibility weight 8)*

14. Factor 5: Availability of Technical Support Staff ***affects*** Factor 2. Availability of IT equipment

• *"its been more of a hardware issue and getting the hardware up to date and cause were running a NT network and it will be obsolete very soon, so I've kind of stressed that we need to upgrade .... I just ask can we do this and kind of stress the importance if they don't the school can be in a difficult position later on ......when I got here I realised that there are a lot of things that need changing and*

they are unaware of what is needed but I've got my point across.....my role now is to support the admin side as well as the curriculum. Any ideas they have I'm in on the discussions now. They are hoping to buy laptops for Science so for the last two months I've researched several laptops by different manufacturers.... I've put in a recommendation to what is suitable for the school." (StaffB5- credibility weight 6)

15. Factor 6. Level of Teachers' ICT skills ***affects*** Factor 11. Availability of educational software

- *".. so once we get to grips with the kit. And I think most members of the staff are beginning to get to grips with kit completely, and then we can think of looking at what software we need."(StaffA1- credibility weight 22.5)*

16. Factor 6. Level of Teachers' ICT skills ***affects*** Factor 20. ICT culture in school

- *"...my particular head of department's IT skills are not particularly advanced in the sense that she could particularly lead in the department sessions on ICT and adoption of software to advance our lessons or teaching."(StaffA3- credibility weight 9.5)*

17. Factor 7. Teachers' training in ICT ***affects*** Factor 4. Amount of ICT usage in School

- *"I think really the teachers need to be trained how to use ICT properly, we have obviously ICT teachers who teach the kids but I think a lot of the staff, maybe some of the older staff as well who are not using ICT is for various reasons, one of which maybe because they're unsure of how to use it and I think they need training in basic ICT so they can then pass that on to the kids."(StaffC5- credibility weight 8)*

- *"Definitely, that's where* [refers to training] *we were introduced to different software and websites, and just how you can make maximum effectiveness of the use of the internet, how you manage pupils in the classroom with computers cause it's a whole different thing, which can be quite off putting some times especially when you've got a bottom set class with behavioural problems you think the last thing you want to do is to take them into an environment like that, how do you restrict certain websites, or use a certain package."(StaffC3- credibility weight 8)*

- *"We've had training on how to use the maths software several days. It's been really good...... Oh, yes definitely, well you couldn't access it until you had the training its quite technical."(StaffA5- credibility weight 12)*

- *"Art teachers who don't have that training would probably shy away from using it* [referring to software and ICT] *I would assume, it's a complicated program to get into once you are into its very straight forward."(StaffC4- credibility weight 10)*

- *"..they* [refers to teachers] *are now using their self training* [refers to ICT related training] *and bringing that into schools into their lessons."(StaffA3- credibility weight 9.5)*

18. Factor 7. Teachers' training in ICT ***affects*** Factor 6. Level of teachers' ICT skills

- *"I actually feel the training was useless at this school at least because the training was meant to get us to use IT in the classroom, it wasn't training us for the skills needed to use IT. What I mean by that is it wasn't to teach us how to use the word processing package it was how are you going to use the word processing package in the classroom. Well if you couldn't use the word processing packages to start of with, how are you going to integrate it into a classroom environment? And we were kept being told it's not to teach you how to use Excel it is how you use Excel in the classroom. Well you know you've got to start from the beginning and they didn't so that was flawed to start of with." (StaffB3- credibility weight 16.5)*

- *"...there was also the training of the graphic tablets use and all these things and people got quite bombarded by it and I think as a result certain members of staff in my department focused on one particular area and focused on that well and didn't necessarily attend other sessions on the other areas of technological advancement."(StaffA3- credibility weight 9.5)*

19. Factor 11. Availability of educational software ***affects*** Factor 6. Level of teachers' ICT skills

"..yes software was available, again more limited for German than for French, there was an awful lot more for French than for German. So the French teacher was able to develop a sense of ICT a lot faster, I believe than the German teacher."(StaffA3- credibility weight 9.5)

20. Factor 11. Availability of educational software ***affects*** Factor 7. Teachers' training in ICT

- *"Yes it's a part of our package; it includes training, and any subsequent updates"(StaffA5- credibility weight 12)*

- *"For instance I'm going to buy a piece of software for year 7 and what I'm going to suggest is that we all have whole day training on it which will have to be funded by the school but I'm not going to buy it unless that's part of the package."(StaffB1- credibility weight 18)*

21. Factor 20. ICT culture in school ***affects*** Factor 1. Availability and access to IT facilities

- *"I think the trouble has been that in the past schools have not been very commercially minded..... they haven't really invested enough resources into the infrastructure for ICT. That's what we are finding now that the network that we inherited was pretty ropey to say the least , it needed a lot of work doing the past two years to bring it up to a certain standard and never mind the computers stuck to the end of this network if the network itself is at a pretty ropey state. .....I think certainly now that this school has started to take IT seriously as an important part of the infrastructure to this school just as the central heating is."(StaffC5- credibility weight 8)*

- *"I think up until recently this school didn't take ICT very seriously and we had a poor network with poor quality hardware. We used to buy second user machines, this is before I came, which have proved to be nothing but problems really"(StaffC5- credibility weight 8)*

22. Factor 20. ICT culture in school ***affects*** Factor 2. Availability of non-outdated hardware/IT equipment

- *"I think up until recently this school didn't take ICT very seriously and we had a poor network with poor quality hardware. We used to buy second user machines, this is before I came, which have proved to be nothing but problems really"(StaffC5- credibility weight 8)*

