USER INVOLVEMENT WITH MICROCOMPUTER SOFTWARE

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by

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ABSTRACT

The literature on the use of computers in education draws attention to the powerful motivation found in students to use certain types of software. This thesis argues that the level of involvement of the user is the factor underlying this variation in software. Two aspects of involvement are considered, how it is related to software attributes and how predisposition towards becoming involved with computers is related to individual attributes.

Using published descriptions of software and following the principles of facet theory it was found possible to classify software in terms of two facets, level of involvement of the user with the software and mode in which the information was presented. The way in which involvement of the user with the software, ie. the degree of variation in the extent to which the user participated in, or interacted with, the software was explored further.

Software used in forty-two local schools was classified into seven types according to its potential for user involvement. These types formed a scale that was found to agree with the teachers' and children's opinions of the software.

Three software attributes that determine the depth of involvement of an individual with the computer were identified. These were:-

i) the amount of user control allowed by the program,

ii) the size of the challenge to the user from the program and

iii) the level of complexity of the program.
These were systematically varied in an experiment, with 300 primary school children, to see how user involvement affects learning from a computer game. It was found that being in control of the program affected learning from it and that children became involved with programs where challenge, or complexity or, better still, both were also present.

This theory of involvement determined by the three factors, control, challenge and complexity, was then compared with other theories of involvement with software in a study with 72 university students. The alternative explanations of involvement were:-

i) reinforcement from within the software,
ii) reinforcement extrinsic to the software and
iii) ego-involvement.

The six possible determinants of involvement were found not to be independent but to combine to form a facet of involvement in an overall structure of software. A second facet in the structure, orthogonal to the first, is the situation in which the software is used.

This structure forms a composite model of involvement where the cognitive variables of challenge, control and complexity are dominant followed in importance by ego-involvement, reinforcement and, lastly, extrinsic reinforcement. Properties of the individual found to correlate with involvement were gender, locus of control and self-esteem. Males, people with an internal locus of control and high self-esteem were more likely to become involved with computers.

Finally, the contributions of this research are discussed with reference to the design of software, to theories of motivation and to educational practice.
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"Thou shalt not do as the dean pleases,
Thou shalt not write thy doctor's thesis
On education,
... Thou shalt not sit
With statisticians nor commit
   A social science."

- W.H. Auden (1907-1973)

Under Which Lyre
1.1) The Area of the Research

The field of computing, especially the use of microcomputers in education, was chosen as the area of research for the thesis. There has been much comment on but little research into the extremely high motivation to use computers often found in individuals. This is especially true in the case of computer games. This high motivation results in the user becoming deeply involved in the computing activity often to the exclusion of other activities. Thus the use of computers appeared to be the ideal area in which to investigate the concept of involvement.

The idea of using the microcomputer as an environment for research was supported by Lepper's (1985) theory that the microcomputer would make an ideal laboratory for the study of intrinsic motivation. Intrinsic motivation is motivation to become involved with an activity that is specifically generated by or through the activity itself and not from any external sources. Lepper proposed that the microcomputer provides a propitious setting where experimental research on variables relevant to each of the traditional approaches to the study of intrinsic motivation could be carried out. The variables could be easily manipulated in computer programs written by the experimenter and their effects on the program user studied. This idea was followed up in the experiments described in Chapters Seven and Eight of this thesis.

The research reported in this thesis was intended to be restricted to the area of computers in education. However, it was found necessary to include computer games since what previous research there is has been concentrated on motivation to play computer games and because of the widespread prevalence of computer
games, even in the classroom. It was noted that the rapt absorption of children in playing computer games was commented upon many times in the literature on educational computing, together with discussion of the potential improvements in learning if such attention were to be transferred to educational computer programs. Thus the intention of the research was to explore the properties of software that engendered such involvement so that they might be incorporated in educational programs.

During the investigation of the properties of computer software that generate involvement of the user, it was noted that there were trends in individual differences in involvement with computers. Attributes of the individual that made them more or less susceptible to the involving aspects of the programs were also explored.

1.2) The Aims of the Research

The research reported in this thesis aims to answer a number of questions, three of which were put forward by Jones (1980) on the subject of computer games, resulting from a survey of the uses of computers in British primary schools.

What is it about these games that makes them so popular?
What is it that is so fascinating about these games?
How can the games' attributes be put to good use as educational tools?

Malone (1980), an American cognitive psychologist who carried out the first theoretically based research into computer games, attempts to answer two similar questions in his doctoral thesis:

Why are computer games so captivating?

and
How can the features that make computer games captivating be used to make learning, especially learning with computers, interesting and enjoyable?

Malone's theories inspired the further investigation of these questions that is reported here, however, as he himself notes, he has only touched on the possibilities of intrinsically motivating environments in instruction.

In setting out to answer these questions this thesis has the following specific aims. To clarify the much commented upon subject of high motivation to use computers by relating it to an underlying, overall concept, that of involvement. To find out how involvement itself is related to the different types of software used in schools, homes and video arcades. To assess the effects of becoming involved with educational software on learning from it. To determine the properties of the software that engender this involvement and, lastly, to determine the attributes of the individual that influence this interaction with the computer.

Another aim is to fulfil the clear need for research into the motivating effects of information technology observed by Sage and Smith (1983) in their assessment of research requirements in the area of microcomputers in education for the Social Sciences Research Council. They note that the results of such research would influence the design and organisation of learning environments and educational material based on information technology. However, it is intended that the results of the research reported in this thesis will not be restricted to the field of computing where it took place but will be applicable to the design of all instructional environments.
1.3) Overview of the thesis

The main body of the thesis begins in Chapter Two with a brief introduction to the ways in which play and games, focussing on simulation games, and computers have been used in education. In Section 2.1 the advantages of the use of educational games and how they enable the student to be active in learning are discussed. This is followed by a review of the uses made of computers in education in Sections 2.2 and 2.3, and an account of how their use has been received in Section 2.4. The concept of active learning reasserts itself in the much recommended uses of computers for instructional games, simulations and tools where the computer provides an environment in which learning may occur. However, computers are mostly used in schools with drill and practice software, based on traditional learning methods, repeatedly drilling the students in arithmetical and spelling rules or in the acquisition of facts. This use of computers may be deplored by educationalists (Self, 1985) but is prevalent at the time of this research since the software is cheaply and easily produced.

Whenever computers are mentioned, the way in which they can motivate and involve their users is noted. In fact arcade computer games are so popular that a number of people including a current member of parliament (Foulkes, 1987) are concerned about young people becoming addicted to them. In Section 2.5 the theories that have been put forward to explain the high motivation induced by computer games are reviewed. Perhaps not surprisingly these fall into two main groups, based on cognitive or behaviourist explanations related to active or traditional learning. However, there is little actual experimental work published on intrinsic
motivation to use educational computer games except for that of Thomas Malone. His work is discussed in Section 2.6 together with two other studies it inspired.

In order to obtain an established theoretical background on which to base the investigation of the high motivation to use computers discussed in Chapter Two, the psychological literature was searched for references to involvement and motivation. The two concepts of involvement and motivation are inextricably related in that once motivated to take part in an activity the individual becomes involved with the activity. High motivation, intrinsic to the activity, results in deep involvement. In Chapter Three previous research and theories put forward on intrinsic motivation to become involved in an activity, which would be applicable to using a computer, are reviewed. The research on involvement, described in Section 3.1, originates in the 1940s with the development of the concept of ego-involvement however, Csikszentmihalyi (1975) provides the most illuminative description of involvement. He considers involvement to be a state of flow representing complete engagement of the individual with an activity so that there is no distinction between self and environment. By examining the previous treatments of involvement a definition of involvement was developed for use in this thesis. However, much of the applicable research has centred on theories of intrinsic motivation.

The theories of intrinsic motivation, reviewed in Section 3.2, are based on three cognitive concepts, desire to control, responding to challenge from and curiosity about the complexity of the environment. However, such motivation may also be explained
using the behaviourist theory of reinforcement as described in Section 3.4. The applications of these two approaches to involvement with computers are discussed in Sections 3.3 and 3.5 respectively and the different approaches will be compared in the study reported in Chapter Eight.

Lastly, since involvement is the result of an interaction between an individual and an activity, it may be related to individual variables such as personality differences or demographic variations. The literature discussing individual attributes such as age, gender, self-esteem and internal-external locus of control, which are hypothesised to be related to a person's reaction to and consequent involvement with computers, is reviewed in Section 3.5.

The first studies in this thesis consist of surveys of local schools in order to find out what hardware and software was available to children in schools, how it was used and how the users reacted to it. Chapter Four presents the results of two surveys, the first was of the use of microcomputers and associated software in over forty local first and middle schools. The teachers' and children's opinions of the software were also recorded. The second survey was of over 1700 teenagers in three local secondary schools on their attitudes towards and use of computers at school and at home.

Nearly all primary schools were found to have at least one microcomputer, a BBC Model B, bought with the aid of the government's subsidy but only two-thirds had disk drives or other peripherals. Differences in teachers' and children's opinions of the different types of software used could be related to their potential for user involvement. Though all the secondary schools had computers
over half the children had not used them, their main use appeared be
in computing courses rather than being generally available as in
primary schools.

In Chapter Five the potential of different types of educational
software to create different levels of user involvement was
explored further, using descriptions of programs published in a
software magazine. A preliminary model of user involvement with
software was developed using the principles of facet theory with its
associated multivariate statistical analyses. Software was found to
vary along two facets: the level of user involvement it generated
and the mode in which the information was presented.

This model combines the following theories from the literature
on computing in education; categories of motivation to use
educational games, styles of interaction with a computer and
conditions of learning in the overall facet of user involvement. Its
presence was confirmed in a further experiment with eight subjects
employing a sorting task to assess whether the categories taken from
the literature had been reliably assigned to the programs. As a
result of this research a scale of the seven different software
types found was developed according to their potential for user
involvement. User involvement with software was predicted to
increase from poor quality programs through drill and practice
programs and problem solving programs to creative software tools and
finally, computer games.

In Chapter Six this scale of educational software types
according to their potential to generate user involvement was tested
with the results of the survey of software used in local primary
schools that is described in Chapter Four. The scale was found to
agree with the children's opinions of the software and the teachers' specific comments on the programs. Differences in involvement according to type of software used were further investigated in Section 6.2 when software used at home was included with educational programs used at school in a questionnaire survey of over three hundred children's attitudes towards the software. The different types of arcade computer games played at home did not differ significantly in their potential for user involvement so their category on the scale was not extended. However, educational adventure games were found to be even more involving than the arcade games so a separate category was added to the top end of the scale to include them.

Having established the existence of different levels of user involvement with different types of microcomputer software, the following two chapters look more closely at its causes. As discussed in Chapter Three, three cognitive factors were proposed to actively involve the individual in a task. These were being in control of the task, curiosity about the complexity of the task and responding to the challenge of the task. Chapter Seven describes a study, using a specifically developed piece of software, to investigate these factors and to assess their effects on involvement with and consequent learning from an educational computer game.

The program developed for the experiment from an earlier prototype was a simulation designed to teach children what to do in the case of a domestic fire. Different versions of the game were produced each providing or lacking one of the determinants of involvement discussed in Chapter Three. The versions provided control by giving the user a choice of routes through the
simulation, complexity in the form of colour graphics to engender curiosity and challenge in the form of a high score table. One hundred and fifty pairs of primary school children were used in the experiment, each pair playing two different versions of the program and comparing them.

The children enjoyed using the simulation very much but did not show much diversity in their choice of routes through it. They appeared to follow two main plans, either to get everything right or to see what happened if they did something wrong. The results, automatically recorded by the computer during the experiment and analysed using multidimensional techniques, showed that being in control of the program was most important in creating involvement with it. Introducing challenge and complexity separately did not increase involvement by any significant amount, however, the children became more deeply involved when the program contained both complexity and challenge. Increased involvement was found to result in increased learning from the simulation.

All three factors were found to increase involvement with control being the most important in affecting learning since, if the users were not in control of the program, they could not become at all involved with it. This supports the concept of active learning where the student is in control of the learning process. However, an alternative explanation to the three cognitive explanations of involvement, based on control, challenge and complexity of the software used to create involvement in the above experiment, was proposed in Chapter Three. This was taken from the viewpoint of traditional learning theories based on connectionist explanations as opposed to that of active learning theories based on cognitive
explanations, and proposed that intermittent reinforcements from the software create involvement in the user. Also earlier theories of involvement, discussed in Chapter Three, made much of the role of the ego in the creation of involvement. These three theoretical frameworks were compared in the questionnaire study described in Chapter Eight.

Seventy-two students completed a questionnaire on how much they agreed or disagreed with 36 statements. Each statement presented an explanation for becoming involved with a computer in one of the following situations; word processing, programming, using financial or data analysis software, or educational software or playing arcade or adventure games. Equal numbers of reasons were derived from each of the six theories hypothesised to explain involvement mentioned earlier. That is to say involvement with a computer occurs through control or complexity of the software, or through challenge or reinforcement from the software, or through ego-involvement in the software or through reinforcement extrinsic to the software. The research design was based on the principles of facet theory and the hypothesis to be tested was that the cognitive explanations with the individual actively engaging with the software would be held to be responsible for involvement.

However, the results showed that the cognitive theories of involvement did not differ significantly from the others and that all the explanations could be combined to form a composite model of involvement with two facets. The first facet was involvement itself, made up of six ordered elements each relating to one of the different theories, and the second was the type of computer use where involvement occurred. This model is used to present a new
theory of involvement which encompasses the previous theories and incorporates them in a single metatheory.

The results also showed that, of the elements in the involvement facet, challenge was held to be most important in creating involvement, followed by control and complexity, then ego-involvement and finally, intrinsic then extrinsic reinforcement. Thus a multi-stage model of involvement is proposed where involvement occurs in stages. Shallow involvement occurs through instrumental reinforcement, when affective behaviour is included in the form of ego-involvement, involvement deepens and is deepest when the cognitive factors of challenge, control and complexity are engaged.

The second facet in the model, the situation in which the computer was used, is orthogonal to the first and does not contain a simple order. Thus the combination of the determinants of involvement forming the first facet was found to occur in the same way in each of the suggested situations where a computer may be used. The sequence in which the situations occurred, through educational programs, adventure games, arcade games, word processing, programming and business software, represents the subjects' view of the different types of software. The software appears to be seen to differ according to the level of control offered to the user.

Thus, the multi-stage process of involvement is independent of the type of software used and therefore, the different levels of involvement with different types of software, found in the studies described in Chapters Five and Six, must represent the stage of involvement reached by the majority of users of that type of
software. For instance, if the software does not allow control, as in most drill and practice programs based on traditional learning theories, active involvement in learning cannot occur and in order to maintain the user's interest at all, reinforcements must be used.

The final study on involvement described in Chapter Nine also used a questionnaire, it was designed to investigate the individual differences, described in Chapter Three, that were hypothesised to affect an individual's involvement with computers. The questionnaire, containing instruments to measure attitudes towards and involvement with computers, and the individual variables of age, gender, internal locus of control and self-esteem was again completed by students.

Analysis of the responses showed that people with a strong sense of being in control of their actions, i.e. had a highly internal locus of control, those who had high self-esteem and males were found to have more positive attitudes towards computers and made more use of them. The relationship between gender and computer use was further investigated using data collected from the surveys made earlier and was found to appear once children reached the age of ten or eleven. It remains to be seen whether girls introduced to computers well before this age will keep up their interest in computers and not associate them with science and other "boys' subjects".

The result that locus of control is associated with an individual's potential for becoming involved with computers is not surprising given the discovery, in the earlier studies, of the importance of being in control in creating involvement. However, it is relevant to the active versus traditional learning debate for
control is important in active learning from simulations, games and programming. It is suggested that people with an external locus of control would be happier in a traditional learning situation such as using drill and practice programs. The relationship found between self-esteem and involvement has less significance, it can be easily explained in that those with higher self-esteem are more confident of their ability, even in a novel area such as computing, and so are more likely to try out a computer than those with low self-esteem.

Finally, the conclusions that can be drawn from the studies reported in this thesis are summarised in Chapter Ten in consideration of whether the aims put forward in Section 1.2 have been fulfilled. The contributions of the research: the importance of involving the user with software, especially educational software, the identification of the causes of involvement and their relationship to each other, and the determination of reasons for individual differences in level of involvement with computers are discussed.

Amongst the potential contributions of this research to the psychology of motivation and learning, discussed in Section 10.3, are the metatheory of involvement combining approaches from different areas of psychology previously considered to be separate, and the advantages of using microcomputers as a research tool. As noted in Section 10.4, the results of this research may also aid the design and development of effective educational software by pointing out the importance of including challenge, opportunities for control and degrees of complexity to ensure involvement of the learner. Also resulting from this research are many points, discussed in Section 10.5, that may aid teachers in the use of microcomputers in schools.
Finally, the future implications of this research are discussed in Section 10.6 with reference to concepts taken from the field of artificial intelligence.

1.4) Conclusion

During the completion of this thesis the instructions quoted at the head of this chapter, taken from Auden's Hermetic decalogue which was inspired by the behaviour of the returning G.I.s who filled American colleges after the second world war, have all been ignored. However, it is hoped that, despite this lack of respect, the research reported in the following chapters will enlighten current understanding of the role and causes of involvement in the fields of motivation and learning.

A major problem with the carrying out and writing up of this research was the transient nature of the main subject, microcomputer software. When the research described in this thesis was started the BBC Micro had just been introduced, during the three years of research the company producing it has folded, been rescued, finally been taken over and now produces more sophisticated models incompatible with its earlier versions. With the rapid rate of change in the hardware there has not been time for psychological and educational research on the software to feed back to its developers. The developers themselves are busy rewriting their earlier programs so that they will run on the new machines or producing quick, cheap, easy to write programs for the new machines in order to make sales. For instance by the time the investigation, described in Chapter Five, of the modes in which software presents information was completed, it was rare to find programs that kept to a single mode. Since individual items of software changed format so rapidly, the
studies reported in this thesis concentrated first, as described in Chapter Six, on identifying recurrent, stable types of software which could be used for further investigation of involvement.