- *"I think there is encouragement. I mean there is the delivering of laptops so teachers are getting those, we were encouraged to put in a bid there were two interactive white boards left, and most departments did, we were encouraged to do that. We are encouraged to try and integrate ICT I guess because that is something that we highlighted in our last departmental meeting."(StaffC3- credibility weight 8)*

23. Factor 20. ICT culture in school ***affects*** Factor 4. Amount of ICT usage in School

- *"At this school, um, I don't think, I think its quite traditional the Arts here, and always has been. They've had quite a good success with Art here and its sort of very classroom based practical based paint, clay, sculpture work and things like that. And the actual curriculum there isn't much saying that you should use ICT, there isn't much in the curriculum or anything, I think it is slow to catch up with"(StaffC4- credibility weight 10)*

- *"Our IT teachers encourage us to go on the internet a bit more to find out how to use it and the available sites and hyper-links that you can get. In maths they encourage us to go on these maths revision games that are available on the school websites"(StuB3- credibility weight 6)*

- *"There's a lot of very important chat that goes on in the staff room, around the school about what people are using* [refers to ICT] *and I'm sure that within departments. Modern Languages is a case in point Ian Whitworth has found this website for £25 for access whatever and he paid it out of his own pocket, its so good that now they all use it, its word of mouth and now its going along."(StaffA1- credibility weight 22.5)*

- *"Having seen the department in work you can see the ones that do actually believe in the power of ICT and they are ones using it as much."(StaffA2- credibility weight 23)*

24. Factor 20. ICT culture in school ***affects*** Factor 5. Availability of Technical Support Staff

- *"Its back to the political within the school, the deputy head in charge of that, many years ago decided we would never need a technician and she was also in charge of finance so she made sure we never had a technician."(StaffB2- credibility weight 18.5)*

25. Factor 20. ICT culture in school ***affects*** Factor 7. Teachers' training in ICT

- *"It* [refers to training in using ICT and software] *was all about introducing it into the classroom, well great, but at that time in this school there were about a least 60% of staff that weren't using* *computers on a regular basis anyway, so they weren't happy about using the software, whereas the school I went to soon after that training started up we were actually give modules to do online and specific tasks and by doing those specific tasks you actually learnt a little bit about how the software works and how to introduce it to the class."(StaffB3- credibility weight 16.5)*

- *"... another NQT was talking about how she felt that how she had gone from a lot of ICT training and then she's gone to the kind of not having that kind of support in ICT. Just basic teaching as how to use the computer for your own personal use, just even the basics, the recaps I think that's quite important.... No there isn't a system put in place, I guess if you have an interest you can request a skills workshop or something like that, but there is nothing that is kind of integrated in this school that I am aware of, it would be interesting to ask and see if they do, I'm sure there must be something, I would like to think so"(StaffC3- credibility weight 8)*

26. Factor 21. Teachers' ICT usage outside of school ***affects*** Factor 6. Level of Teachers' ICT skills

- *"..that I think a lot of teachers themselves develop professionally themselves, obviously a majority of households now have a computer at home, and I think they have gone away developed themselves professionally with their ICT skills using packages they well may have bought themselves. And they are now using their self training and bringing that into schools into their lessons."(StaffA3- credibility weight 9.5)*

- *"It happens with most things, there is very little specific training and you are left up to your own devises of learning by yourself in your own time."(StaffB4- credibility weight 18.5)*

27. Factor 23. Teachers' usage of educational software ***affects*** Factor 11. Availability of educational software

- *"We are now buying another piece of software which I've used before because we are going to do what's called GNVQ ICT with year 10s and that's quite good." (StaffC1- credibility weight 25)*

- *"..the ultimate problem is the shortage of educational software in schools. I think the more you have them, the more you are exposed to them the more you are going to put into practice and the more you are going to want to find educational software which is appropriate for your lessons." (StaffC3- credibility weight 8)*

Appendix H: M-files and functions in Matlab® related to the FCM simulation process

H.1 M-files and Functions

The following include details of the M-Files created and functions used in Matlab® to conduct the mathematical operations entailed in the simulation of the FCM model described in section 7.4.1.

1. The matrix form of the FCM model was imported from the Word document as a E.dat file via Import Wizard and Clipboard and constituted the first m-file. Named FCM matrix and known as variable E can be seen below in an extract from the Matlab® workspace screen.

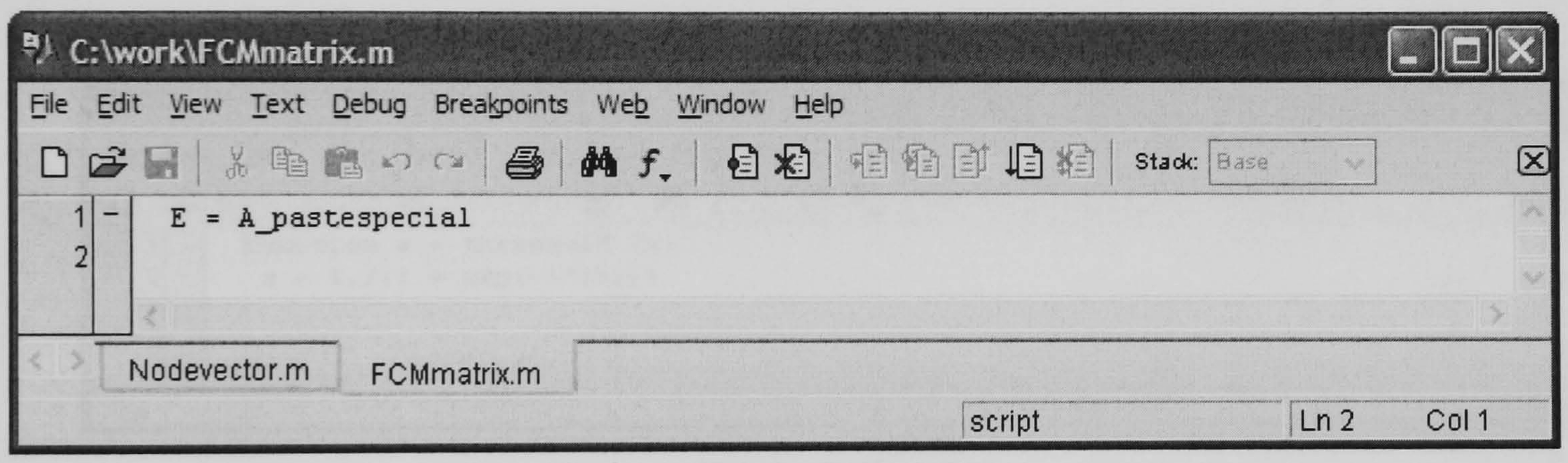


Figure 1: Box 1

2. The state vector A0 representing the activity levels of all 24 nodes/factors in the FCM model at time t =0, constituted another m-file, as can be seen below in an extract from the Matlab® workspace screen. Although the activity level of the first node is seen as 1 this was always changed according to the scenario being simulated.

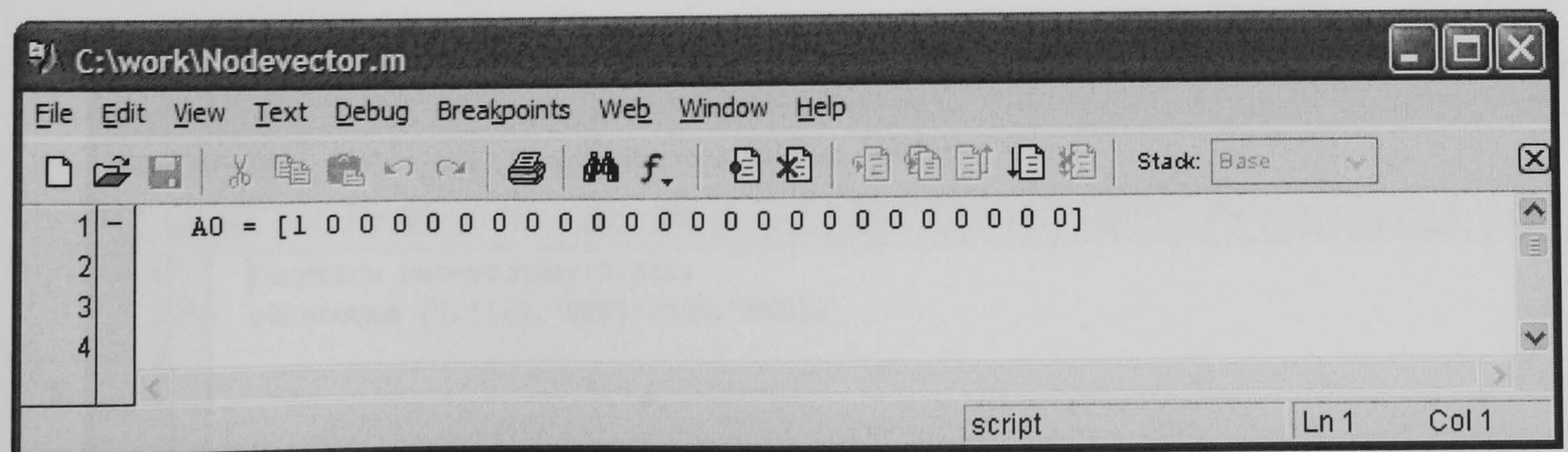


Figure 2: Box 2

3. The An(i , j) = ‘number’ Matlab® function was used to clamp down on node activation levels. Where An represents the state vector at time t = n, i represents the number of the row, and j represents the number of the column of the row vector An. Therefore by identifying the exact node to be clamped down on by its position in the row vector, the value of the node could then be set by inserting the appropriate value. For example if the first node seen in the box above needs to clamped to value 0, then A0(1, 1) = 0. In addition by inserting a ‘:’ for example An(i , j:k) would allow all of the nodes in row i, in the columns from j to k to be clamped to one specific value (as will be demonstrated in the example later).