In addition, as a result of the novelty of using microcomputers as a research field, what literature there is on the use of microcomputers in education and on motivation to use microcomputers has been written hastily in attempts to provide practical advice. Also there has not been time for the authors to test the theories they proposed. Finally, although the usual conventions for presenting research have been followed in this thesis, it should be noted that much of the relevant literature was actually published during the course of the research.
CHAPTER TWO

BACKGROUND TO THE USE OF GAMES AND MICROCOMPUTERS IN EDUCATION

"Do not . . . . instruct the boys in these studies by force, but in play,"

- Plato (c. 429-347 B.C.)

Republic, Book VII
2.1) Play, Games and Active versus Traditional Methods of Learning

Throughout history philosophers and teachers have advocated that play and games should form an integral part of children's education. Even though Plato is regarded as one of the instigators of the traditional approach to education, in which learners are required to acquire a body of knowledge through coercion by a teacher (Bowen and Hobson, 1974), he asserted that nothing learned compulsorily would stay in the mind. Rousseau (1762) also stated that in the ideal world the pupil should be free to learn. However, the traditional approach remained to the fore until the early twentieth century when the progressive model of education was developed through the influence of the early ideas of men like Rousseau and, more recently, those of Dewey. Dewey (1928) asserted that skills and information are acquired while activities are carried out for their own sake without the threat of punishment. In the progressive model the learner's needs and interests are regarded as paramount in what is taught, and activity methods and learning by discovery replace formal instruction (Bowen and Hobson, 1974). Even more recently, eminent educational psychologists such as Piaget (1962) and Bruner (1966) were to emphasise the importance of play as a learning activity.

In his book on education, Eble (1966) considers that education not only begins in children's play but continues in play throughout our lives. Fines and Verrier (1974) propose that children learn through play, for in play children test their perceptions of reality, checking them for accuracy and whether they fit with one another in a moving, working model. Thus play is now viewed as an essential element in the social and intellectual development of
children. This recent reconsideration of learning through play has led to the now popular use of simulation and other educational games in learning. The rapid rise in the use of simulation games was noted by Zuckerman and Horn (1973) in their guide to available simulations and games for use in education and training. They observed that in the two years between 1970 and 1972 there was a 50% increase in the number of educational games and simulations that were readily available. This increased use of simulation games may be attributed to the coincidence of three trends (Seidner, 1978). These are the questioning of the traditional socialisation function of educational institutions, the current emphasis on the active learner and discovery learning and the appearance of the simulation game as a new medium.

A useful description of simulation games is given by Taylor and Walford (1978) in their book on the topic. A simulation game customarily consists of a group of players placed in a prescribed setting, interacting through competition or co-operation and following rules or methods of procedure. The skill being learned or the information being acquired is gained through active participation in the game. The games themselves may be developed to simulate any topic that it is desired to teach but lend themselves more readily to topics where the learners may easily take up roles and interact with each other in hypothetical situations.

The many advantages of the use of simulation games in education had already been noted in an earlier book by Tansey and Unwin (1969). For example, simulation games motivate the participants, they use techniques of co-operation as opposed to competition, they inject a feeling of realism and relevance into the classroom, they
enable complex problems to be made simpler and so more easily understood, they change social conditions under which learning takes place since the teacher becomes less directly concerned with discipline and judging, they follow a structured or programmed presentation of information and finally, decision making without censure is possible. They also note that, in a simulation game, participation builds a high degree of motivation and gives a purpose to learning. Because of this the learning of facts and skills is facilitated even though it becomes a secondary function and not the primary one as in traditional teaching methods.

Seidner (1978), in her comprehensive discussion of the use and effectiveness of simulation games, considers that the student engaged in a simulation game is an active learner who, through his or her experiences with the simulated environment, may discover certain concepts or principles embedded in the simulation model. She also notes the high degree of motivation shown by most students engaged in a simulation game which suggests the presence of intrinsically motivating goals within the game. In fact, Livingston et al (1973), stated that the most consistent finding of research with simulation games in the classroom is that students, from elementary school to high school, prefer simulation games and nonsimulation games to other classroom activities.

Seidner brings together the two concepts of active learning and strong motivation to learn in the field of simulation games. Active or discovery learning was first developed as part of the progressive educational ideas of innovative teachers such as Montessori (1920) and A. S. Neill (1962). The importance of its role in education is supported by the work of developmental psychologists such as Piaget.
(1952) and Bruner (1966). The learner is no longer regarded as a passive receptacle to be filled with knowledge but to be an active agent in the discovery of knowledge. One of the most important characteristics of active learning is the emergence of motivation intrinsic to the task being learnt and not the result of persuasion by or threats from the teacher. High motivation to become involved in the learning task is one of the most consistently reported features of active learning.

However, occurring even more recently than the introduction of the simulation game, is the development of a new educational tool, ideally suited for the presentation of simulation and other educational games, that is to say, the microcomputer. With the rapid introduction of microcomputers into our society, a large amount of educational software was quickly published. Despite the now large body of evidence in favour of active learning and the potential of the microcomputer for providing a suitable learning environment, this software concentrated on traditional learning techniques such as the use of rewards. These owe more to connectionist theories of learning such as Thorndike's laws (1911) and Skinner's reinforcement theory (1938) than to the cognitive theories appropriate to active learning put forward by Bruner and Piaget. This has resulted in the predominant use in education of drill and practice programs with rewards in the form of points or entertaining graphics for correct answers. This in turn brought about much criticism of the software used in schools (Self, 1985). The main critique, amongst a diatribe of complaints about the quality of software produced, is the use of a new educational tool for repetitive, mundane tasks that do not begin to explore its potential for education. However, during the
course of the research reported in this thesis, in schools where there are teachers interested enough in computing to report their work to educational journals, the emphasis has changed to the use of active learning software such as educational adventure games, simulations and simple programming languages eg. LOGO.

The intention of this thesis is to investigate the use of computers for active and traditional learning in schools, to explore the differences in how the learner becomes involved with the software and whether this is related to learning from it. The possible uses of microcomputers in education are described in greater detail in the following sections.

2.2) The Introduction of Microcomputers into Education

Computers first appeared in educational establishments towards the end of the 1950s and by the 1970s most universities in England and America had a mainframe. These occupied large, air-conditioned rooms on site and were accessed using paper tapes or punched cards that were processed in batches. With the rapid advances in computer technologies soon these could be accessed in real time from display terminals situated all over the campus. As their components decreased in size, computers of considerable power could be made that were only the size of filing cabinets and departments began purchasing their own minicomputers. Some secondary schools even acquired a minicomputer or time on the local college or university computer. Towards the end of the 1970s continued miniaturisation resulted in the appearance of the microcomputer and cheap, portable computers became available to all. There was a massive increase in the production of software, mainly games, as many people bought one of the new, cheap home computers. In the wake of this 'microcomputer
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revolution' the British government, keen to advance the study of technology in schools, subsidised the purchase by schools of two British made microcomputers. By mid 1985 when the survey reported in Chapter Four was carried out practically every primary school and all secondary schools had at least one microcomputer for use by students.

Microcomputers can be used in a number of ways in schools according to the software acquired. The most common uses, described in the following section, are tutorials, simulations, instructional games and drills (Alessi, 1985). Most of the software produced for use in education is in the form of drills testing the student's memory or ability to apply simple rules.

The use of microcomputers in education has rapidly acquired several acronyms, for example computer aided learning (CAL), computer based training (CBT) and computer managed learning (CML). The educational software investigated in this thesis consists of examples of computer aided learning, known as CAL. The computer is used to present information to be learnt and other learning tasks, it may even test whether the required information has been learnt but it plays no part in selecting the topics to be taught or other administrative tasks.

2.3) Use of Microcomputers in Education

The following are the main ways in which microcomputers are used with educational software.

2.3.1) Tutorials

In a tutorial information is presented to the student, the use of the information is demonstrated and finally whether the student has learned how the information is used is tested. Feedback on the
student's ability is provided and if he or she has proved successful they move on to acquire more information. Early computer aided learning (CAL) mainly consisted of tutorials which were based on techniques from programmed learning as advocated by Skinner (1968). Tutorials can be built around any topic that can be presented in the restricted text format of a video display terminal. However, the introduction of graphics has made it easier to display information. The high level of expertise needed, in the theories of education, in the subject being taught and in writing the software means that the development of good tutorials is very expensive. They are mainly used for training by the armed forces and in teaching undergraduates in science subjects, such as chemistry and engineering, where computers are already used.

2.3.2) Drills

Microcomputers are often used for drilling students in previously learned information. The student's ability to apply a rule or a combination of rules is tested by presenting a large number of questions using the rule but operating on different variables chosen using the computer's random number generator. The student's performance can be recorded by the computer for the teacher to look at later. Many different problems can be generated easily by repeating the same question with different variables randomly selected from a list and so the software is simple to write. Therefore, these programs are cheap, many have been produced and they are now widely available.

These 'drill and practice' programs can be enlivened by using entertaining graphics as a reward for doing well or by encouraging competition between students or the student and the computer by
giving points for correct answers. Sometimes the user is rewarded by being allowed to play a version of a popular arcade game. This use of reward is based on early learning theories of Skinner (1938) associating learning of a task with positive reinforcement. These were later developed into the more complex programmed learning theories used in tutorial programs.

2.3.3) Simulations

A microcomputer simulation is used to teach a process by imitating or replicating it. There are many advantages to the use of simulation software as a learning tool in schools (Chandler, 1984). In the case of experimental sciences like physics, chemistry and biology these are reduced costs, less time used and increased safety. Experiments are often expensive to run and the use of an interactive simulation provides some experience, more than, say, watching a demonstration. Experiments can take too long for learning by discovery to be practical and they can also be dangerous. In all subjects another advantage of using simulations is their manageability, models that are too complex to build can be explored by using a computer. The software can also provide graphical representations of the changing data making it easier to understand the processes involved and it is easy to re-run the simulation with varying factors and conditions.

Chandler also notes that by giving the user control of the simulation they become more involved in the processes being studied. Unlike tutorial and drill and practice software which are based on traditional learning theories, computer simulations involve the user in discovering the processes being simulated and so are examples of active learning. However, like tutorials, simulation
software is expensive to develop since a high level of expertise is required both in the process being simulated and in writing the software.

2.3.4) Instructional Games

The extreme popularity of video games together with favourable reports on the use of simulation games in education has led to the development of instructional games for the computer. An instructional game, as with a simulation, provides an environment that facilitates active learning and the acquisition of skills by the student.

There are a number of types of games that may be used in education. These are simulation games where the user learns about a process, such as how a nuclear power station operates, by playing a role in the simulation, say a control room worker in this example. Problem solving games where the user has to develop a logical strategy to succeed, such as learning to use compass directions and co-ordinates to find buried treasure on an island. Adventure games which combine both role playing and problem solving in a fantasy situation, such as using the correct combination of foods to tempt all the dragons out of the cave in order to rescue the princess. Finally, there are video games which are not usually regarded as instructional but may encourage the development of cognitive learning strategies such as discovering the patterns of aggression in the alien spaceships so as to choose the optimum moment to refuel the starfighter. Also, according to Chandler's (1984) discussion of the educational issues of the use of microcomputer in schools, teachers have justified the use of arcade games in the classroom for the development of confidence in using the computer keyboard, better
hand-eye co-ordination and a less passive attitude to the video medium. Even science fiction authors have noted the potential educational benefits of video games (Asimov, 1982).

In common with other examples of active or discovery learning, one of the most noticeable features of instructional computer games is the strong motivation induced in the user to play or continue playing them. Banet (1978), a director of an American educational research foundation, notes the discovery, made during work with preschool and elementary school children, that using computer games can powerfully motivate the learning both of basic skills and sophisticated concepts. Motivation to use computer games is discussed further in Section 2.5.

2.3.5) Tools

Microcomputers are also used in schools in the same way as they are in offices, as labour saving tools. Simple versions of word processing and data analysis software have been developed for use in schools. These enable the users to produce neat, easily amended written work and to collate and analyse facts for projects and other work. Also in subjects like chemistry and mathematics, computers can be used to perform repetitious calculations freeing the learner to concentrate on studying the underlying principles.

Children have also been successfully introduced to programming computers in a variety of languages. From his experience in teaching children to program in the high level language, LOGO, Papert (1980) states that this can promote understanding of mathematical concepts and the development of logical thinking strategies. For example, by writing programs to draw geometric patterns on the computer screen, the student is active in the
learning of concepts such as logical sequencing and the relationships between angles and shapes.

2.4) Reactions to the Use of Microcomputers in Education

Microcomputers have been received into the classrooms with mixed feelings. Numerous advantages have been put forward for the use of information technology, that is to say, microcomputers and their peripherals, in education. These have been grouped into the following three main categories by Omrani (1984). That computers enhance the learning process by inviting active participation of the learner, that they provide a richer learning environment through varied sensory and conceptual modes thus increasing motivation and encouraging participation, and that they can individualise learning allowing students to work at their own pace. As noted earlier computers may also save money by presenting otherwise costly simulations or experiments and save time and effort by performing repetitive calculations.

However, these advantages all relate to the use of computers in active learning situations and the most common use of computers in schools is in traditional learning situations such as 'drill and practice'. This was noted as early as 1974 by Ellis (1974) in his remarkably perceptive book intended to provide information for educators on the potential uses of computers in education. He states that automating educational practices that are ready made for automation accounts for most of the uses of computers in schools, and he considers this to be misusing the technology by using it to imitate the teacher. More recently Papert (1980) noted that teachers are using the new technology with old instructional methods and thus
failing to observe the potential of the computer as a tool that could revolutionise teaching.

Despite these observations computers are still mostly used in traditional learning situations. This is confirmed by a recent survey of primary schools (Jackson, Fletcher and Messer, 1986) which found that 57% of schools with computers used drill and practice software with infant teachers being significantly (p<.01) more likely to use it than junior teachers. In a discussion of the uses of computers in schools, Licklider (1984) states that the basic philosophy underlying most applications of computers to education has been wrong. The main thrust has been to use computers to push facts into students however, the approach that works best is to use the computer to create a stimulating learning environment. This is supported by Kelly (1984), who, when investigating the uses of microcomputers in the curriculum, notes that there is an need for children to be actively engaged and involved in the experiences offered. The microcomputer can provide opportunities for active cognitive involvement but not if it is merely used for drill and practice.

However, Fogrow (1983), though he advocates the use of computer simulations and games in teaching basic skills, higher order cognitive skills and technology specific skills, considers that drill and practice may also be appropriate for teaching the basic skills. This is based on Gagne's (1982) theory of the importance of automating certain specific, basic pieces of information as a prerequisite for engaging in higher modes of thought. Despite this, the opinion of the majority of modern educational theorists is very negative towards drill and practice software. This was graphically
DAMAGED TEXT IN ORIGINAL
stated by Chandler (1984) who called the use of drill and practice programs crude behaviourism in a seductive new guise.

Chandler also criticises the use of simulation games on computers since children concentrate on the game like aspects and may develop a strategy for successfully winning the game without gaining any deeper understanding of the events being simulated. Self (1985) in his critical review of available educational software also considers that though children may be highly motivated to play computer games they have no learning objectives and so do not learn from the experience. However, these criticisms may be refuted if the use of the instructional games is supported by an experienced teacher or adequate documentation to explain the concepts being learnt.

Self also notes that there is a world of difference between say, directly experiencing an archeological expedition and using a computer simulation of one, and that it is simplistic in the extreme to assume that the pupil learns the same sort of thing from both activities. This is supported by Olson and Bruner (1974) who distinguish between learning through media such as computers and learning from direct experience. These have differing potential roles in the intellectual development and acculturation of children and Olson and Bruner note that there has been a certain blindness to the effects of the medium of instruction as opposed to its content. However, this should be reconsidered in the light of Papert's (1980) theory that using computers is a direct and active experience for children.

Finally, there is the danger, noted by Hawkridge (1983), that the use of new information technology will increase educational
elitism. Parents with money will be able to buy their children computers to use at home and the gap in abilities between these children and less fortunate children will widen. Also schools are often reliant on parental contributions to help with the purchase of new technology so schools in poorer areas will be less able to keep up with those in richer areas.

2.5) Focus on Motivation to Use Microcomputers

The huge attraction of computers was first noted when they were used to run arcade or video games. Mothers complained that their children spent all their lunch money on arcade games, people wrote letters to national newspapers about the apparent addiction of teenagers to arcade games, even doctors wrote to the Journal of the American Medical Association about the psychiatric complication they termed Space Invaders obsession (Ross et al, 1982). In 1982 it was estimated that nearly ten billion dollars were spent on arcade games and a Gallup poll showed that 93% of American young people played arcade games at least sometimes (Dominick, 1984). However, the popular idea that game players were mainly young adolescents was refuted by a survey of arcades (Katz, 1982) which found that about half of the players were over 26 years old. Playing computer games was even found to be the most popular use of computers in the classroom, according to Jones' (1980) early survey of the few British primary schools that had obtained computers. It has, however, been noticed that high motivation to use computers has not been confined to video games. For instance, Hisoft claimed in their advertisement for the programming language "C" that it is more addictive than any arcade game.
Theorists from a wide variety of disciplines ranging through psychiatry, psychology, education, journalism and design have put forward many explanations for this high motivation to use video games. The more realistic of these are discussed below, however, it should be noted that none of the hypotheses have been rigorously tested but are more or less successful attempts to explain observations made by the proposer.