4. The Matlab® function that was used to multiply the state vector by the FCM matrix was ‘*’ e.g. (A0*E).

5. The threshold function i.e. the logistic function that was applied, constituted another m-file as can be seen below:

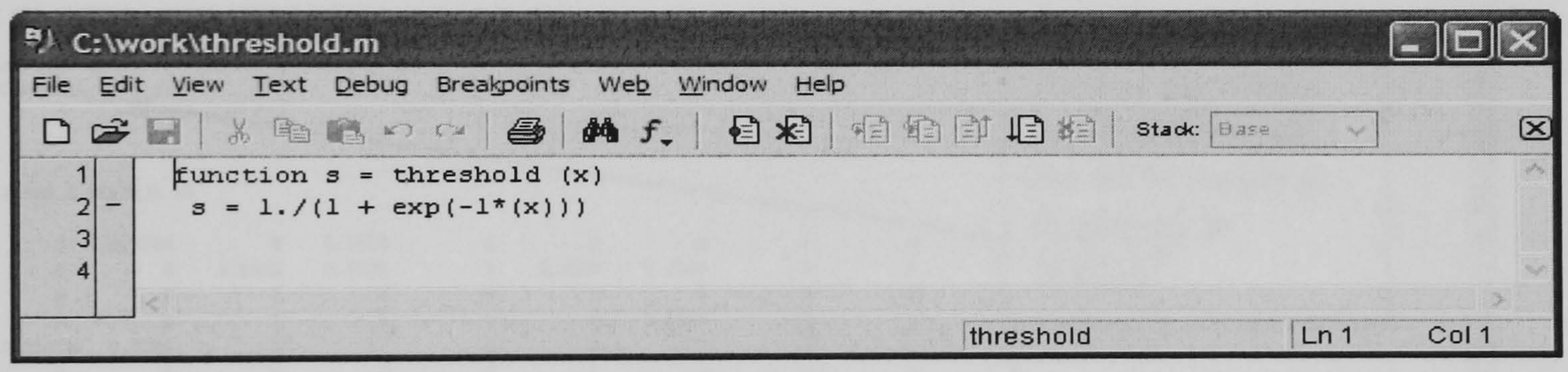


Figure 3: Box 3

6. Another m-file was created which could round the decimal points of the activation levels of the nodes/factors in the state vector. This would mean that when the state vectors would be compared to check if equilibrium had been reached, each node value would be compared for example to the 6th decimal place instead of to 10th decimal place.

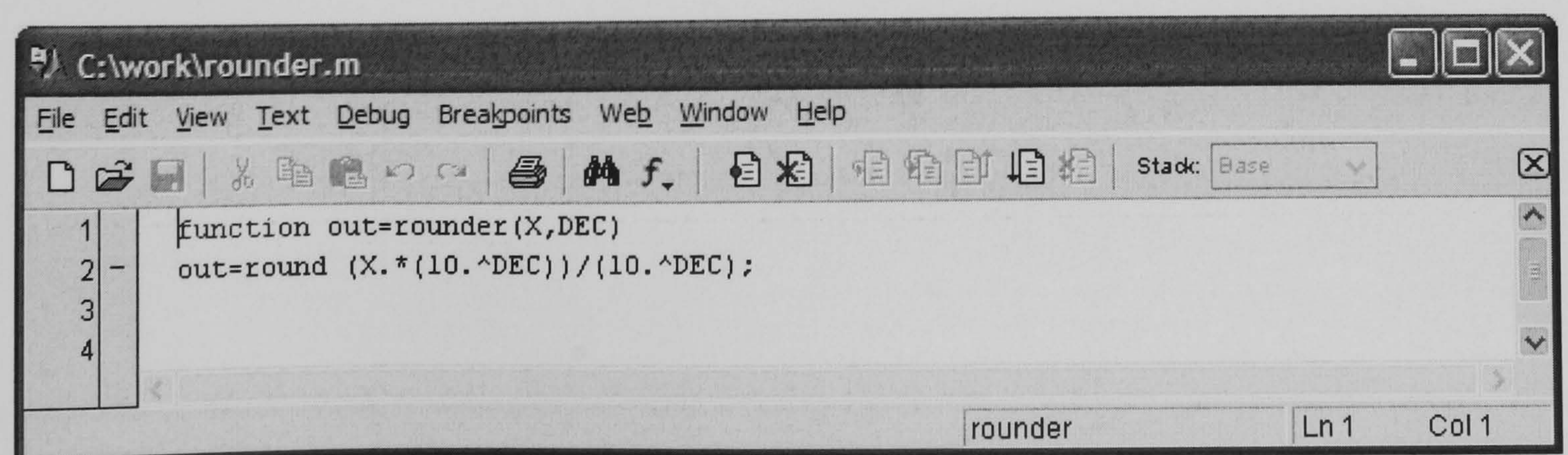
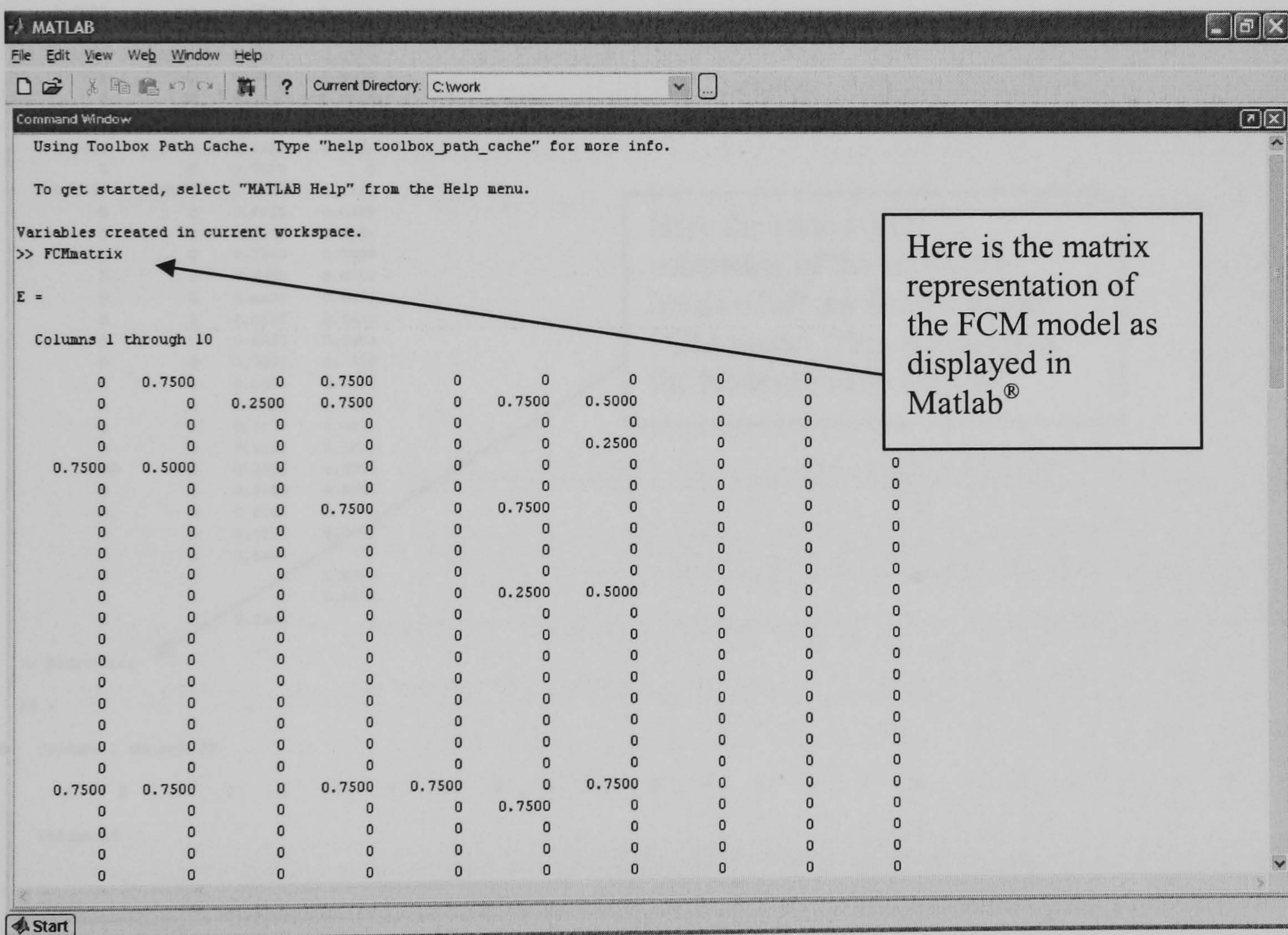