Perry, Truxal and Wallich (1982), in an interesting article written for an in-house magazine for electrical and electronic engineers, interviewed video game designers and asked what they thought attracted people to video games. Bushnell, who, with others, set up Atari and designed the first successful video game, Pong, expressed the basic idea that video games should be easy to learn and hard to master. That is to say novices should get some gratification for their money and experts should walk away knowing that next time they will do better. Meninsky, a video game designer for Atari stated that "What makes a game addictive is that your own stupidity got you and you could do better next time.". Both of these designers highlight the importance of the level of complexity of the game in attracting the player and maintaining their interest. According to Hector, president of Videa, good video games provide continuing satisfaction with a learning schedule, a series of discoveries and strategies that evolve as one plays. This is an interesting view emphasising that players learn from video games and are motivated by this. Rotberg, a designer for Videa, pointed out that video games can give you the rare sense of beating a computer, before 1979 video games where two players challenged each other were popular but since then they have died out. Kaplan, another of the
founders of video games now vice-president of Atari, said "We philosophically want to max life but we can't. You can max a computer game; you can get a perfect score.". These last two views put forward the rather alarming idea that playing video games can replace other social activities where the player is less successful. Turkle (1984) provides evidence to support this view from her interviews with keen computer games players and programmers known as "hackers".

Turkle goes on to explain that hackers gain a sense of mastery from being in control of the computer that they do not feel in real life where they are at risk of being put down or humiliated by other people. Hon (1981) had earlier noted the importance of being in control of a video game in an article on how Space Invaders, a typical example of an arcade game, engages the player's interest. He considers that the appeal of such computer games is based in the concept of interactivity and, above all, in the offering of control to the user. Greenfield (1984) elaborates on the appeal of interactivity explaining the attraction of video games in terms of the tremendous amount of visual action combined with the active participatory role of the player. During her research on children's attitudes towards different media Greenfield asked some of the children whether they preferred video games or television and why. Though she had only four subjects they were unanimous in that they preferred video games because they were able to actively control them.

However, in their book on the psychology of video games Loftus and Loftus (1983) present an entirely different approach to the explanation of high motivational appeal of such games. They address
motivation to play video games using explanations based on the concept of partial reinforcement taken from the behaviourist theories of learning originally put forward by Skinner (1938). When playing a video game the player is continually performing actions that lead to positive reinforcements such as high scores and free games. However, the player is only reinforced intermittently at irregular intervals and keeps responding in the absence of reinforcement in the hope that another reward is just around the corner. The compelling, irresistible aspect of video games occurs because the game automatically adjusts the schedule of reinforcement according to the player's ability by making reinforcements more difficult to obtain as the player becomes more expert. Though this theory may explain their observations Loftus and Loftus appear to have added considerably to Skinnerian reinforcement theory by introducing the concept of hope.

Banet (1979) combines the explanations for motivation to use video games discussed here when, from informal observation of children's use of computers, he defines four features that make for a successful computer game. These are; that audio and visual effects are used to reward successes and present the game situation, highlighting the use of reinforcement, that the game can increase in its ability to challenge the player, involving the concepts of complexity and interactivity, that the game incorporates fantasy elements and that the computer can time player's responses and calculate scores.

The approach taken up by Loftus and Loftus differs from those put forward by Hon, Greenfield, Turkle and the games designers interviewed by Perry et al in that the player does not have to be
cognitively active in interacting with the computer but is being passively reinforced for interacting with the computer. Thus, as in the discussion in the earlier sections of this chapter on the uses of computers in active and traditional learning situations, there are two perspectives from which to investigate motivation to use microcomputers. Having presented these two approaches and discussed previous research into the underlying theories in Chapter Three, it is intended, in this thesis, to investigate and explain any differences in involvement of the user with software generated using design principles taken from both these perspectives.

2.6) Experimental Studies on Motivation to use Microcomputers

The many suggestions and hypotheses discussed in the previous section as to the causes or explanations of motivation to use computer games have not been experimentally tested by their exponents. However, Malone (1980, 1981a and b) carried out by far the most comprehensive experimental work on motivation to use computer games for a Ph.D. thesis.

From a survey of computer game preferences of American elementary schoolchildren and experiments using the children to assess different versions of a sensorimotor game and a cognitive skill game, altered to demonstrate different motivational properties, he proposed a theory of instructional game design to promote motivation based on the following three categories challenge, fantasy and curiosity.

Challenge - The concept of challenge is taken from White's (1959) theory of intrinsic motivation resulting from the individual's desire to develop competence and feelings of efficacy when dealing with the environment. A computer game provides a strong
challenge to the user in the form of a variety of goals. The goal is personally meaningful, the game has an uncertain outcome due to multiple level goals and a variable level of difficulty.

Fantasy - The role of fantasy is developed from Piaget's (1962) explanation that it is an attempt to "assimilate" experiences without having to "accomodate" to demands of external reality. Computer games often involve fantasies with which the users can become emotionally involved. These can be intrinsic where the skill being learnt is part of the fantasy or extrinsic where the fantasy is not related to the skill.

Curiosity - This is based on Berlyne's (1960, 1965) work on curiosity, arousal and exploratory behaviour which can be summarised in that environments produce curiosity by providing an optimal level of informational complexity. The computer can provide sensory curiosity in the form of captivating audio and visual effects and cognitive curiosity. The latter is produced by giving incomplete information or showing the user how much they know about a subject so motivating them to find out more.

Attributes of computer games considered by Malone to be related to challenge such as the program has an overall goal, it keeps a score and speed of the player's answer counts were found to be significantly correlated (p<.05) with the subjects' (65 children) preferences for the games. Attributes considered to be related to sensory curiosity such as audio effects and randomness in the game were also found to be significantly correlated with the subjects' preferences. The correlation between the third measure of sensory curiosity, visual effects, and game preference was 0.34 which did not reach significance and no attempts were made to measure or test
the importance of cognitive curiosity. The correlation between fantasy and preference was found to be only 0.06 indicating that it was not important to the players. However, in a closer examination of preferences for different versions of an instructional game called Darts, designed to teach fractions on a number line, fantasy was shown to be important to the players but the overall effects did not show as the boys liked the fantasy whereas the girls disliked it.

As Malone says, his three category theory of intrinsic motivation to play computer games compares nicely with the following simplification of Piaget's (1952) theory. "People are driven by a will to mastery (challenge) to seek optimally informative environments (curiosity) which they assimilate, in part, using schemes from other contexts (fantasy)."

However, Malone's ideas, though well grounded in theory, are perhaps over facile and are not conclusively proved by the experimental evidence he provides. The evidence does confirm the importance of both challenge, in the form of a varied number of goals that the computer game player must try to achieve, and curiosity, stimulated by audiovisual effects, but is less clear on the question of fantasy. Malone also omits entirely the concept of user control and interactivity that was mentioned several times in Section 2.5 as being responsible for motivation to use computer games. However, in his experimental work he has proved that it is possible to assess the motivation of young children to play computer games by asking them which they prefer and to compare two games. He also introduces the idea of investigating motivation by developing different versions of a computer game each lacking or providing the
proposed motivational features. It is his experimental ideas that the studies based in Chapters Five, Six and Seven in this thesis are developed from.

The motivation found in the computer games player can be induced in students through the use of computers in schools. Every author writing about computers in education has noted the high attraction of computers for schoolchildren. Chandler (1984) notes that for many teachers who have begun to use computers with children, one of their most exciting discoveries is the way in which small groups of children can become completely absorbed in a computer-based activity and discuss it amongst themselves with real excitement.

Malone (1981b) produced the following checklist for the design of enjoyable educational programs based on his three category theory, discussed earlier. Though the theory in its entirety may not be completely acceptable the list provides an extremely helpful starting point for the investigation of motivation to become involved with educational software.

**Challenge**

**Goal** - Does the activity have a clear goal? If not is it easy for students to determine goals of appropriate difficulty for themselves?

- Are the goals personally meaningful?

**Uncertain Outcome** - Does the program have a variable difficulty level?

- Determined by the student
- Determined automatically, depending on the student's skill
- Determined by the opponent's skill
- Does the activity have multiple goal levels?
  
  Scorekeeping
  
  Speeded responses

- Does the program include randomness?

- Does the program included hidden information selectively revealed?

**Fantasy**

- Does the program include an emotionally appealing fantasy?

- Is the fantasy intrinsically related to the skill learned in the activity?

- Does the fantasy provide a useful metaphor?

**Curiosity**

Sensory curiosity - Does the program have audio and visual effects?
  
  as decoration
  
  to enhance fantasy
  
  as a reward
  
  as a representation system

Cognitive curiosity - Does the program include surprises?
  
  - Does the program include constructive feedback?

Much mention has been made of Malone's work in discussions on motivation to use computer games especially in the field of computer aided learning. However, his ideas have not yet been fully explored or experimentally tested though the two studies described below make a start to be followed up by the experimental work described in this thesis.

In an investigation of computer arcade games, in order to find predictors of successful arcade machines, Schaffer (1981) considered a number of motivational attributes of the games, taken from
Malone's theories of intrinsic motivation and commonly held beliefs in the arcade industry. He assessed thirty arcade machines on these attributes and, as a measure of the frequency of their use, recorded the average daily revenue taken by each machine over a period of a week. Six of the proposed motivational attributes, newness of the machine, complexity of the game, colourfulness of and movement on the display, game involved fantasy and realism of the fantasy were found to be able to significantly predict at p<.05 the revenue taken by a machine.

Using a factor analysis of the results Schaffer produced five dimensions underlying the proposed motivational attributes of the games. He called these complexity, type of fantasy, user involvement and control, novelty and loudness. Factors that loaded onto the complexity dimension were amount of information, colour, sound and movement displayed when game was not being played, the colourfulness of and perceived amount of motion in the displays. Types of fantasy in the fantasy dimension were realistic to impossible, violent to non-violent and funny to serious. Factors making up the user involvement dimension were game involved fantasy, fantasy was humorous, user was in control of the game and the controls could be moved a lot. The novelty dimension contained the apparent age of the machine and the machine being operated by electronic as opposed to mechanical technology and the loudness dimension was the perceived volume produced by the game.

Although Schaffer did not obtain any independent verification of his measures of the motivational attributes of the arcade machines, the study showed that computer games could be systematically characterised with some degree of objectivity. He also confirmed the
importance of the concepts of complexity and user involvement and control that had been postulated to be related to motivation to use video games as discussed in Section 2.5. The concept of fantasy is less clear, according to Schaffer's factor analysis, it loads on to both its own dimension and that of user involvement. Also loudness and novelty are not strictly separate dimensions as, according to Schaffer's definition of complexity which includes amount of information, colour, sound and movement etc. displayed by the machine, they can both be considered to be part of the complexity of a machine. However, as Schaffer does not publish the actual loadings that resulted from the factor analysis this possibility cannot be investigated.

Bobko, Bobko and Davis (1984) mention Malone's theories of motivation to use video games but note the lack of empirical evidence on qualities of video games actually perceived by or salient to the user. They go on to carry out a similar study to Schaffer's but using multidimensional scaling techniques to determine those dimensions along which video games are actually perceived to vary. Twenty American college students, all of whom were experienced video games players, assessed ten commercially available video games and a further "ideal" game using pairwise similarity ratings. The analysis produced three dimensions destructiveness, dimensionality and graphic quality. The "ideal" video game falls between destructive and non-destructive games, at the highest level of graphic quality and between two and three dimensional action. Again the importance of the role of complexity in the user's perception of video games is emphasised as both
graphic quality and dimensionality contribute to the complexity of the game. It is interesting to note that high levels of complexity may be offputting since the "ideal" game lies towards but not at the end of the dimensionality continuum.

2.7) Conclusion

This chapter has been used to introduce a number of ideas and theories that are considered to be relevant to a study of involvement with computer software. As this involvement is particularly noticeable with computer games the chapter started with a brief history of the uses of instructional games. During this the importance of the concept of active learning in bringing about the acceptance of these games by educators was noted.

This was followed in Section 2.2 by a review of the technological developments that led to the introduction of the microcomputer and associated software into nearly all schools and educational establishments in Europe, America and Japan. The potential uses, advantages and disadvantages of such an educational tool were then discussed in Section 2.3. During this discussion it was noted that though the microcomputer was recommended for use in areas where active learning could take place it was actually mostly used, and this use was much criticised, in traditional learning situations.

However, whatever learning was involved, the most obvious feature of the use of microcomputers in schools is the high motivation induced in the students to use them and the depth of their involvement in the programs. This is extremely similar to the motivation found in video games players discussed in Section 2.5 for which many theories and explanations have been put forward. It is
interesting to note that these fall into two groups, those based on theories where the player is cognitively active in a desire to control or interact with the computer and those based on the theory that the player is merely instrumental, being rewarded for interacting with the computer. These two main ideas fit well with the active or traditional learning dichotomy found in the use of computers for education however, these theories are mainly untested.

The little experimental work, mainly done by Malone (1980, 1981a and b), discussed in Section 2.6, that has taken place on motivation to use microcomputers has also concentrated on video games. However, from this Malone developed a comprehensive theory of intrinsically motivating instruction which provides an excellent starting point to follow up in the investigation of involvement with and learning from microcomputer software.

In the following chapter psychological theories, including those on which Malone based his, that might be used to explain the motivation to use and involvement with microcomputers noted in this chapter are discussed. In Chapter Seven the effects of deep involvement with computers also noted earlier on active learning from a computer simulation game are investigated. Finally, in Chapter Eight, explanations of involvement with computers in all situations based on the active and traditional learning theories first discussed in this chapter are experimentally compared.
CHAPTER THREE

SURVEY OF THE LITERATURE ON THE CONCEPT OF INVOLVEMENT

"Involvement: The action or process of involving; the fact of being involved; the condition of being implicated, entangled or engaged;"

- Oxford English Dictionary (1901)

"That's a great deal to make one word mean", Alice said, in a thoughtful tone."

- Lewis Carroll (1832-1898)

Through the Looking Glass
3.1) Theoretical Background

Csikszentmihalyi (1975), gives an excellent description of involvement with an activity in his book "Beyond Boredom and Anxiety", which discusses the development and testing of a theoretical model of enjoyment based upon the results of interviews with chess and basketball players, rock climbers, dancers and surgeons. He calls involvement "the flow experience" and considers it to be a condition of complete and total involvement of the actor with his activity. In this state action follows upon action according to an internal logic that needs no conscious intervention by the actor. He is in total control of his actions, there is an unified flowing from one moment to the next, and there is little distinction between self and environment, between stimulus and response and between past, present and future.

Csikszentmihalyi notes a number of aspects that characterise the flow experience, these are, firstly, the merging of action and awareness. When a person is involved he or she is aware of their actions but not of the awareness itself. As soon as their concentration is interrupted by questions such as "Am I doing well?" the flow is broken. Secondly, there is the centering of attention on a limited field, attention is focussed on the activity in order to keep out potentially intruding stimuli. Then there is the loss of the self in the experience, the loss of consciousness of oneself as an identity separate from the task. Another characteristic is that the individual senses that he is in control of his actions and of their effects on the environment. Also in the flow experience there is unambiguous feedback of the results of one's actions, the individual is not at the mercy of conflicting demands. Finally,
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there is a lack of external goals or rewards, people seek the flow experience primarily for itself and not for any extrinsic rewards that may accrue from it.

For involvement to occur the demands of the activity must be matched by the skills of the actor. When the individual believes that the actions required are too demanding for his capabilities he becomes too anxious to experience flow. When the individual's skills are greater than the opportunities for using them then he becomes bored.

Early work on involvement of individuals with an activity was based on theories about the ego, the loss of self in an activity, described by Csikszentmihalyi above, was first noted by Allport (1943) who termed it ego-involvement. In a review of the conceptions of the ego used in the psychology of the time, Allport defines ego-involvement as a condition of total participation of the self - as knower, as organiser, as observer, as status seeker and as socialised being. He notes several characteristics of ego-involvement taken from experimental evidence. For instance, when there is ego-involvement there are general traits in personality but when there is no ego-involvement, there are no general traits. When the ego is involved there is a lack of objectivity in reporting of traits and a lack of accuracy in reporting memorised material as people distort the evidence to fit their own ego-involved frame of reference. For maximal motivation in learning the student must be encouraged to become ego-involved with the tasks though not to too intense a level as it may be disruptive.

Sherif and Cantril (1947) also defined ego-involvement but from the point of view of social behaviour and reactions. Attitudes that
define a person's status relative to other individuals, groups or institutions can be said to be ego-involved. When a stimulus or situation is consciously or unconsciously related by the individual to their social norms or frames of reference then ego-involvement occurs.

A common factor in these two definitions is the idea that the ego becomes involved, either in an attitude or a task, when the individual upholds the attitude or participates in the task to such an extent that they perceive the activity to be an extension of themselves. Generally, in experiments on ego-involvement, the subjects' egos have been engaged by informing them that the results of the experimental task will be reported to their supervisor or someone of similar status. In the non ego-involved condition the subject may be told that they are being used to evaluate the task rather than the task being used to evaluate them. Thus the subjects are either task-involved or ego-involved. This coarse distinction does not allow for the fact that subjects may actually become ego-involved in the task in the task involved condition which may account for the differing results in the many experiments on ego-involvement summarised by Greenwald (1982). In order to make sense of the previous research Greenwald eventually divided ego-involvement into three different concepts; concern about evaluation by others, concern about self-evaluation and personal importance. If, in an experiment, the experimental task becomes subordinated to an ego task related to one of the above three concepts such as seeking a satisfactory evaluation by others or oneself or evaluating a social goal, then ego-involvement occurs.
Other work on involvement has concentrated on political involvement or job involvement. Levy (1979) tentatively defines the universe of observations on political involvement in her First Law of Involvement which is stated below in the form of a mapping sentence. A first law is concerned with the signs of correlations amongst certain kinds of variables such as attitude, intelligence or involvement. It gives conditions under which a monotone relationship with positive correlations between items may be expected.

An item belongs to the universe of involvement items if and only if its domain asks about the amount of contact in a modality with an object and its range is ordered from to amount of contact with that object.

According to the mapping sentence, positive correlations between involvement items may be expected subject to the following three conditions, that the items are within the common range of involvement items, that all the items relate to involvement with the same object and that the population whose involvement is being studied is not specially selected with respect to that object. When these conditions are satisfied then positive correlations amongst the items being studied will occur whether cognitive, affective or instrumental behaviour is being measured.

Levy considers that for involvement to occur with an object, there must be contact with that object which may range from a very low to a very high amount of contact. However, unlike the other proposed First Law concerned with behaviour towards an object, that
of attitude (Gratch, 1973) which is bidirectional (attitudes may be for or against). involvement has only one direction.