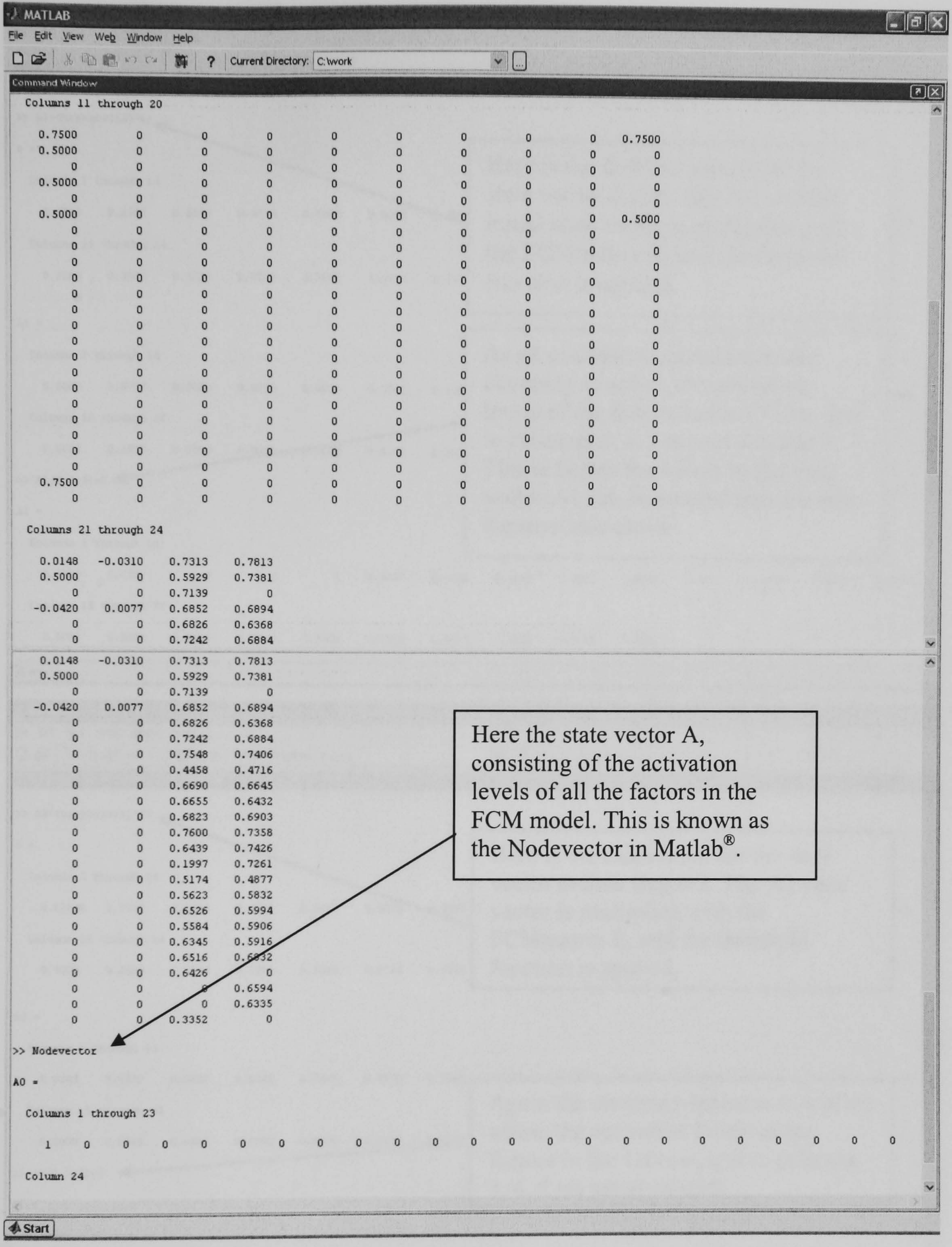
Figure 4: Box 4

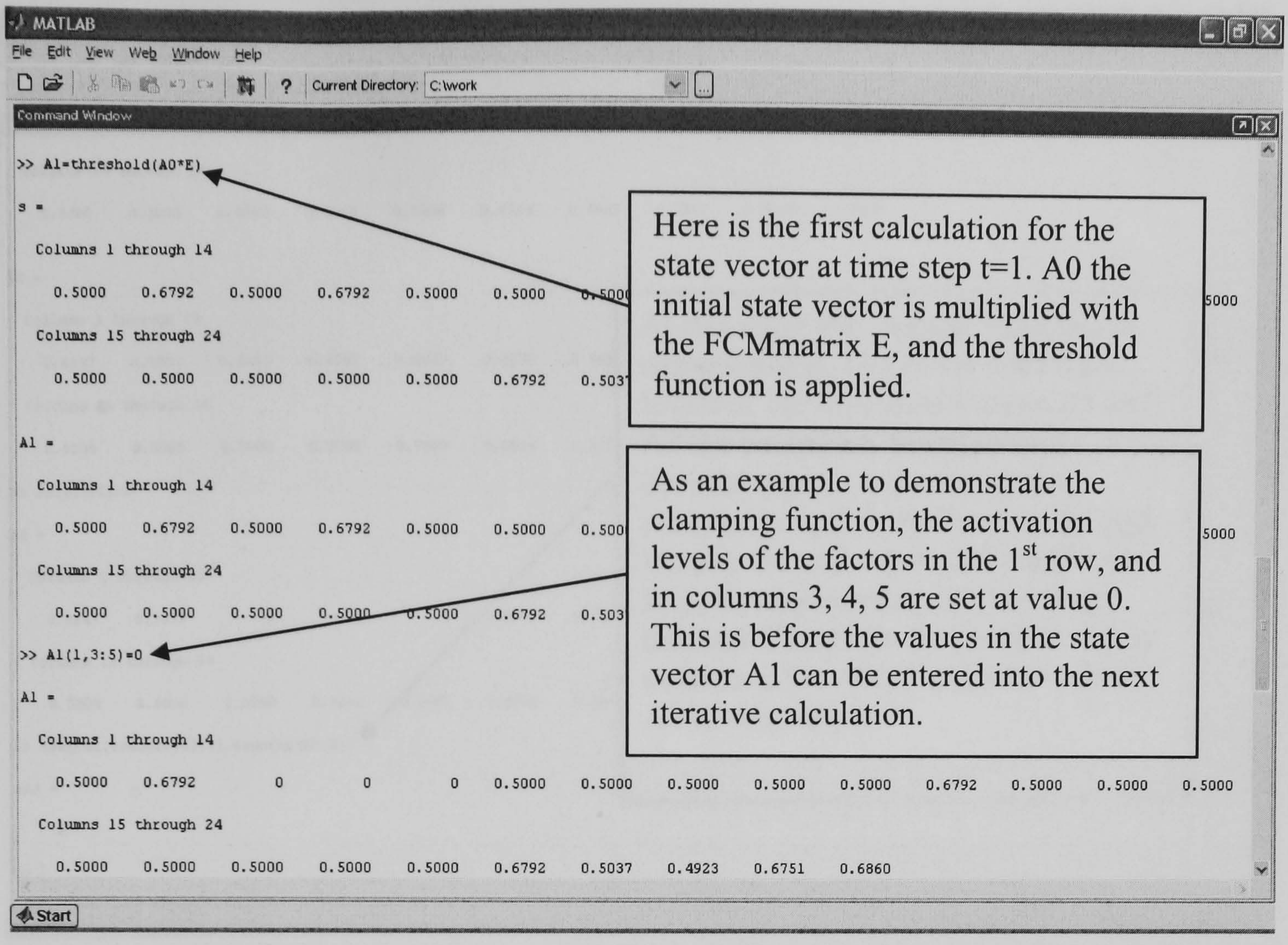
7. Finally the 'isequal' Matlab® function was used to check for the equality between two variables i.e. in this case the equality between two consecutive state vectors. Where if isequal (A1, A2) returned a scalar logical value of 0 this represented false i.e. where A1 and A2 are not the same. If it returned a scalar logical value of 1 this represented truth i.e. where A1 and A2 are the same.