Levy goes further to study the interrelationships among various kinds of political involvement using data obtained from interviews with adults during a pre-election survey in Israel. Again she defines the universe of involvement items that the survey is concerned with using a mapping sentence.

The extent to which the respondent is involved in a

(A) (cognitive ) modality with respect to political
(instrumental)

(B) very high
issue economy --> to involvement.
( very low
( general )
( security and
foreign relations)

The survey was made up of items referring to each of the possible combinations of the elements in the facets (A and B) of the mapping sentence. When the results were analysed using Smallest Space Analysis, it was found possible to reproduce the structure of the intercorrelations between items as a three dimensional cylinder. The modality facet (A) extends along the axis of the cylinder and the political issue facet (B) divides the cylinder radially into wedge shaped regions. This relationship can be summarised as whatever the political issue involvement with it extends from more instrumental modes such as discussion at home to more cognitive modes such as interest in lectures.

Evidence for the axial role of the modality facet has also been found in later, independent studies in both Switzerland and Israel reviewed by Guttman and Levy (1977). However, neither of the studies
contained data on the different political issues so the existence of the radial facet could not be tested.

In their study of worker's involvement with their jobs, Rabinowitz and Hall (1977) have made a useful summary of previous research in a literature review. They note that there appear to be two different concepts of job involvement, the first based on a relationship between performance and self-esteem and the second as a component of self image. In the first, which is similar to ego-involvement discussed earlier, the job involved person is one for whom their work is a central life interest whereas in the second the job involved person is one who identifies psychologically with their work. Job involvement has also been studied from three different theoretical perspectives, as an individual difference variable, as a function of the situation and as an individual-situation interaction.

In their review, mostly of studies using questionnaire or interview techniques with workers in large organisations, Rabinowitz and Hall summarise the variables found to be related to job involvement according to the three theoretical perspectives. Individual differences that were found to correlate with increased job involvement were increased age, longer education, more internal locus of control, longer tenure of job, larger community size, stronger higher order needs such as achievement or fulfillment and greater belief in the Protestant work ethic. Characteristics of the situation that were found to correlate with increased job involvement were greater participation in decision making, greater social involvement with others on the job and greater difficulty of the job. Also that the job provided opportunities for control and
for achievement, that there was feedback on performance and the chance to learn new things. Research on the interaction between the individual and the situation (Lawler and Hall, 1970) concludes that the more the job is seen to allow the worker to influence what goes on, to be creative and to use his skills and abilities the more job involved he or she will be.

However, in previous research, whether on ego, political or job involvement, there has been little consideration given to the process of becoming involved instead involvement has been treated as an all or nothing state. Hall (1971) suggests the following process as a general model of career development: challenging goal -> effort -> goal attainment -> psychological success -> increased self-esteem -> increased commitment and involvement. This could also be used to represent the process of becoming involved, especially if the increased involvement led to the construction of new goals thus making the process continuous. This model provides a good starting point for consideration of the process of becoming involved with a computer, the subject of this thesis. For example, the challenging goal might be to get a good score on an arcade game or to write an operational program. On attaining the goal, the increased involvement would lead to creating further challenges such as beating the score just obtained by playing the game at a higher difficulty level, or rewriting the program code in a more compact way to incorporate it in a more sophisticated program.

In order to investigate the concept of user involvement with computers, involvement must first be defined for the purposes of this study. From the above discussion of previous research into involvement it can be immediately be noted that involvement is a
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nebulous concept that has been researched from a variety of theoretical angles. However, by considering factors common to those angles, a working definition of involvement may be produced.

Firstly, involvement whether through enjoyment, the ego, political beliefs or a job is always part of an interaction between an individual and an activity and secondly, that it is unidirectional with respect to the activity. Lastly, involvement is the result of merging the individual with the activity in such a way that the individual comes to regard themselves as inseparable from the activity. This is the most obvious characteristic of the flow experience as described by Csikszentmihalyi (1975), the starting point of Allport's (1943) definition of ego-involvement, the combining of ego tasks and experimental tasks in Greenwald's (1982) analysis of ego-involvement, the underlying basis of Levy's (1979) theory of political involvement and is present in both Rabinowitz and Hall's (1977) concepts of job involvement. However, the idea that involvement is a dynamic process, first noted by Rabinowitz and Hall and implicit in Levy's ordered range of amount of contact with an object must also be included.

Therefore, for this study, involvement with a computer is defined as the extent to which the computer user is actively participating in or interacting with a program. Although it is considered to be an interaction, involvement with computers is actually studied from two perspectives, those of the two components that make up this interaction. The first perspective is from the activity that the individual has become involved with, in what way is the activity related to any involvement that occurs, in this case, what are the properties of computer software that generate
This involvement? The second perspective is from the individual who is involved in the activity, in this case, what are the properties of the individual that make them more or less susceptible to the involving aspects of computer software? Literature on psychological theories that could be used to explain involvement is reviewed in Sections 3.2 and 3.3 and individual attributes that might relate to involvement with computers are discussed in Section 3.5.

3.2) Cognitive Factors Hypothesised to Determine Involvement

Previous work on potential causes of involvement has concentrated on the causes of the motivation to be become involved with an activity. This is intrinsic motivation, that is to say motivation that is intrinsic to the activity itself and not the result of any external goals or rewards. There have been three approaches to the study of intrinsic motivation, that it is caused by the complexity of the activity which produces a desire in the individual to explore it, that the individual is challenged by the activity producing a desire to master it, and that the individual is motivated by a desire to be in control of the activity.

The role of complexity in intrinsic motivation was investigated by Berlyne (1960) in his theory of exploratory behaviour based on arousal potential, perceptual curiosity and learning. This theory originates from the work of Yerkes and Dodson (1908) who proposed an inverted U shaped relationship between arousal and learning known as the Yerkes-Dodson law. Berlyne proposes that for an individual organism there is an optimal influx of arousal potential and an increase or decrease from the optimum will be drive inducing or aversive. The organism will try to keep its arousal potential at this optimum and Berlyne gives three reasons why it should seek out
stimulation with a relatively high arousal value. The stimulation may increase the influx of arousal potential back towards its optimum thus alleviating boredom, or continued exposure to the stimulation may reduce arousal after an anticipatory rise, or a temporary increase in arousal may be sought for the sake of the drop in arousal that follows it. Perceptual curiosity is the state of high arousal that can be relieved by specific exploration of the stimulation. The amount of perceptual curiosity created by the stimulation depends on its complexity. The complexity of a stimulus pattern increases with the number of distinguishable elements and with dissimilarity between elements but it decreases with the degree to which several elements may be responded to as one unit.

Experimental evidence for this theory found in both humans and animals has shown that individuals will look for longer at more complex patterns, chimpanzees played more with patterned and odd shaped blocks than those that were uniformly coloured or regularly shaped, and rats prefer to take a more complex path in a maze or one that is different from the one explored on the previous trial (Berlyne, 1960). In experiments using randomly drawn figures with a varying number of turns Munsinger and Kessen (1964) found that people preferred the figures with an intermediate number of turns. In the case of the over complex stimuli, too great an influx of arousal potential is provided to be reduced easily to the optimum. However, after repeated encounters with figures with many turns i.e. increased familiarity with the more complex figures, people were found to prefer the figures with many turns. Though these results were obtained in the artificial, experimental environment, the same
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pattern of preference for complexity occurs in the real world, for example, with preferences for types of music (Hunt, 1965). Simple melodies without orchestration lose their appeal more quickly than the same melodies with orchestration. Also complex melodies are found to be less appealing than simple melodies on first hearing, however, after repeated hearings providing increased familiarity, the more complex melodies are preferred. People were also found to prefer poems that contained a greater degree of complexity to simple ones (Kamman, 1964).

Thus as the complexity of an activity increases so does the motivation of the individual, caused by curiosity about the activity, creating a desire to explore the activity and consequent involvement. However, if the complexity increases to too great a level the individual becomes anxious about the consequences of becoming engaged in the activity and so will not get involved. This is as predicted by the Yerkes-Dodson law since as complexity increases so does perceptual curiosity or arousal but over arousal is aversive.

However, White (1959) considers that the drive reduction theories that Berlyne based his theory on cannot satisfactorily explain exploratory behaviour. He suggests a theory of competence motivation where instead of being driven to explore an object the individual is driven to try to effect his will over it. He terms this effectance and the experience is characterised by a feeling of efficacy. Harter (1981), in the development of a scale to test intrinsic and extrinsic orientations in school children, states definitively that intrinsic motivation is an orientation towards mastery and learning not the result of curiosity or interest. This
theory of motivation through mastery is in accordance with Piaget (1952) who considers that play is centred on a result produced in the external environment. Piaget goes on to say that the exploratory behaviour of a child towards an object is both focussing the child's attention upon an object and also directing its actions upon the object in an attempt to master it.

This drive for mastery is the result of a challenge from the object or activity that the individual is motivated to explore. The importance of challenge is noted by Eifferman (1974) who used it to explain the differences in popularity of different types of children's playground games but she has not tested this explanation. Challenge consists of goals that the individual sets out to achieve and, according to Deci's (1975) theory of intrinsic motivation which is based entirely on the concept of goal directed behaviour, the individual selects goals to master that are neither too challenging nor too easily overcome. This is in agreement with Csikszentmihalyi (1975) in that involvement with an activity or the flow state occurs when the individual feels that the challenges from the activity are matched by his skills. However, the attainment of these goals that provide the challenge must be uncertain (Kagan, 1978) for if the person knew that they would always achieve the goal, or could never achieve it, there would be no challenge. The goals themselves can be fixed or emergent (Csikszentmihalyi, 1975), the former being predetermined by cultural convention and the latter those that arise out of the interaction between the individual and the activity. In order to be motivating the activity should be structured so that the emergent goals are of an appropriate difficulty thus ensuring that
the individual is continuously challenged. Motivation through challenge provided by fixed goals is similar to the concept of achievement motivation where the goals to be achieved are improving personal performance or doing better than others (Vidler, 1977). However, this is motivation which is extrinsic to the activity that the individual is involved with.

Bruner (1971) reviews both of the above approaches to intrinsic motivation in his proposals for a technology of teaching and considers that the will to learn is made up of intrinsic motivation through both curiosity and the drive to achieve competence. These are produced, respectively, by the complexity and challenge of the task. However, he does not consider these proposals in any detail.

There is an further factor in the production of involvement that must be considered for, although Csikszentmihalyi (1975) notes that a person must be challenged by an activity in order for involvement or the flow state to occur, he states that the most salient feature of this state is the person's sense of control over the environment. In fact the drive for mastery discussed earlier may be reinterpreted in the light of de Charms' (1968) theories as a desire to be effective in changing the environment. De Charms considers that man is motivated primarily by a desire to produce changes in his environment, that is to say, to control it. The relevance of the concept of control to intrinsic motivation is supported by Donaldson (1984) who states that people enjoy best and engage most readily in activities which are experienced as being freely chosen.
Experimental work also supports the importance of control. For example, giving people control in the form of choice, or even just the illusion of choice in a task to be performed, has been found to increase their motivation to do the task (Zimbardo, 1969). Even children as young as four months old have been shown to be motivated to learn a sequence of head movements in order to control a display of lights (Papousek, 1969). Nuttin (1973) set up a simple experiment to investigate to what extent people take pleasure in producing effects (motivation to control) and to compare this with pleasure from the effects themselves (motivation through complexity). Five year old boys were allowed to play with two identical machines, each with handles and light bulbs. Machine A was set up so the bulbs flashed automatically at differing time intervals and machine B was set up so that the lights were either on or off but when its handle was moved the light flashed off or on respectively. In all conditions, whether the lights on A flashed slowly or quickly, whether the handle extinguished or turned on the lights on B, the children preferred machine B, used it more and spent more time at it. Though there were few subjects they all actively preferred to play with a machine that they could control to one that produced equivalent sensory stimulation but at random.

Control, though not the variable being tested, has also been used to explain experimental results. Condry (1977) notes several experiments that have shown that motivation to do a task falls if the task had previously been rewarded compared to motivation where there has been no external incentive. He hypothesises that this effect occurs because the reward detracts from the pleasure involved in self-initiation of the task, that is to say the child feels that
they are not in control of the task but being controlled by the influence of the reward. In a study of involvement in learning Corso and Mandinach (1983) state that highest form of cognitive engagement in learning occurs when it is self-regulated i.e. when it is controlled by the student.

Throughout the literature these three approaches applying the concepts of complexity, challenge and control to the causes of intrinsic motivation have been discussed separately. However, similarities can be seen between them, for instance, responding to a challenge to master the environment appears to be almost identical to a desire to control it. Also the inverted U shaped change in motivation occurs through both increasing challenge and heightening complexity. The similarity between these approaches was noted by Lepper (1985) when presenting the study of the determinants of intrinsic motivation as a research issue of both potential theoretical significance and social interest in the field of educational computing. Lepper considers that the three hypotheses as to the cause of intrinsic motivation are not incompatible but the result of independently developed research paradigms that has made comparing results exceedingly difficult.

However, except for the early experiments of Berlyne and others on complexity of line drawings and those of Papousek and Nuttin on desire for control in infants and young children, the arguments that the three hypotheses are based on have not been rigourously tested. They have been put forward to explain the results of observations, interviews and even experiments but the concepts of control, challenge and complexity have not themselves been manipulated as the experimental variables. As has already been discussed in Section
1.1, the microcomputer forms an ideal environment in which these theories may be investigated experimentally. Therefore, this thesis aims to carry out the suggested research comparing the concepts of control, challenge and complexity and their roles in determining involvement.

3.3) Control, Challenge and Complexity and Involvement with Computers

Previous work on motivation to use microcomputers, discussed in Sections 2.5 and 2.6, has utilised the concepts of control, challenge and complexity to explain the high motivation found in their users, especially noted when the computers are used to play video games.

The explanation that has occurred most often, in a wide variety of fields, is being in control of the computer. A schoolteacher, discussing his own introduction to programming (Green, 1987), noted that he felt he could make the computer do what he wanted to do, that he was in control, and wondered whether the children in his class might be motivated in the same way. Stonier (1984), an educational psychologist, states that the most important reason why the computer constitutes such a powerful pedagogical tool is that it is interactive which gives children a sense of control. Lawler (1983), a cognitive psychologist who had developed several programs in order to give his three year old daughter access to their computer, found that her desire to control the machine was so strong that it led to her typing her first written word. A large part of Papert's book "Mindstorms" (1980), based on Piagetian theory of developmental psychology, is concerned with the advantages of learning mathematics through the child controlling the computer.
Desire for mastery or control of the computer is a recurring theme throughout Turkle's book "The Second Self" (1984) which describes the total involvement of the heavy computer user from the viewpoint of social psychology. Indeed she says "People are not addicted to test piloting or race car driving or computer programming. They are addicted to playing with the issue of control." (p. 216). Finally, control of a simulation by the user was given by Chandler (1984) as one of the advantages of using simulation software as a learning tool.

In an experimental study, described in detail in Section 2.5, to find what makes arcade machines successful, Schaffer (1981) used a stepwise multiple regression on various machine attributes. He found user control together with newness of machine, fantasy and display motion predicted 53% of the variation in revenue from the machines. Greenfield (1984), though she concentrates on the effects of television on young children, found that her small sample were unanimous in that they liked video games because they could control them.

The main proponent of the causal role of the concepts of challenge, based on White's (1959) theory of effectance, and complexity, based on Berlyne's theory of exploratory behaviour, in motivation to use computers is Malone (1980, 1981a and b). Malone's theory of intrinsically motivating instruction provided by educational computer games was discussed in detail in Section 2.5, however, it should be recalled here in the context of theories determining involvement with computers.

Malone considers that the challenge of a program is made up of a number of goals (Deci, 1975) which may be varied during the program.
If the attainment of these goals is uncertain then the game is even more challenging (Kegan, 1978). An obvious way to provide a goal is to keep a record of the players scores and to display a high score table, challenging the player to get a good score, to beat their previous scores and to beat their peers scores. A goal may also be variable, in theory a computer game can provide a continuous challenge by having increasingly difficult levels. Of all Malone's suggested motivational features, using the presence of a clear goal as a measure of the challenge provided by a game produced the highest correlation (.65, p<.01) with the popularity of the games as assessed by American schoolchildren. Presence of a goal was closely followed by whether the game kept a score (.56, p<.01) which is another way of providing challenge in a game.

The importance of challenge has been noted in another experimental study investigating the personality characteristics of video games players (McClure and Mears, 1984). In a questionnaire survey of over 300 American high school students they found that 40% gave challenge as their reason for playing the games. However, when the reasons for playing given by frequent and infrequent players of video games were compared a significant difference was found. Frequent players said they played for the challenge or to escape outside pressures whereas infrequent players gave fun as their reason for playing or did not like playing the games. Also, Shaw (1980) notes the importance of challenge in an examination of the use of computers for simulations in chemistry. He states that, without doubt, there is considerable motivation in the challenge presented by simulated experiments and investigations.
Malone also considers that complexity in a computer game, created by the use of graphics and sound, will arouse curiosity in the user who is then motivated to explore the game. The more curious the user is about the software the more they become involved. Malone terms this sensory curiosity, the more exciting the audiovisual effects the more the child will want to see them. When correlating American schoolchildren's preferences for certain computer games with features of those games he found that audio effects and randomness in the game, both forms of complexity, figured prominently with correlations of .51 and .48 (p<.01) respectively.

The role of complexity in involvement with computers has been investigated in other experiments, described in detail in Section 2.5. Schaffer (1981) found display motion, a form of program complexity, to be one of his four successful predictors of revenue taken by arcade machines. In an investigation of dimensions along which video games are perceived to vary, Bobko, Bobko and Davis (1984) used experienced video game players, to assess the games. A multidimensional scaling of the players' responses using pairwise similarity ratings produced three dimensions destructiveness, dimensionality and graphic quality. The latter two, whether the action takes place in one, two or three dimensions and the use of colour and high resolution, are both examples of perceptual complexity showing its importance to the video games player.