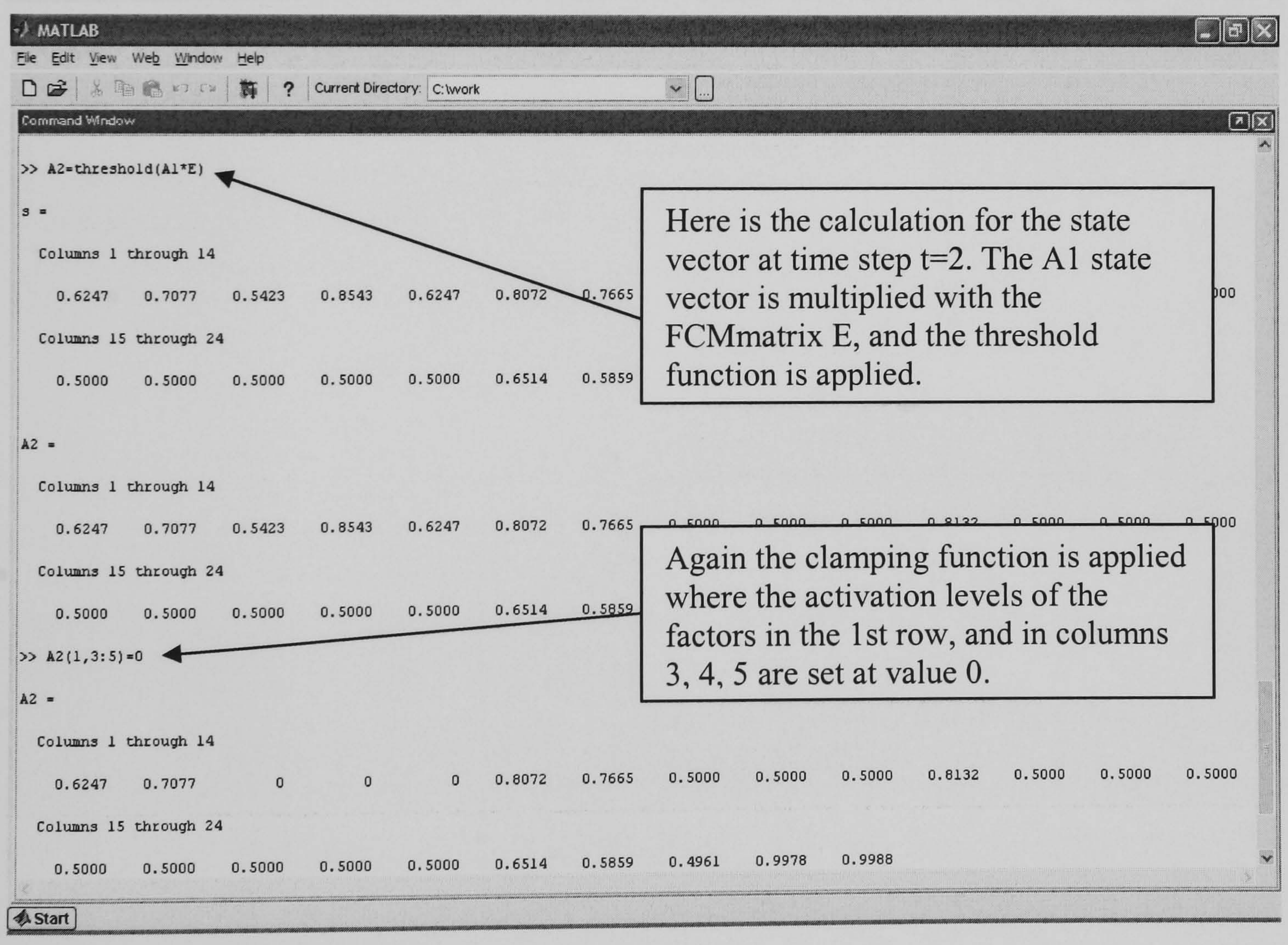
H.2 Example demonstrating Matlab® M-files and Functions used in FCM simulation

The following provides extracts of the Matlab® work space screen providing a brief and basic example using all the above m-files and functions as would have been used in running the simulation process described within this thesis, refer to section 7.4.1.




MATLAB
File Edit View Web Window Help
Current Directory: C:\work
Command Window
Columns 11 through 20
0.7500 0 0 0 0 0 0 0 0 0.7500
0.5000 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0.5000 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0.5000 0 0 0 0 0 0 0 0 0.5000
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0.7500 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
Columns 21 through 24
0.0148 -0.0310 0.7313 0.7813
0.5000 0 0.5929 0.7381
0 0 0.7139 0
-0.0420 0.0077 0.6852 0.6894
0 0 0.6826 0.6368
0 0 0.7242 0.6884
0.0148 -0.0310 0.7313 0.7813
0.5000 0 0.5929 0.7381
0 0 0.7139 0
-0.0420 0.0077 0.6852 0.6894
0 0 0.6826 0.6368
0 0 0.7242 0.6884
0 0 0.7548 0.7406
0 0 0.4458 0.4716
0 0 0.6690 0.6645
0 0 0.6655 0.6432
0 0 0.6823 0.6903
0 0 0.7600 0.7358
0 0 0.6439 0.7426
0 0 0.1997 0.7261
0 0 0.5174 0.4877
0 0 0.5623 0.5832
0 0 0.6526 0.5994
0 0 0.5584 0.5906
0 0 0.6345 0.5916
0 0 0.6516 0.6832
0 0 0.6426 0
0 0 0 0.6594
0 0 0 0.6335
0 0 0.3352 0
>> Nodevector
A0 =
Columns 1 through 23
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Column 24
Start
Here the state vector A, consisting of the activation levels of all the factors in the FCM model. This is known as the Nodevector in Matlab®.


MATLAB
File Edit View Web Window Help
Current Directory: C:\work
Command Window
>> A1=threshold(A0*E)
s =
Columns 1 through 14
0.5000 0.6792 0.5000 0.6792 0.5000 0.5000
Columns 15 through 24
0.5000 0.5000 0.5000 0.5000 0.5000 0.6792
A1 =
Columns 1 through 14
0.5000 0.6792 0.5000 0.6792 0.5000 0.5000
Columns 15 through 24
0.5000 0.5000 0.5000 0.5000 0.5000 0.6792
>> A1(1,3:5)=0
A1 =
Columns 1 through 14
0.5000 0.6792 0 0 0 0.5000 0.5000 0.5000 0.5000 0.5000 0.6792 0.5000 0.5000 0.5000
Columns 15 through 24
0.5000 0.5000 0.5000 0.5000 0.5000 0.6792 0.5037 0.4923 0.6751 0.6860
Start
Here is the first calculation for the state vector at time step t=1. A0 the initial state vector is multiplied with the FCMmatrix E, and the threshold function is applied.
As an example to demonstrate the clamping function, the activation levels of the factors in the 1st row, and in columns 3, 4, 5 are set at value 0. This is before the values in the state vector A1 can be entered into the next iterative calculation.