However, the determinants of involvement discussed above, whether or not they are equivalent or incompatible, have all been taken from a cognitive perspective and there is yet another approach to the generation of involvement with computers to be considered.
This is from the behaviourist's point of view and is discussed in the next section.

3.4) Reinforcement Theory and Involvement with Computers

Skinner (1984), himself, notes the strong motivation of video game players and their intense involvement with the game in an article that is mostly taken up with a diatribe against cognitive psychology. Concentration upon cognitive theories is a retreat from behaviourism which has caused educators to ignore improved teaching methods based on behaviourist principles and has contributed to the ruin of American education. Skinner declares that the high motivation to play video games is the result of the reinforcing effect of successful play and suggests that similar motivation could easily be engendered in students using properly programmed educational software. Motivation would be produced by scheduling reinforcements to ensure a good deal of successful action. Loftus and Loftus (1983) use the same theory of reinforcement, in their book on the psychology of video games discussed in Section 2.5, to explain the apparent addiction of arcade games players. Here the concept of reinforcement theory and how it might be used to explain involvement will be discussed in greater detail.

Reinforcement theory originates in learning through operant conditioning as developed by Skinner (1938) from Thorndike's (1911) work on connectionism and the laws of learning. Thorndike's law of effect states that if a connection is made between a stimulus and a response and is accompanied by a satisfying state of affairs then the connection will be strengthened. Should a similar connection be associated with an unsatisfactory state then it will be weakened. In operant conditioning the same rules apply except that the stimulus
is omitted, any response or form of behaviour will be strengthened or repeated if it is rewarded and weakened or extinguished if it is punished. Thus if an individual is rewarded through engagement in an activity, that is to say receives positive reinforcement, they are more likely to continue to participate in the activity and become involved.

Skinner (1968) considers the knowledge that one has performed successfully to be extremely reinforcing so, if a task is broken down into small components whose performance is reinforced immediately, an individual will become more and more involved in completing the task. He incorporated this theory into the development of programmed learning and teaching machines. Information that has to be learnt is broken down into small portions and presented to the student. The student is then tested on their acquisition of the information and if it has been correctly learnt they are reinforced by being told they are right and moving on to the next piece of information. By presenting the information in small enough chunks the student is nearly always right, is continuously reinforced and so becomes engrossed in learning the information. However, teaching machines based on these concepts were not successful, good programs took a lot of effort to develop and students did not take to their use in the big way predicted by Skinner.

Much of the educational software published now for microcomputers follows these Skinnerian ideals concentrating on providing positive reinforcement in the form of big ticks and smiling faces for right answers and negative reinforcement in the form of big crosses and audible raspberries for wrong answers. However, it does not produce the same concentrated involvement as
with video games which is explained by Skinner (1984) in terms of partial reinforcement.

Partial reinforcement is the reinforcement of a proportion of occurrences of the activity being learned since, if reinforcement is continuous, an error causing reinforcement to be stopped will cause the activity to be rapidly extinguished. However, if reinforcement occurs at intermittent, unpredictable intervals the activity will be continued during the interval when reinforcement is absent. Much experimental work has been done with animals in attempts to find out what is the best schedule of reinforcement that will cause them to continue to make the required responses. It has mostly concentrated on comparing the effectiveness of reinforcement at fixed or variable intervals of time or number of responses made. The most effective way of ensuring the response rate was found to be to continually increase or 'stretch' the ratio of reinforcement to responses making reinforcement more and more difficult to obtain.

Based on this work with animals, Skinner (1968) considers that most involvement of a student with an educational program occurs if the ratio of reinforcement to responses is 'stretched' throughout the learning activity making reinforcement more difficult to obtain as the student's competence increases. This is exactly what happens in a video game, as the player gets more competent they move on to playing at a more difficult level thus making it more difficult to gain reinforcement for playing well. Skinner (1984) goes on to point out that it is the success at the game that is reinforcing and not the action of 'shooting down' aliens or 'gobbling up' food capsules because, as soon as the player clears one screen, they move on to the next which is full again.
The reinforcement discussed so far has been intrinsic to the activity being engaged in, however, it may also take the form of rewards that are external to the activity. This is the case when someone performs an activity for such as programming for money, using the computer in order to obtain a supervisor's approval or playing a video game to impress their peers.

The relationship between reinforcement theory and involvement has already been noted by Allport (1943) when considering the roles of Thorndike's (1911) original law of effect and ego-involvement in learning. Allport states that "... in order to employ the law of effect with human learning we must view it as secondary to the principle of ego-involvement." (p.468). If a person is both ego-involved and successful in a task he is unlikely to repeat that task for the reinforcement of success but to demand a greater challenge. Whereas in the case of lower animals or if the task is routine and fails to engage the ego it will be repeated for reward. Thus reinforcement only becomes important in human learning if ego-involvement has not occurred. This failure of reinforcement theory to account for the role of the ego in human learning is because it has been developed from experiments with animals or human beings deprived of their egos for the duration of the experiment.

3.5) Individual Differences Related to Involvement with Computers

The issue of involvement with computers is based on the interaction between the computer user and the software. In earlier sections factors that may determine involvement have been based on software attributes, however, individual attributes of the users must also be considered. Of course every individual will hold a slightly different attitude towards the use of computers but several
personality variables, taken from the research on job involvement discussed in Section 3.1, have already been noted to influence an individual's involvement with computers.

3.5.1) Gender differences

The difference that has received the most comment and study is gender, even in the present day girls are far less likely to take courses in computing at school or university or to hold jobs in computing. There are large numbers of women in office jobs who use computers to enter and manipulate data and to word process but relatively few who work in electronics or programming. This has so worried people that workshops have been set up in most cities designed especially to involve women in computing. The trend appears to start at school, computing is usually taught by the maths teacher and maths is considered to be a boy's subject whereas the girls concentrate on the arts. There has been considerable research into this division of the sexes but no definite conclusions, it is not proven whether this is a genetic difference or caused by socialisation and conditioning.

A number of studies show that women have less experience of and achieve less in mathematics than men (de Wolf, 1981, Sherman, 1981 and 1982, Fox, 1980) which means that they are less likely to gain entrance to computing courses at university. In fact the ratio of males to females involved with computers increases at more advanced levels (Lepper, 1985) and a study of computing science majors at an American university found two men for every woman (Sorge and Wark, 1984). Players of arcade computer games are significantly more likely to be male (McClure and Mears, 1984). This lack of familiarity with computers means that women are more anxious about
using computers and are even afraid of using them (Vredenburg, Flett, Krames and Pliner, 1984). One study of sex differences in attitudes towards computers in American university students (Dambrot, Watkins-Malek, Silling, Marshall and Garver, 1985) found small but statistically significant differences between the sexes for computer aptitude, computer experience, computer attitude and prerequisite maths ability and experience.

In general it appears that women and girls are less likely to become involved with computers though it is hoped that as very young children are first introduced to computers in their primary schools these sexist attitudes both in the students and their mentors will disappear. However, Griffiths (1985) noted that even at the age of eleven there are substantial gender differences in levels of interest in science and its related technology. Also Siann and Macleod (1985) found significant differences in amount of interest in computers between boys and girls as young as seven.

3.5.2) Age differences

A second obvious trend in involvement with computers is age, computers are regarded by many to be the province of young people. Though many senior executives have familiarised themselves with the new machines many others have been defeated by the rapid changes in technology that have brought computers into nearly every office. This image of the company chairman deferring to the bright young executive with the VDU is fostered, like the previous one of computers being men's toys, by our society and is especially noticeable in advertising. One study on word processing (Arndt, Feltes and Hanak, 1983) found that secretaries that used word
processors were significantly younger than those that had not used them.

Again, as with gender differences and computing it is to be hoped that as children grow up with computers that ageism in computing will disappear, however, it is more than probable that at the speed with which the field is changing there will always be new developments and old ways will need to be relearned.

3.5.3) Locus of Control

It is hypothesised that other less obvious differences than age and sex affect an individual's attitude towards and involvement with computers. One concept that has attracted a lot of attention in this field is that of locus of control.

Rotter (1966) introduced the concept of locus of control as a continuum that ranged from internally controlled individuals who believe any reinforcement they receive is contingent upon their own behaviour to externally controlled individuals who believe reinforcement is due to fate or contingent upon others. Thus it is a development from reinforcement theory, discussed in section 3.4, which includes mediating cognitions in the individual's attributions of the source of reinforcement.

Rotter developed the theory of locus of control from his work with patients in psychotherapy where he found that some patients gained by new experiences and others discounted them by attributing them to chance or to the work of others. He argued that well adjusted individuals have a reasonably internal locus of control whereas psychiatrically ill people will have an extremely external locus of control. He also developed the first instrument to measure how much people perceive that they are in control, the Internal
External (IE) Locus of Control scale. A number of studies using this scale found significant differences between normal and maladjusted individuals such as schizophrenics (Harrow and Ferrante, 1969, Cash and Stack, 1973, and Palmer, 1971, cited in Lefcourt, 1982) as did others using different scales to measure locus of control.

Lefcourt (1982) has summarised much of the research on the concept of locus of control which was also found to vary widely among normal individuals. Individuals with an internal locus of control are more likely to be resistant to outside influence, attain higher academic achievement and to be more active cognitively. Locus of control has been found to be related to an individual's sex, ethnic origin, class, socioeconomic status and upbringing. In general, people with an external locus of control are likely to come from poorer families and ethnic minorities and to achieve less than internals.

Locus of control has also been found to influence the likelihood of an individual's participation in various activities. Runyon (1973), in an investigation on management style and job involvement, unexpectedly found that, whatever the management style, locus of control was related to job involvement with internals being more involved. Rabinowitz and Hall (1977) in a review of organisational research on job involvement state that the job involved person has an internal locus of control. Locus of control could also be used to predict worker's motivation and job satisfaction using valence-instrumentality-expectancy theory (Andrisani and Nestel, 1976). Generally, an internally controlled individual believes that the results of a job are up to him or her and so becomes involved in the work, whereas an externally controlled individual believes that the
results of a job are nothing to do with them and so does not learn from mistakes nor gain any satisfaction from a job well done. In a later study, an individual's locus of control was found to be related to their involvement in academic work. Tobin and Capie (1982) measured academic engagement in an experiment to test whether students with an internal locus of control would become more deeply involved in objective related behaviour when learning scientific skills. They found a low but significant correlation ($r=.2, p<.05$) between locus of control and engagement but locus of control was not related to achievement at or retention of the task in the presence of other variables such as reasoning ability.

Similar reasoning may be applied to involvement with computers and indeed Coovert and Goldstein (1980), in a study described in detail in Chapter Nine, found that internally controlled individuals had a significantly more positive attitude towards computers than externally controlled individuals. Arndt et al (1983) also measured locus of control in a study investigating the anxiety, eagerness and curiosity of secretaries about word processing equipment. They found that externally controlled individuals were more reluctant to use word processors and less curious about them. For secretaries with experience of word processing locus of control was also related to anxiety (externals being more anxious).

It appears from these studies that there is a definite relationship between an individual's locus of control and their attitude towards and consequent involvement with computers. However, a low but significant correlation between job involvement and attitude to computers has been found (Rafaeli, 1986) and it is
possible that as locus of control is related to job involvement it is affecting attitude to computers only indirectly.

3.5.4) Self-esteem

Self-esteem is the value a person assigns to themself, an individual with high self-esteem considers him or herself favourably whereas a person with low self-esteem does not consider themself worthy of merit. The first psychologist to discuss the concept of self-esteem was William James (1890) who defined self-esteem to be the ratio of a person's successes to their pretensions to success. If a person does unexpectedly well this will raise their self-esteem but if they do badly they will have to lower their expectations of themselves unless they can attribute their performance to an outside cause. According to Brisset (1972) self-esteem is a combination of self evaluation and self worth. Self evaluation is the making of a judgement upon the significance of oneself, or aspects of oneself and self worth is the feeling that one is important. If the self evaluation meets certain standards that the individual has assigned to themself then the result is self-esteem. Maslow (1943), in his theory of motivation, considers self-esteem to be more important to the human than understanding and knowledge and the desire to fulfil oneself.

In a study of over 5,000 American high school students Rosenberg (1965) found that an individual's self-esteem was related to their social class, their ethnic origin and whether they had been an only child. People with low self-esteem were more likely to come from a lower class, an ethnic minority and less likely to be only children. Self-esteem was also found to affect an individual's participation in outside school activities and whether they held a position of
leadership inside or outside school. Many studies (Burns, 1979) have discovered that self-esteem is related to academic achievement, people with low self-esteem have shown little academic attainment and poor academic performance has lowered self-esteem.

Thus research has shown that self-esteem is related to participation and consequent academic attainment and it follows that it too might be related to involvement with computers. Computing is usually seen as an academic activity and so it is hypothesised that individuals with low self-esteem will make less of an attempt to learn how to use a computer. Even in a computer games arcade those with low self-esteem may not attempt to play the games for fear that others will mock their low scores.

3.6) Conclusion

This chapter reviewed previous research related to the idea of involvement of an individual with an activity. Though the research approaches involvement from many different angles such as enjoyment, the ego, satisfaction and amount of contact in the different fields of leisure and work activities, it has a common theme. This is the idea of involvement as an interaction between an individual and an activity in which the individual participates to a greater extent as they become more involved. As the subject of this thesis is user involvement with computers this has been defined as the extent to which the user is actively participating in or interacting with a computer program.

Three cognitive factors that have been hypothesised to cause the high involvement with computers described in Section 2.5 were identified from the literature on involvement. These were control, the users being highly motivated by a desire to control the
computer, challenge, the users being motivated by a challenge from the computer made up of goals to be achieved. and complexity, the users being motivated to explore the complexity of the software. The possible role of behaviourist factors in creating involvement was then discussed with reference to reinforcement theory. Thus there are a number of independent angles from which involvement has been considered especially if ego-involvement is included as yet another perspective on involvement. In this thesis it is intended to compare these theories using computing as the field of research and to test their relevance to involvement with computers and learning from educational software. This research is described in Chapters Seven and Eight.

Finally, a number of individual attributes were noted that were hypothesised to relate to the ease or difficulty with which an individual becomes involved with computers. These were gender, computing though not the use of computers for menial tasks has been assigned as a man's subject, and age, computers are generally regarded as something only the young understand. Also included were locus of control, how much a person believes that they are responsible for the consequences of their actions and self-esteem, how much a person values themselves and their abilities. It is proposed that these variables would be correlated with attitude towards and involvement with computers. The testing of these theories is described in Chapter Nine.
"When we mean to build,
We first survey the plot, ..."

- William Shakespeare (1564-1616)

Henry IV Part II
4.1) Microcomputers and Software Used in Primary Schools

4.1.1) Introduction

In order to set up a study on involvement of children with educational software it was necessary to find out what computing equipment was available to the children in schools and what their attitudes were to the programs they used.

The method chosen to obtain this information was a questionnaire survey of local primary schools. It was decided to use primary schools as the skills being taught by computer such as spelling and simple arithmetic were less complex and so more easily observed than those in secondary schools. Also in secondary schools, more emphasis is placed on using computers for electronics and programming rather than for running educational programs.

The results of such a survey could then be used to test hypotheses relating aspects of both the individual and the software used to level of involvement with the software.

This is a summary of the information received as a result of sending questionnaires on microcomputers and software to local first and middle schools.

4.1.2) Method

A list of first and middle schools in the south-west Surrey education area was obtained and the head teacher of each school contacted by telephone to see whether they would take part in a questionnaire survey on what use they made of computers. A questionnaire asking for details of hardware and most popular software used was sent to those who said that they would take part. A copy of the questionnaire is given in Appendix 4.1, it consists of a section for hardware and ten identical sections for software (for
information on up to ten programs). The questionnaires were returned through the mail using a FREEPOST facility.

4.1.3) Results

From the telephone survey of the 103 first and middle schools in the South West Surrey education area, 77 schools said that they would complete a questionnaire on the programs they used, 21 schools were not interested and five schools did not have a microcomputer. In all, 42 questionnaires were returned, a 40.8% return rate from the original sample, with entries for between 3 and 10 programs each. There were 287 entries for 143 different programs.

4.1.3.1) Microcomputer Information

Every school that replied had at least one BBC 'Model B' microcomputer, nine schools had two and four had three or more. Five schools had other microcomputers which were in order of popularity the Commodore PET, the Sinclair Spectrum and ZX81.

Information Storage:-

28 schools had one or more disk drives on which to store programs/data.

14 schools used cassette recorders only for storing programs and data.

52 programs were on disk.

40 programs were on tape.

50 programs were available on both disk and tape.

1 program (Edword) was on a plug in ROM chip.

In general a disk system is much preferred through ease of use, however, many schools do not have the money for a disk drive. Disks are recommended for the following reasons; programs can be loaded almost instantly and infinitely more easily and reliably and data
can be saved as easily. If a student breaks out of a program it can be reloaded immediately and many programs can be used in the course of a lesson. A disk system is much easier to learn to use and operate than tape so teachers can become more confident about using the computer. Thus there is infinitely less chance of the teacher having to face a class of restless pupils while trying to load a program for the nth time.

Other Peripherals:

- 5 schools had one or more printers
- 1 school had a light pen
- 1 school had a plotter
- 1 school had a teletext downloader

A printer is a very useful item to have though not necessary for most software however, having a 'hard copy' of the results of a child's session with the computer can be a great help to the teacher. Other advantages are the child gets a copy of what they have been doing to keep and can refer back to see how far they have got with one program, and instructions can be printed out so they can be consulted at any point. A printer is essential if the children are involved in word processing, say in producing a class newspaper. In fact it has been reported (Chandler, 1984) that young children thoroughly enjoy writing using a computer due to the ease with which errors can be corrected and have been producing longer pieces of work than when using paper and pen or pencil.