MATLAB
File Edit View Web Window Help
Current Directory: C:\work
Command Window
>> A2=threshold(A1*E)
s =
Columns 1 through 14
0.6247 0.7077 0.5423 0.8543 0.6247 0.8072 0.7665
Columns 15 through 24
0.5000 0.5000 0.5000 0.5000 0.5000 0.6514 0.5859
A2 =
Columns 1 through 14
0.6247 0.7077 0.5423 0.8543 0.6247 0.8072 0.7665
Columns 15 through 24
0.5000 0.5000 0.5000 0.5000 0.5000 0.6514 0.5859
>> A2(1,3:5)=0
A2 =
Columns 1 through 14
0.6247 0.7077 0 0 0 0.8072 0.7665 0.5000 0.5000 0.5000 0.8132 0.5000 0.5000 0.5000
Columns 15 through 24
0.5000 0.5000 0.5000 0.5000 0.5000 0.6514 0.5859 0.4961 0.9978 0.9988
Start
Here is the calculation for the state vector at time step t=2. The A1 state vector is multiplied with the FCMmatrix E, and the threshold function is applied.
Again the clamping function is applied where the activation levels of the factors in the 1st row, and in columns 3, 4, 5 are set at value 0.

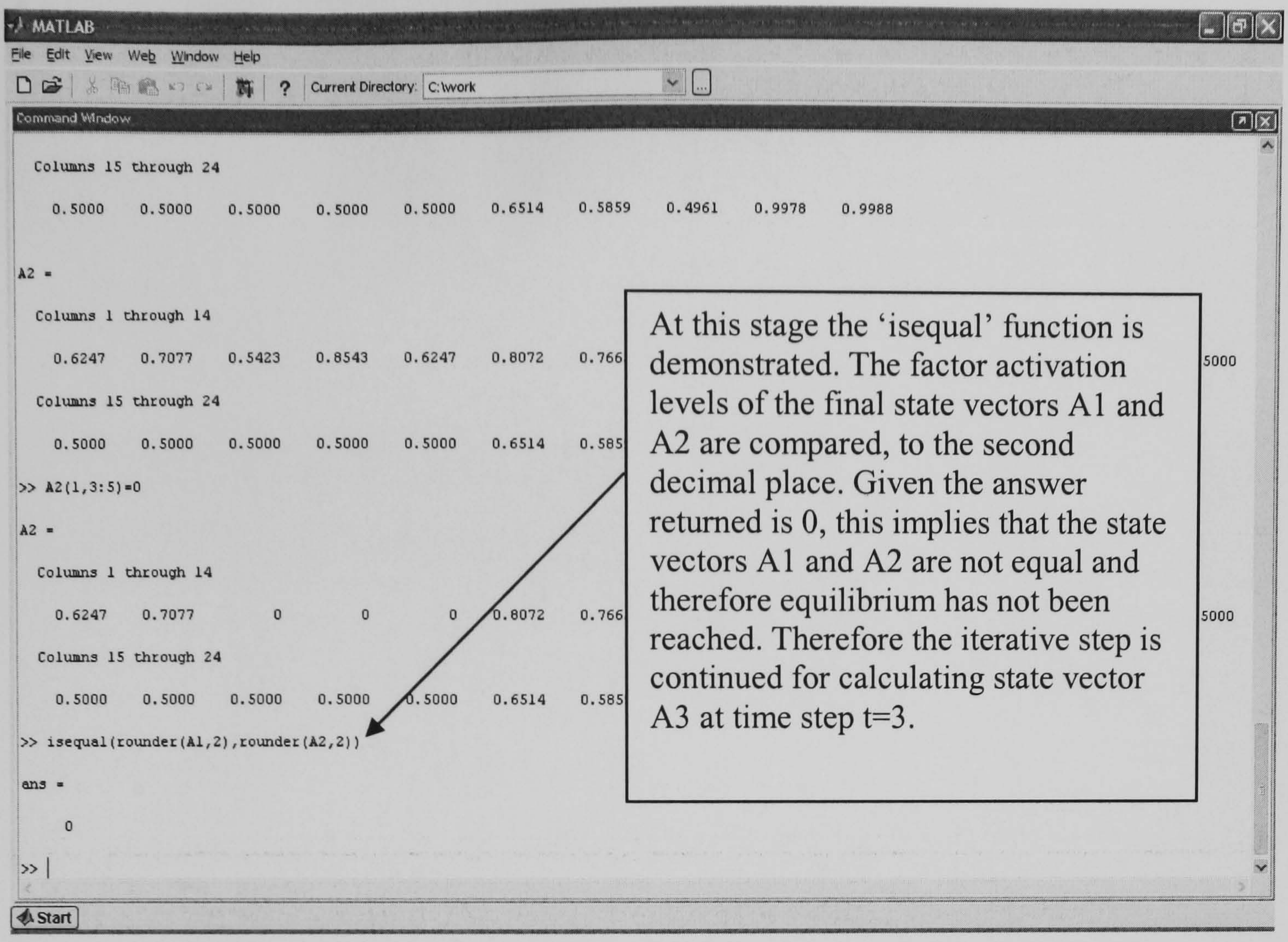


Figure 5: Basic example demonstrating the m-files and functions used in FCM simulation