4.1.3.2) Software Information

Of the 143 programs for which entries were returned, 87 (60.8%) were described once, 30 (21%) were described by two respondents and 26 (18.2%) were described by three or more respondents. By far the
most popular was Granny's Garden on which 18 entries were received, twice as many as any other program. The more commonly available programs, those for which three or more entries were received, are shown in the table given in Appendix 4.2.

108 programs were considered to be educational.
5 programs were considered to be recreational.
19 programs were considered to be both educational and recreational.

For 11 programs opinions were mixed.

**Children's Opinions of the Software**

In general the children found that:-

23 programs were very popular or much enjoyed.
82 programs were enjoyable, popular or considered good.
14 programs were enjoyed but contained problems or faults.
5 programs were considered to be interesting.
6 programs were considered to be fun.

for 3 programs opinions were mixed.
6 programs were considered to be fair.
2 programs were considered poor.

for 2 programs no information was given

* Where opinions were mixed people's views appeared to depend on which age group the program had been used with e.g. a program could be considered boring by 10 year olds and challenging by 7 year olds. Also a poor opinion was possibly caused by the program being used with the wrong age group.

The programs that were considered to be very popular by the children are given in the table in Appendix 4.2. Most frequently programs were considered to be good or enjoyable and very few were
thought to be poor. This is because the respondents were asked to
fill out the forms for the programs they used most often which would
naturally be the better ones.

A number of specific comments were made about particular aspects
of the programs that were important to or enjoyed by the children.
These are given in Table 4.1 below.

Table 4.1. Aspects of educational software noted by teachers as
being particularly enjoyed by or important to the children.

<table>
<thead>
<tr>
<th>Aspect children enjoyed</th>
<th>Number of times comment made</th>
</tr>
</thead>
<tbody>
<tr>
<td>Challenge</td>
<td>11</td>
</tr>
<tr>
<td>Competition</td>
<td>9</td>
</tr>
<tr>
<td>Increasing difficulty</td>
<td>1</td>
</tr>
<tr>
<td>The puzzle</td>
<td>3</td>
</tr>
<tr>
<td>Seeing the score</td>
<td>1</td>
</tr>
<tr>
<td>The game</td>
<td>5</td>
</tr>
<tr>
<td>The action</td>
<td>10</td>
</tr>
<tr>
<td>The pictures or sound</td>
<td>7</td>
</tr>
<tr>
<td>The fantasy</td>
<td>2</td>
</tr>
<tr>
<td>Being right</td>
<td>2</td>
</tr>
<tr>
<td>The reinforcement for being right</td>
<td>3</td>
</tr>
<tr>
<td>Not being able to go wrong</td>
<td>3</td>
</tr>
<tr>
<td>Being in control</td>
<td>2</td>
</tr>
<tr>
<td>Making and saving programs or data</td>
<td>2</td>
</tr>
<tr>
<td>Makes the children think</td>
<td>6</td>
</tr>
</tbody>
</table>

Finally, one comment seems to be particularly valid at the
moment: "They (the children) enjoy using the computer so much I
don't think they would mind which program they did."
Teacher's Opinion

In general:-

17 programs were considered to be very good or excellent.
84 programs were considered to be good.
7 programs were considered to be fun.
8 programs were considered to be good but contained problems or faults.
13 programs were considered to be fair.
8 programs were considered to be poor.

For 4 programs opinions were mixed.
For 2 programs no information was given.

The programs that were considered by teachers to be very good are given in the table in Appendix 4.2. Specific comments made by the teachers are shown below in Table 4.2.

Table 4.2. Specific comments made by teachers giving their opinions of educational software.

<table>
<thead>
<tr>
<th>Comment</th>
<th>Number of times comment made</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advantages:-</td>
<td></td>
</tr>
<tr>
<td>Makes children think logically</td>
<td>13</td>
</tr>
<tr>
<td>Generates discussion</td>
<td>6</td>
</tr>
<tr>
<td>Encourages work away from the computer</td>
<td>5</td>
</tr>
<tr>
<td>Encourages use of imagination</td>
<td>3</td>
</tr>
<tr>
<td>Incorporates other work</td>
<td>6</td>
</tr>
<tr>
<td>Disadvantages:-</td>
<td></td>
</tr>
<tr>
<td>Problems with the instructions</td>
<td>5</td>
</tr>
<tr>
<td>Problems with the different way program</td>
<td></td>
</tr>
<tr>
<td>does sums to that taught</td>
<td>2</td>
</tr>
<tr>
<td>Good keyboard skills needed</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 4.2. (cont'd)

<table>
<thead>
<tr>
<th>Comment</th>
<th>Number of times comment made</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disadvantages (cont'd)</td>
<td></td>
</tr>
<tr>
<td>Previous knowledge of vocabulary needed to read or spell</td>
<td></td>
</tr>
<tr>
<td>Difficulty reading screen</td>
<td>7</td>
</tr>
<tr>
<td>Sound too loud</td>
<td>1</td>
</tr>
<tr>
<td>Program goes on too long</td>
<td>3</td>
</tr>
<tr>
<td>More levels needed to cope with age and intelligence differences</td>
<td>5</td>
</tr>
<tr>
<td>Program could be improved (suggestions specific to program)</td>
<td>6</td>
</tr>
</tbody>
</table>

Method of Use

62 programs were used by small groups (of two or three) and individuals.

22 programs were used by small groups.

20 programs were used by individuals.

13 programs were used in large groups.

18 programs were used by the whole class, usually as a demonstration followed by use by small groups or individuals.

No information was given for the remaining eight programs.

By far the most frequent use of programs (72.7%) is by individuals, pairs or small groups. When the class has the computer for a limited amount of time it seems reasonable to have several children having a go together. Also it is helpful to have a small group for the problem solving programs for "two heads are better than one". When large groups were used it was with programs that took a long time to complete, usually historical simulations, and
the children worked in teams taking it in turns to enter the group's decisions into the computer. Few programs were used by the whole class in this study except for demonstrations on how they worked but programs are available that are to be watched by a class rather like an 'electronic blackboard'.

**Frequency of Use**

Different schools used the same programs with different frequencies. The frequency with which a program was used depends as much on the availability of the microcomputer to a class as on its popularity. Therefore, as different classes have different amounts of access to a microcomputer the frequencies with which the programs are used cannot be directly compared.

However, the programs fell into three main categories.

i) Those that were used on a regular basis eg. once a week or once a month throughout the year.

ii) Those that were used when it was considered appropriate, eg. when the class was learning a topic and the program dealt with the same topic or using a program remedially with a student who was having difficulty with the subject.

iii) Those used once with each year until all members of the class had completed the program.

**4.1.3.3) Checks on Returned Questionnaires**

When the numbers of the pupils in the schools who returned the questionnaires were compared with the numbers in those who did not using the Mann-Whitney test for two unrelated distribution free samples no statistically significant difference was found between them (z=1.09).
When the geographic locations of the schools who returned the questionnaires were compared with those that did not both were found to be evenly spread over the South West Surrey education area.

The return rates of questionnaires for first and middle schools were also compared as shown in Table 4.3 below.

Table 4.3. Comparison of questionnaire return rates from first and middle schools.

<table>
<thead>
<tr>
<th></th>
<th>No. originally contacted</th>
<th>% returned from schools who said yes on phone (n=77)</th>
<th>% returned from original sample (n=103)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>66</td>
<td>62</td>
<td>42</td>
</tr>
<tr>
<td>Middle</td>
<td>30</td>
<td>44</td>
<td>40</td>
</tr>
<tr>
<td>First &amp; Middle</td>
<td>7</td>
<td>40</td>
<td>28.6</td>
</tr>
</tbody>
</table>

The overall return rates are similar, slightly down for first and middle schools, but, of those who said they would take part in the survey, about 20% more first schools actually returned the questionnaire than middle or combined schools.

4.1.4) Discussion

It was found that nearly all (95.1%) of primary schools in the local area had at least one microcomputer, a BBC Model B. This is a direct result of the government's policy subsiding the purchase of British makes of computers such as BBC or Research Machines by schools and the county education authority recommending the BBC. It has now become clear that this was not a good plan, ACORN, the makers of the BBC, being assured of the educational market did not improve the BBC to compete with other commercial microcomputers and the BBC became overpriced. Once the schools had purchased a
microcomputer, there was no market for the BBC and ACORN folded. However, a large amount of software was published for the BBC, much of which is available cheaply to schools via the local Teacher Centre.

For ease of use of programs a disk drive is highly recommended and 67% of local primary schools had managed to obtain one. The purchase of peripherals was not subsidised and though having already had to raise money for a disk drive makes it difficult to get money for other peripherals, 7.8% of local schools had obtained a printer or some other form of additional hardware.

The software used in schools was generally found to be good by both teachers and children though the teachers were much more aware of specific faults. However, in this survey, reports were only asked for on programs that were used and there is a lot of software hastily and poorly written for the 'microcomputer boom' which is too bad to be used. Even so, teachers reported faults or bad design for 25.2% of the surveyed programs that are used regularly. Much of the best software is found in the form of games though teachers tend not use these in schools for only 3.5% of programs used were considered to be recreational. However, 18.9% of programs were considered to be both recreational and educational.

Several aspects of the software were noted as being particularly enjoyed by the children. These are all implicated in increasing the involvement of the user with the program. They are; the challenge issued by the program, competition between children and the computer, having a game or fantasy incorporated into the program, being able to operate the program, the pictures or sounds made by the program and getting the answer right. Thus the teachers'
observations confirm a number of the hypotheses discussed in Chapters Two and Three as to the causes of involvement with computers. Another aspect that was repeatedly commented on was that the program made the children think logically, this was considered an advantage by 31% of the teachers.

One major observation made during this survey was that the use of microcomputers in schools depends greatly on the attitude of the teachers and the physical availability of a computer. There is great potential for the use of microcomputers in teaching but environmental problems common in schools, for example, having to carry the computer from a safe place and set it up when it is needed or having to supervise children using the computer if it is kept in a separate room, mean that it takes a dedicated teacher to attempt to overcome these difficulties.

A further problem with teachers introducing computers in class is a lack of training and experience in their operation. Difficulties in running programs or in storing data embarrass the teacher and cause them to lose confidence in the computer and their ability to operate it. The use of cassette tape recorders and the poor quality of a lot of the software available do not help and may even bias teachers against using computers.

4.1.5) Conclusion

The majority of local primary schools were found to have microcomputers, however, their use varied widely with the attitudes and efforts of the teachers responsible for the microcomputers. A large number of programs were used and these appeared to fall into four main groups according to the involvement they generated in their users.
1) Low involvement due to poor quality of program.

2) Involvement due to basic interaction with the program, for instance in the "drill and practice" of simple arithmetic or spelling rules.

3) Greater involvement due to properties added to programs such as exciting graphics or games as rewards.

4) High involvement due to challenge and other intrinsic motivations in problem solving and adventure programs.

One program, an educational adventure game called Granny's Garden, was easily the most popular. It had graphics and sound, the challenge of completing the adventure, reinforcement from solving the problems and a fantasy to identify with. This program was recommended by all its users, held the children's attention and generated much work away from the computer. It follows that this is the most involving sort of program available in schools and further research into its intrinsic properties needs to be carried out in order to discover which create such involvement. Such research is described in Chapters Seven and Eight of this thesis.

4.2) Use of Computers by Secondary School Students

4.2.1) Introduction

This information is taken from the results of a questionnaire survey of secondary school students attending three local comprehensive schools. The survey was carried out in 1985 by G. Breakwell, C. Fife-Schaw and J. Spencer who were investigating young people's attitudes to new technologies. Several of the questions they included in their questionnaire were pertinent to the research discussed in this thesis and the results are included here with their permission. Some of these results have been recently been
published (Fife-Schaw, Breakwell, Lee and Spencer, 1986) but the work reported here is an original analysis of their data.

4.2.2) Method

Over 1700 children aged between 13 and 18 were asked to complete a questionnaire, in school, of which a section asked about their use of computers. The questions were on the frequency of computer use at school, whether it was enjoyed, whether they used a home computer, what uses they made of it and which languages they could program in.

4.2.3) Results

In all 1751 schoolchildren, 842 boys and 905 girls (data on gender missing from 4) with a mean age of 15.3 from the 4th, 5th and upper and lower 6th years of three secondary schools completed the questionnaire. The results are given in Table 4.4 below, where the figures do not add up to the total expected data is missing from the questionnaires.

Table 4.4. Results of survey of computer use by secondary school students.

<table>
<thead>
<tr>
<th>Question</th>
<th>Response Category</th>
<th>Number of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of use of</td>
<td>never</td>
<td>1025</td>
</tr>
<tr>
<td>computers at school</td>
<td>&lt; once a month</td>
<td>404</td>
</tr>
<tr>
<td></td>
<td>monthly</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>&gt;= once a week</td>
<td>256</td>
</tr>
<tr>
<td>Enjoyment of using</td>
<td>not at all/ not much</td>
<td>152</td>
</tr>
<tr>
<td>computers at school*</td>
<td>quite a lot</td>
<td>456</td>
</tr>
<tr>
<td></td>
<td>very much</td>
<td>215</td>
</tr>
</tbody>
</table>

* It is assumed that 100 children who said they do not use computers at school answered this question using past experience.
Table 4.4. (cont'd)

<table>
<thead>
<tr>
<th>Question</th>
<th>Response Category</th>
<th>Number of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership of home computers</td>
<td>do not have</td>
<td>863</td>
</tr>
<tr>
<td></td>
<td>have but do not use</td>
<td>119</td>
</tr>
<tr>
<td></td>
<td>use</td>
<td>763</td>
</tr>
<tr>
<td>Uses made of home computers</td>
<td>help with maths homework</td>
<td>192</td>
</tr>
<tr>
<td></td>
<td>writing games</td>
<td>438**</td>
</tr>
<tr>
<td></td>
<td>word processing</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>writing machine code</td>
<td>152</td>
</tr>
<tr>
<td></td>
<td>keeping files</td>
<td>229</td>
</tr>
<tr>
<td></td>
<td>using education programs</td>
<td>259</td>
</tr>
<tr>
<td></td>
<td>learning computer languages</td>
<td>357</td>
</tr>
<tr>
<td></td>
<td>playing games</td>
<td>709</td>
</tr>
<tr>
<td>Number of uses made of home computers</td>
<td>1 or 2</td>
<td>276</td>
</tr>
<tr>
<td></td>
<td>3 or 4</td>
<td>322</td>
</tr>
<tr>
<td></td>
<td>5 or 6</td>
<td>152</td>
</tr>
<tr>
<td>Number of computer languages known</td>
<td>0</td>
<td>1063</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>545</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>3 or 4</td>
<td>35</td>
</tr>
</tbody>
</table>

** As this figure is unexpectedly large it is assumed that children included copying games programs from books or magazines in writing games.

Chi square was then used to test for association between subjects' age, sex, school and number of exams passed and expected to be taken and their use of computers. The resulting values for are given in Table 4.5 on the next page.
Table 4.5. Association between computer use and age, sex, school and scholastic ability for secondary school students.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Use of computers at school</th>
<th>Enjoyment of computing at school</th>
<th>Use home computer</th>
<th>No. of uses</th>
<th>No. of computer languages</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>22.1**</td>
<td>17.9**</td>
<td>32.7**</td>
<td>20.2**</td>
<td>81.8**</td>
</tr>
<tr>
<td>15</td>
<td>53.4**</td>
<td>7.3*</td>
<td>33.1**</td>
<td>28.5**</td>
<td>79.7**</td>
</tr>
<tr>
<td>16</td>
<td>29.7**</td>
<td>3.27**</td>
<td>27.2**</td>
<td>16.1**</td>
<td>37.4**</td>
</tr>
<tr>
<td>17</td>
<td>16.6**</td>
<td>11.7**</td>
<td>17.0**</td>
<td>7.4</td>
<td>27.3**</td>
</tr>
</tbody>
</table>

* significant at p<.05
** significant at p<.001

The subjects were then divided into age groups to see whether the difference between sexes in their use of computers changed with age. Chi square was again used to test for association between gender and the other variables and the results are given in Table 4.6 below.

Table 4.6. Association with gender and computer use for the different age groups.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Use of computers at school</th>
<th>Enjoyment of computing at school</th>
<th>Use home computer</th>
<th>No. of uses</th>
<th>No. of computer languages</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>22.1**</td>
<td>17.9**</td>
<td>32.7**</td>
<td>20.2**</td>
<td>81.8**</td>
</tr>
<tr>
<td>15</td>
<td>53.4**</td>
<td>7.3*</td>
<td>33.1**</td>
<td>28.5**</td>
<td>79.7**</td>
</tr>
<tr>
<td>16</td>
<td>29.7**</td>
<td>3.27**</td>
<td>27.2**</td>
<td>16.1**</td>
<td>37.4**</td>
</tr>
<tr>
<td>17</td>
<td>16.6**</td>
<td>11.7**</td>
<td>17.0**</td>
<td>7.4</td>
<td>27.3**</td>
</tr>
</tbody>
</table>

* significant at p<.05
** significant at p<.001
4.2.4) Discussion

Children appear to use computers much more in primary schools than in secondary schools where, in the three surveyed, 58.5% of fourth, fifth and sixth year pupils had never used a computer at school. This is mainly because the computers are reserved for those doing computer studies, often kept in a separate room and are not easily made available for use in other lessons. There may be introductory courses in computing where a class uses the computers for a short while but these are widely spaced, only 18.2% of the subjects used computers every month or more often at school. These regular computer users are either doing an examination in computing or belong to a club which uses the computers in breaks or after school. However, of those who do use computers at school 81.5% enjoyed doing so.

Slightly more children (43.6%) use home computers than use them in school. By far the most popular use of home computers is playing games (92.9%) followed by writing games or copying them from magazines and books (57.4%). Other uses of home computers are using educational programs (33.9%), keeping files (30%), help with maths homework (25.2%), writing in machine code (19.9%) and word processing (12.6%). It is not surprising that nearly all home computers are used for playing games since the cheapest and most popular computers are designed for game playing only. Their keyboards are uncomfortable, difficult to type with and each has its own idiosyncratic version of BASIC to program in. However, quite a number of the subjects (38.8%) can program in one or more languages.

When computer use was compared for the different sexes, boys were found to be significantly more likely to use computers more
often at home and at school, to enjoy using them more, to make more uses of a home computer and to be able to program in more languages. This statistically significant difference holds throughout the age range from 14 to 17 years old except for two associations, between 16 year olds and enjoyment of computing at school, and 17 year olds and number of uses made of a home computer.

Other variables found to affect computer use are age, school and number of exams (CSEs, O and A levels) taken or intended to be taken. Fourteen and sixteen year olds are more likely to use computers at school, probably because these age groups coincide with computing courses. Younger children are also more likely to have a home computer. The school attended is related to, as would be expected, computer use at school and to number of computer languages used for one school appears to teach a computer language whereas the others do not. The greater the number of exams taken and to be taken by the student, the more often they use computers in schools and the more likely they are to use home computers. Computing courses appear to be available to those who are already able to cope with a wider range of subjects and with more computing experience, the more likely it is that home computers will be acquired.

4.2.5) Conclusion

The results on computer use are very different from those for primary schools, with over half the secondary school students having never used a computer compared to very few of the primary school children. In secondary schools, computers appear to be used mainly for teaching computing whereas in primary schools computers are used for work in all subjects. Also the results show clearly that once
children get older the sex of an individual is likely to affect their involvement with computers, boys becoming much more involved with computers.

The most popular use of computers outside school is playing games with very nearly all those with home computers using them to play games. Children appear to become much more involved with playing games, usually arcade games, than with other software. Further research on involvement, described in Chapters Seven and Eight of this thesis, includes studies of the various aspects of computer arcade and adventure games that appear to cause such great involvement with them.
CHAPTER FIVE

A PRELIMINARY MODEL OF USER INVOLVEMENT WITH EDUCATIONAL SOFTWARE AND COMPUTER GAMES

"..., then draw the model;"

- William Shakespeare (1564-1616)

Henry IV Part II
5.1) Introduction

As discussed in Section 3.1, the concept of user involvement with a microcomputer program consists of many different components but can generally be defined as the extent to which a student is actively participating in or interacting with a program. Examples of differing levels of user involvement with software appear in the survey of computer use in local primary schools discussed in Section 4.1. For instance, low involvement might occur with an arithmetic, drill and practice program where the user merely has to produce the right answer and high involvement with an adventure game where there are many problems to be solved. In the former case, to paraphrase Papert (1980), the computer is programming the child (to produce correct answer at the correct moment) and in the latter the child programming the computer (making decisions to solve problems and reach the end of the adventure).

5.1.1) Types of Involvement

Previous work on computers in education has shown that the amount of involvement of the user with the software varies considerably. For instance, in a study of computer use in maths lessons in secondary schools Philips, Burkhardt, Coupland, Fraser and Ridgeway (1984) noted three styles of computer use in a classroom. These are the electronic blackboard where the pupil is merely watching the computer screen, competitive use, where there is a competitive challenge in the program and pupils can win by beating the computer or each other's scores, and investigative use, where the computer provides a system, usually a simulation, to be explored. Thorne (1982) goes further in a critical look at the hardware and software currently available to teachers and states
that the most important non-technical aspect of a program is the style adopted in its interaction with the user. In the evaluation of the National Development Program for Computer Assisted Learning (NDPCAL), Kemmis, Atkin and Wright (1977) developed a framework to help in the understanding of CAL consisting of four educational paradigms which describe the different types of computer software. These are the instructional paradigm, encompassing programmed learning and drill and practice, the revelatory paradigm, involving learning by discovery through the use of simulations, the conjectural paradigm, using the computer to build and evaluate models and the emancipatory paradigm, using the computer for calculations and information handling so freeing the user to concentrate on the learning experience.

There appears to be a major division between one style of interaction with a computer mentioned above and the others. When the computer is used as an electronic blackboard, it is separate from or external to the actions of the user. In other styles of interaction such as answering questions or playing a game the user's actions are incorporated into or internal to the software. Some programs may use both these styles for example, a tutorial provides information and then tests to see whether the user has absorbed it.

5.1.2) Types of Learning

Different aspects of involvement can also be seen in the different styles of learning noted by Gagne (1977) who described four types of learning capabilities which may be applied to learning from computers. These are: intellectual learning which is learning and testing rules or concepts, cognitive learning which is problem solving using previously learned rules, verbal information learning
which is learning from reading or hearing about a subject and motor skill learning which is developing and testing motor skills. Software produced for games or education can readily be described using Gagne's types of learning. Examples are adventure games and interactive simulations which are cognitive learning, arcade games which are motor skills learning, programs used as an electronic blackboard which are verbal information learning and drill and practice programs which are intellectual learning. Since computer software makes use of graphics to present information, visual information will also be included with verbal information learning.

Different types of learning were also produced by Guttman (1965) in work on the structure of interrelations among intelligence tests. He found that intelligence is measured in two ways: the first, the analytical ability, tests understanding of rules and the second, the achievement ability, tests ability to use rules. However, these are already combined in Gagne's concept of intellectual learning. Guttman goes on to note that information in a test can be communicated in three modes: visually, in the form of pictures, verbally, in a natural language and symbolically, using a more formalised language e.g. arithmetic or music. The information presented by educational computer programs can also be considered as being presented in these three modes.

5.1.3) Motivation to Use Software

Previous work on involvement of a user with software has concentrated on motivation to use the computer, especially on motivation to use arcade or video games. The more motivating a program is, the more likely the user is to become involved with it. The research, described in this section, has itself concentrated on
discovering the potentially motivating properties of computer software.

In a study to find predictors of successful arcade machines Schaffer (1981) looked at a number of attributes of the games which could motivate people to play them. He rated the machines on a number of motivational attributes taken from studies on intrinsic motivation and common beliefs in the arcade industry. A factor analysis of these ratings produced five dimensions underlying the motivational attributes of the games, motivation to use a game being indicated by the amount of revenue it took. Schaffer called these dimensions complexity, type of fantasy, user involvement and control, novelty and loudness. Dimensions along which video games are perceived to vary was also the subject of a study by Bobko, Bobko and Davis (1984). They asked American college students who were experienced video game players to make pairwise comparisons of the similarity of ten commercial video games and an "ideal" game. Using multidimensional scaling they found three underlying dimensions destructiveness, dimensionality and graphic quality. Their concept of destructiveness is very similar to Schaffer's violent/non-violent type of fantasy dimension, in addition, dimensionality can be considered as a form of complexity.

Even when discussing the motivation produced in students by the introduction of computers into the classroom Nash and Ball (1982) feel the need to draw parallels to arcade games. They argue that the computer itself is new and exciting, it can provide a game structure in which to learn. It may also produce strong motivation intrinsic to learning in the use of simulation games.
In the first major study of arcade games, Malone (1980, 1981a and b) investigated motivation to use computer games in greater depth and found that educational computer games could provide intrinsically motivating instruction. His theories are described in detail in Chapters Two and Three. From experiments with different versions of a sensorimotor game and a cognitive skill game, altered to demonstrate different motivational properties, he proposed a theory of instructional game design based on three categories of motivation: challenge, fantasy and curiosity.

The work of Schaffer, Bobko et al, Nash and Ball and Malone, when taken together, provides a number of ways of considering most qualities of software used by children but leaves open the question of differences between educational programs and games. The theories of the motivational basis of educational software focus on the attractive features taken from arcade games. However, it is not possible to specify from these studies just what ought to be introduced to educational programs in order to make them as motivating as games. The present study proposes that a further, fruitful way of looking at motivation is in terms of degrees of involvement of the user with the software.

Central to this argument is the proposal that all the ideas discussed so far except for mode of information presentation are providing different labels for a single dimension underlying all interactions between users and software, and that these labels represent varying degrees of involvement. The concept of software forming a single dimension is supported by Psotka (1982) who suggested defining computer based instruction using a unidimensional taxonomy that ranged from passive drill and practice or information
display software to fully interactive tutorials. It is further proposed that it will be possible to relate the qualitatively different styles of computer use caused by the motivational properties of the software discussed here to quantitative differences in the amount of involvement produced in the user.

Thus the present model suggests that the motivational difference between games and educational programs is the degree of involvement of the user. If we can specify what aspects of software change as user involvement changes we will learn more about motivation itself. This would also contribute to the design and development of motivating software.

Investigating the argument that there is a central hypothesis underlying various category schemes requires an experimental approach which allows the exploration of both quantitative and qualitative differences. For this reason and, in order to organise the different aspects of user involvement with software, the facet approach was chosen.

5.1.4) The Facet Approach

This approach (Brown, 1985) offers a set of principles to guide research design and also provides a companion set of multivariate statistical procedures with which to analyse data. A facet is a category underlying a group of observations and the relationships between facets and their content are given by the mapping sentence.

A mapping sentence is used to relate formally the categories of the different facets involved to the range of behaviour produced. It is a device for summarising all the facets involved in a domain and for indicating broadly the relationship between those facets. Put simply a facet is any exhaustive set of exclusive categories for
classifying a population of observations. Empirical data are then collected in terms of this specification. It is expected that there will be a demonstrable correspondence between the conceptual structure and the empirical observations and a rationale produced as to why this is so.

In fact, as described in Section 3.1, early facet researchers have already looked at and produced a general principle relating to involvement. Levy (1979) proposed the following mapping sentence called the First Law of Involvement.

An item belongs to the universe of involvement items if and only if its domain asks about the amount of contact in a modality with an object and its range is ordered from to amount of contact with that object.

In the mapping sentence above items are being classified on the basis of their content and modality. In the present study the objective is to classify educational software and use that classification as a basis for establishing the major variations in such software. In facet terms there are a number of potential facets for categorising software but it is hypothesised that the two facets of mode of and involvement will account for them all.

Facet Model

As a preliminary stage in carrying out the study, the following mapping sentence was produced to describe educational computer software with the objective of producing a coherent model of motivation, involvement and learning based on existing software.
Program (p) motivates a user through ( goal ),
( variable goal )

( no fantasy ) ( no curiosity )
( extrinsic fantasy ) and ( cognitive curiosity ) with
( intrinsic fantasy ) ( sens+cog curiosity )
( sensory curiosity )

( external ) ( verbal mode )
( external+internal ) interaction in the ( visual mode ) producing
( internal ) ( symbolic mode )

( verbal/visual information )
( intellectual ) learning and its range is ordered
( cognitive )
( motor skills )

( lesser )
from ( to ) amount of involvement with that program.
( greater )

It is based on the theories of different types of motivation and involvement discussed earlier. In Malone's (1980, 1981a and b) three category theory the most important part of challenge is the existence of a goal, if the goal is variable, i.e. success in attaining the goal becomes more difficult to achieve as the program user becomes more skilful, the challenge is maintained at a high level. Fantasies may either be extrinsic or intrinsic to the material being learnt, Malone claims that intrinsic fantasies are both more interesting and more instructional than extrinsic ones. Curiosity may be stimulated by sensory effects such as sound and graphics or in a cognitive way creating a desire in the user to know more. Interaction with the computer may be external to the user as in the electronic blackboard style of use proposed by Philips et al (1984) or internal when the user is required to physically interact with the software. Like Guttman's (1965) intelligence tests educational software presents the information to be assimilated in one of three modes. Finally, software may be grouped according to
Gagne's four types of learning, each of which is proposed to
generate different levels of involvement in the learner.

As each facet is an independent classification scheme for all
programs, the following mapping sentence represents a great number
of possible combinations of the categories from each of the six
facets. These combinations are called structuples. The object of the
study is to see which structuples are represented by existing
programs, this will help focus on the most productive facets.

The following study was set up to explore the ways in which the
different categories and facets taken from the literature to form
the above mapping sentence relate to each other. The hypothesis
being tested is that these facets form a coherent system when
applied to a representative random sample of software and that this
system will be explicable by a more parsimonious facet structure.

5.2) Method

Fifty educational and fifty games programs were chosen at random
from the Software Index. This magazine provides short descriptions
of software produced for a variety of microcomputers by companies
that have registered for VAT. The study was restricted to software
available for the BBC Micro because of its extreme popularity in the
educational field.

Using each facet of the mapping sentence, goal, fantasy,
curiosity, interaction, mode and type of learning, as a variable
each program was assigned to one of its categories. The assignment
was based on information contained in the program description. This
produced a data matrix of 100 programs by six facets where each cell
contained the category number. This matrix was then analysed by the
MSA-I program (Lingoes, 1973) which produced two and three dimensional spatial plots representing the data.

The MSA-I program performs a Guttman-Lingoes Multidimensional Structuple Analysis (MSA) and was chosen because it is particularly applicable to qualitative or categorical data where each object (in this case a microcomputer program) is represented by a profile of categories within variables. The profile of a program will represent a structuple of the mapping sentence but all structuples may not be represented by existing program profiles. MSA represents the structuples/profiles as points in a geometric configuration in space and enables the researcher to establish whether for every category comprising the structuple there will be a clear partition of the space into regions. MSA is most often used to produce a two dimensional configuration but a three dimensional solution can be produced if the data cannot be adequately represented in two dimensional space. Unlike factor analysis, which has been previously used in software research (Schaffer, 1981) MSA makes no assumptions of ordered variables and linear dimensionality.

5.3) Results

Of the 100 programs entered into the data matrix many were assigned to the same categories in each facet. For instance, Stratobomber and Space Shuttle are just two of the games sharing profile number 30. In all, 40 separate profiles were produced from the 100 programs, the 50 games programs produced only 12 different profiles whereas the educational programs reduced to 28 profiles. Therefore, games tend to be more similar to each other than educational programs in terms of the facets used. Educational programs differ in style and methods of presentation as well as
subject whereas games programs fall into a few styles and differ mainly between subjects. The overall plot of program profiles resulting from the two dimensional MSA solution is shown in Figure 5.1 below. The position each profile is plotted in is indicated by a numbered point in the plot.

**Figure 5.1. Overall plot produced by MSA showing configuration of program profiles of types of motivation and involvement**

This plot shows the resulting configuration of points in space, each point representing a program profile, that the MSA has produced after several iterations in order to provide contiguous regions for as many of the categories of each facet as possible. The plot shows a wide semicircular spread of educational programs culminating in a close group of games at the upper right hand corner. The educational
programs range from those where the user is expected only to attend to what is on the screen (on the left) through interactive drill and practice programs (middle and lower right) to those where he or she is expected to be actively involved in problem solving and simulation (middle right).

The individual plots showing the categories for each of the five facets where regions can be seen are shown in Figure 5.2 below.

Figure 5.2. Individual plots produced by MSA showing regions for the categories of each facet of the mapping sentence (except for mode).

* Profile plotted out of expected region
The individual plots have the same configuration as the overall plot but in place of the profile number the number of the category that the programs were assigned to is shown.

For each variable except mode of information presentation the individual plots can be divided into regions for each category of the variables. In these there can be seen that there is a change in the amount of involvement or motivation of the user when moving anti-clockwise from region to region. For instance, in b), there is anti-clockwise movement from no fantasy through extrinsic fantasy to intrinsic fantasy. In general there is an increase in involvement when moving anti-clockwise until reaching the games in the upper right hand corner.

Programs with variable goals, an intrinsic fantasy and sensory curiosity have the highest involvement which supports the work of Malone (1980, 1981a and b). Motivation can be seen to increase from no goal through goal to variable goal in a), from no fantasy through extrinsic fantasy to intrinsic fantasy in b), and from no curiosity through cognitive curiosity to sensory curiosity in c).

Interaction increases from information presented for the student to learn (external) to learning gained by interacting closely with the program (internal) as shown in d).

The types of learning in f) also show different aspects of involvement of the user: verbal/visual information learning where the user is passively watching, intellectual learning where the user is interacting with the program, cognitive problem solving and learning complex motor skills where the user becomes increasingly involved.
Thus the facets of the mapping sentence except for mode of information presentation can be incorporated into an overall facet of involvement. Involvement with the computer programs increases as their profiles are plotted further, in an anti-clockwise direction, around the overall plot as shown in Figure 5.1.

The three dimensional solution to the MSA was also calculated and plotted. In this case three overall plots are produced showing the solution from the three orthogonal angles, the X, Y and Z directions in Cartesian geometry. For the purposes of the analysis these directions are termed vector 1, vector 2 and vector 3. In the three dimensional solution to the MSA the individual variable plots, except for mode, show the same division into regions when vector 2 is plotted against vector 1. However division of categories into separate regions for each mode of information presentation occurs when vector 3 is plotted against vector 2 as shown in Figure 5.3 on the next page. It is also possible to partition the plot of vectors 3 against 2 for type of learning into separate regions for each category.

The existence of regional divisions for mode in a plot drawn from an orthogonal viewpoint to that in which the divisions for involvement occur implies that there is a second orthogonal facet to that of involvement, and that is mode of information presentation. This may also be related to types of learning involved.
Figure 5.3. Individual plot for mode of information presentation produced by 3 dimensional MSA

* profile plotted out of expected region

5.4) Discussion

From the results of this study educational software can be seen to have an overall structure that differs along two facets. The first shows division between levels of involvement with the software and motivation to use it and the second the different modes in which the information is presented. Involvement with a program can be seen to consist of many aspects such as challenge, curiosity and type of learning which act together to produce the facet.

The first facet, the level of involvement of the user with the software is the most apparent. This encompasses motivating aspects as the more motivating a program is, the more the user becomes
involved with it. The three styles of computer use of Philips et al (1984); the electronic blackboard, competitive use, and investigative use fall along this facet. The level of involvement of the user in each of these cases is minimal for the electronic blackboard, high with motivation through direct challenge for the competitive style and high with motivation through curiosity for the investigative style. Also the different paradigms of Kemmis et al (1977) represent different levels of user involvement. Involvement being low for the instructional paradigm (drill and practice) and high for the revelatory paradigm (learning by discovery).

The importance of user involvement with software in both education and games can be seen in that involvement underlies the passive-interactive dimension of computer based instruction (Psotka, 1982) and together with control was found to be one of several dimensions of arcade machines (Schaffer, 1981). User involvement is also related to the continuum of internalisation developed by Krathwohl, Bloom and Masia (1956) when producing a taxonomy of educational objectives in the affective domain. They proposed a continuum of internalisation when learning attitudes which goes from being aware through being willing to attend and respond to actively seeking out. In the study discussed here, users are aware of a demonstration program, respond to an interactive program and actively seek the rewarding game type programs.

Finally, software falling into Gagne's four types of learning can be seen to have different levels of user involvement. Visual/verbal information learning requires the user merely to read the screen, intellectual learning requires more involvement, the user has to learn and be tested on rules. Cognitive learning requires the
user to become more involved in solving problems and lastly motor skill learning requires the user to become highly involved in practising the skills used.

The second facet supported is the mode of information presentation visual, verbal or symbolic. Interaction with a computer is primarily a process of communication and so this facet represents the different "languages" in which the computer communicates with the user. In this case the mode refers to the information being taught or used, otherwise, most programs could be considered as visual since many use graphics for illustration or reward. It is suggested that the occurrence in the 3-dimensional MSA of similar regions for mode and types of learning is because, at the moment, intellectual learning software uses verbal or symbolic modes, cognitive learning software tends to use the verbal mode, information learning software uses verbal and visual modes and motor skills software uses the visual mode. In the future other modes may have to be added to the three originally developed by Guttman (1965) for pen and pencil intelligence tests as microcomputer hardware becomes more sophisticated. For instance a light pen or digitiser pad can already provide graphic input and speech synthesis and recognition are considered to be feasible.

However, before significant conclusions could be drawn from this study further research needed to be carried out to confirm both this overall structure and the correct assignment of programs to the categories for each facet using information gained from software descriptions.
5.5) Further Investigation of the Model

In this second investigation of the categories and facets taken from the literature program examples were selected to illustrate the overall proposed structure in a more representative fashion. This was in order to look for clearer indication of the structure. It also examines inter-rater reliability in the interpretation of the descriptions of the programs and the facet categories taken from the literature.

5.5.1) Method

A sorting task was used in order to assess whether the assignment of the categories to software discussed earlier was replicable by others. The multiple sorting task described by Canter, Brown and Groat (1985) was used with the subjects being given the categories into which they were to sort the software.

Eight subjects were given typed descriptions of 12 games and 12 educational programs taken from Software Index and asked to sort them in several ways. The software was deliberately chosen to provide as wide a variety of programs as possible and to contain examples of all the categories previously suggested. The subjects were first asked to sort the software descriptions freely into groups according to similarities between them. This was to accustom them to the idea of the sorting task. They were then given a description, taken from the literature, of each of the following variables; challenge, fantasy, curiosity, interaction, type of learning and mode of information presentation. They were asked to sort the software according to these descriptions. Each variable represents a facet of the original mapping sentence. Finally, they
were given the opportunity to do another free sort if they could think of further ways in which to describe the programs.

The results of the six compulsory sorts, a data matrix of 24 programs by 48 sorts (six sorts for each of the eight subjects) where each cell of the matrix is occupied by the number of the category of each variable that the program was assigned to, were analysed, again using MSA-I (described in Section 5.2).

5.5.2) Results

In this case the MSA produces a configuration of points in two dimensional space where each point represents a program profile so that regions of that space are produced for as many of the categories of the six facets as possible. The program profile is made up of the categories that the program was assigned to in each sort. The plot resulting from the MSA of the sorting task is shown in Figure 5.4 on the next page.

Each program used in this sorting task is listed in Appendix 5.1 together with the number of its profile shown in Figure 5.4 and the number of its profile used in the original analysis shown in Figure 5.1.

The points representing the profiles of the educational programs can be seen to be spread around a horseshoe with a close group of profiles of games at the right hand point, again showing a wider variety of educational programs (their profiles are more spread out) than games.
Figure 5.4. Overall plot of MSA of program profiles produced by the sorting task.

The horseshoe shown in Figure 5.4 above is made up of a number of definite groups of profiles and by using PASTA, a microcomputer program developed by the author to analyze sorting tasks, to look at the categories common to each group six types of software are proposed. PASTA (Program Analysing Sorting Tasks) operates on the data matrix produced by the sorting task and can produce the descriptions of the categories that the programs were assigned to or the descriptions common to a particular group of programs. Each of the six types of software shows different aspects of user involvement and there is a trend of increasing involvement from a)
to f). Mode of information presentation was found not to be related to these groupings.

The programs are shown, in their groups as plotted by the MSA, in Table 5.1 on the next page, where an X in a column represents the assignment of a program to that category by more than half of the subjects.

5.5.3) Discussion

The MSA plot resulting from the sorting task appears as a horse shoe shape, indicative of a single dimension running through the points (Kruskal and Wish, 1978). In this case it suggested that the dimension is the amount of involvement expected of the user with the software. The user involvement increases in an anticlockwise direction from demonstration type programs through learn and test programs to highly motivating games.

The results of this experiment confirm the existence, postulated earlier in Section 5.4, of the continuum of involvement underlying the different types of software. This replaces the theory that earlier researchers have suggested of games having specific motivational properties that once discovered could be tacked on to educational programs to make them more fun. Instead there is a central, underlying dimension with highly involving games at one end and non-involving, non-interactive educational programs at the other. Inbetween these lie programs that engender varying amounts of involvement through different combinations of these motivational properties.
Table 5.1. Software groupings and the categories of the involvement facets they were assigned to.

<table>
<thead>
<tr>
<th>Software Type</th>
<th>Profile No.</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Simulation or demonstration programs providing information.</td>
<td>5</td>
<td>X X X X X</td>
</tr>
<tr>
<td>b) Educational programs providing information and testing knowledge.</td>
<td>10</td>
<td>X X X X</td>
</tr>
<tr>
<td>c) As b) but with fantasy and graphics added to provide motivation.</td>
<td>7</td>
<td>X X X X X</td>
</tr>
<tr>
<td>d) Game in text only or simulation of a traditional game.*</td>
<td>2</td>
<td>X X X X X</td>
</tr>
<tr>
<td>e) Adventure or puzzle solving game with graphics.</td>
<td>11</td>
<td>X X X X X</td>
</tr>
<tr>
<td>f) Arcade type game involving motor skills, sensory stimulation and fantasy.</td>
<td>12</td>
<td>X X X X</td>
</tr>
</tbody>
</table>

* A possible reason for the separation of these from the other problem solving games (group e) is lack of motivation to play them. Either they have no graphics or they are not novel and so do not hold any sensory curiosity for the user.

** These can be divided into two further types destructive and non-destructive. When producing a multidimensional scaling of video games Bobko et al (1984) considered this to be an underlying dimension along with graphic quality and dimensionality.
It should be noted that there was little agreement between subjects on the concept of goal when they were judging to which category to assign the program descriptions. It is suggested that there are several different goals to be obtained by a program user and the subjects had conflicting ideas as to which goal was in question. The idea of the goal being the overall challenge provided by the program is too vague and needs clarification into component goals. Even for the goal variable in the first MSA, shown in Figure 5.2, two profiles were plotted in a region that corresponds to a different category.

As the level of involvement of the user has been shown to vary quantitatively with the type of program used it is proposed that programs could be assigned to points on a scale of involvement produced by them. The following scale has been developed from the results of the two studies described in this chapter and will be tested as described in the next. The types of software given below are listed in order of increasing involvement.

1) Poor quality programs - If a program is of very poor quality it is difficult to get at all involved with it.

2) Drill and Practice programs - These present the user with a number of questions, check the user's answers and provide feedback on their correctness. Usually each program tests a rule using some questions based on the rule that are repeated with different numbers or subjects. The better programs explain the rule when errors occur.

3) Drill and Practice programs with graphics - These are similar to those in 2) but are enhanced by the use of graphics and sound effects. Graphics are used most often to differentiate between right and wrong answers and reinforce the right answer. They are also used
to illustrate questions and to entertain the user.

4) Drill and Practice programs with a game - Again these programs are similar to those in 2) but enhanced by a the inclusion of a game of some kind. The programmers have noted the highly motivating effect of computer games and use the game either as reinforcement for correct answers or incorporate it into the answering routine e.g. shooting down the right word.

5) Problem Solving programs - These programs are more complex, the user has to apply learned rules in order to solve problems. The most popular of these are known as 'adventure games'. There are now several educational adventure games incorporating mathematics and language skills.

6) Creative programs - These are programs that enable the user to create something else. For instance a graphics package to enable picture drawing, word processing software or even data processing software where the user creates files and manipulates the data within them.

7) Computer Games programs - These are computer versions of arcade games involving motor skills. They are well known for their apparently infinite attraction to children and teenagers.

5.6) Conclusions

The results of the two studies reported here support the idea that computer software, whatever topic it is dealing with, can be described using two facets. The most obvious facet is the extent of involvement of a user with the software and a second, orthogonal facet is the communication mode in which the information is presented. Thus several facets of the original mapping sentence can
be seen to be working together to produce the overall facet of involvement of a user with a program.

It has been demonstrated that software can be assigned to separate groups according to the amount of involvement required from the user. In this case involvement is defined as the extent to which the user actively participates in and interacts with the computer program. This applies over a spectrum of software from educational programs to arcade games, and is hypothesised to include operations software such as word-processing or computer languages. This continuum of involvement, together with the mode of communication through which this involvement occurs can be considered as an overall method of classifying software.

This concept of user involvement depends on the motivation caused in the user by the software, the more motivating the software, the more likely it is that users will become heavily involved in it. However, further research is required to clarify how such motivation to use problem solving and games software is created. From observation of the results of the two studies described here and of the survey of software used in primary schools, described in Chapter Four, it is proposed that this motivation is mainly due to challenge from the programs to the user and the curiosity of the user to explore the programs. Studies investigating these ideas are reported in Chapters Seven and Eight of this thesis.

It has been shown that users become involved to a certain level with a program according to its type but not whether they learn more when more deeply involved. It seems obvious that the more attention that one is paying a program the more that is being learnt from it.
but again further research is required. A study investigating this hypothesis is described in Chapter Seven of this thesis.

Another possibility for research is to identify those involving aspects of arcade and adventure games that are actually amenable to introduction into educational software. If this research were taken up by software developers, along with more consideration of the abilities of the potential users, the poor state of much of the current educational software (Sage and Smith, 1983) could be remedied.

One of the most important aspects of these studies is the potential contribution to the psychology of learning and motivation. Should the different aspects of involvement with microcomputer software be clarified the results will be transferable to other learning situations. This is discussed further in Section 10.3.
CHAPTER SIX

A SCALE OF SOFTWARE TYPES ACCORDING TO POTENTIAL FOR USER INVOLVEMENT

"Where order in variety we see,"

- Alexander Pope (1688-1744)

Windsor Forest
6.1) Development and Testing of a Scale of Software Types According to Potential for User Involvement.

6.1.1) Introduction

In Chapter Five it was proposed that microcomputer programs used in schools could be assigned to points on a scale of potential for user involvement. The scale, given below, was developed from the results of the two studies described in Chapter Five. Section 6.1 describes a third study using the results of the survey of computer use in primary schools, reported in Chapter Four, to test the scale. The proposed types of software given in the following scale are listed in order of increasing involvement.

1) Poor quality programs - If a program is of very poor quality it is difficult to get at all involved with it. In order for involvement to occur with a program there must first be successful interaction between the user and the program. This will not occur if the user cannot make the program run or cannot make head nor tail of what appears on the screen.

2) Drill and Practice programs - These programs present the user with a number of questions, check the user's answer and provide feedback according its correctness. Usually each program tests a rule using some questions based on the rule that are repeated with different numbers or subjects. The better programs explain the rule when errors occur. These have a lot in common with the teaching machines advocated by Skinner (1968) for programmed learning. Involvement occurs with these programs mainly through challenge (Malone 1980, 1981a and b), the user responding to the challenge of the program to get the answers right. They may also provide challenge through the use of a variable difficulty level, abler
pupils being able to go on to a harder level or being given less time to answer the questions in.

3) Drill and Practice programs with graphics - These programs are similar to those in 2) but are enhanced by the use of graphics and sound effects. Graphics are used most often to differentiate between right and wrong answers and reinforce the right answer. They are also used to illustrate questions and to entertain the user. Sound and graphics increase the user's original involvement through challenge by creating sensory curiosity (Malone, 1980, 1981a and b) in the user. The increasing graphic complexity of the program motivates the user through curiosity to see what effects can be produced.

4) Drill and Practice programs with a game - Again these programs are similar to those in 2) but enhanced by the inclusion of a game of some kind. The programmers have noted the highly motivating effect of computer games and use the game either as reinforcement for correct answers or incorporate it into the answering routine e.g. shooting down the right word. As well as creating involvement through challenge and curiosity, the introduction of a game produces involvement through attempting to control the game. De Charms (1968) proposed that people are primarily motivated to produce change i.e. to control other objects. The game is nearly always an unsophisticated copy of a popular arcade game where the player has to control a spaceship, aeroplane or an imaginary animal. However, the graphics are much less complex than in commercial arcade games. In discussions with two educational software writers they both insisted that the rules to be learned should be incorporated as part of a game. However, it has been noted (Chandler, 1984) that in this
case children may learn merely how to win the game and do not manage to transfer the concepts learned to other situations.

5) Problem Solving programs - These programs are more complex, the user has to apply learned rules in order to solve problems. The most popular of these are known as 'adventure games'. There are now several educational adventure games incorporating mathematics and language skills. Involvement through challenge, curiosity and control are all included in the adventure game but are actually incorporated into the subject being taught as opposed to in a game added to a teaching program. The user is involved in the lesson itself and not in the game provided as a means of getting attention or a reward.

6) Creative programs - These are programs that enable the user to create something else. For instance a graphics package to enable picture drawing, word processing software for creative writing or even data processing software where the user creates files and manipulates data within them. The user becomes involved in controlling the computer to produce material which, if the user is successful, is extremely reinforcing (Skinner, 1984). There are all sorts of challenges to be taken up and as the user controls the level of complexity at which they work, this will increase as the user becomes more skillful causing greater involvement.

7) Computer Games programs - These are computer versions of arcade games involving motor skills. They are well known for their apparently infinite attraction to children and teenagers. The games manufacturers are highly skilled at manipulating the complexity of a game so that the initial curiosity and challenge felt by the user does not wear off. For, once the user becomes competent at the game,
they move to a higher, usually faster, level that provides a greater challenge. Through high involvement the users may even identify with the animal or spaceship they are controlling which is involving the ego as described by Allport (1943).

This study was set up to see whether the predicted increase in level of involvement with each type of software discussed above was reflected in the users' opinions of the software.

6.1.2) Method

First and middle schools in the local educational area were surveyed by telephone to ascertain whether they would complete a questionnaire about their computers and one was sent to all who said they would. The questionnaire was designed to discover what software was used in schools and which programs were the most popular. The recipients were asked to provide information on up to ten programs that they used. The questionnaire is given in Appendix 4.1 and the results of this survey are described in full in Chapter Four.

A content analysis was carried out on the responses to the questions asking the teachers for their and the children's opinions of the programs. Twenty programs, listed in Section 6.1.3, were chosen as representative of a wide range of user involvement and the responses on these programs were then analysed using MSA-I to give a spatial representation of the data. The procedure of and resulting plots produced by MSA-I are described in detail in Sections 5.2 and 5.3.

Also the scale of user involvement discussed earlier was directly compared with the results of the content analysis of the questionnaire survey. The children's and teachers' opinions of the programs were cross-tabulated with the level of involvement that the
programs were assigned to on the scale (from 1 to 7) described in Section 6.1.1. Chi square was used to test for association between the variables and Kendall's Tau to measure the strength of any association. These tests were carried out using the Statistical Package for Social Sciences.

6.1.3) Results

Information on 143 programs was returned from 42 schools, 61% of these were used by one school only, 21% were used in two schools and 18% in three or more schools.

The descriptions obtained from the content analysis of the teachers' and children's opinions of the programs they used are shown in Table 6.1 on the next page with the frequency with which they occurred. The table also gives the results of the cross-tabulation of opinion and scale of involvement, the number in each column is the number of programs assigned to that point on the scale.

For poor in the children's opinion and scale of involvement over half the cells have an expected cell frequency of less than 5.0 so the $\chi^2$ statistic cannot be relied on. However, there is a slight negative correlation ($\gamma = -.1$, $p<.05$) between the variables and 67% of the programs considered poor are assigned to points 2 and 3 on the scale.

There is no statistically significant association between programs considered good by the children and the scale of involvement, most (72%) of the programs were considered to be good.
Table 6.1. Opinions of the programs and crosstabulation with the scale of involvement.

<table>
<thead>
<tr>
<th>Children's opinion of program</th>
<th>Frequency</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>15</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Good</td>
<td>102</td>
<td>2</td>
<td>18</td>
<td>25</td>
<td>16</td>
<td>26</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Very good</td>
<td>36</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>9</td>
<td>13</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Fun</td>
<td>13</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Enjoy challenge</td>
<td>17</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>&quot; competition</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&quot; graphics or game</td>
<td>23</td>
<td>0</td>
<td>1</td>
<td>11</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>&quot; being right</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Teachers' opinion</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>17</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Good</td>
<td>101</td>
<td>2</td>
<td>15</td>
<td>29</td>
<td>17</td>
<td>25</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Very good</td>
<td>48</td>
<td>1</td>
<td>6</td>
<td>14</td>
<td>7</td>
<td>15</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Fun</td>
<td>12</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Recreational</td>
<td>35</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>14</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Requires logical thought</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>10</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Programs considered very good by the children are associated with the scale of involvement ($\chi^2 = 15.6$, $p < .02$) though again the correlation is low ($\gamma = .18$, $p < .02$). 44% of these programs were assigned to points 5 and 6 on the scale.

There is no statistically significant association between programs considered by the children to be fun and the scale of involvement, nor between the scale and children enjoying challenge,
competition, being right or the added games or graphics in the programs. However, for the latter four, programs have been assigned more often to particular points on the scale. 35% of programs considered to have challenge were assigned to point 5, the cognitive problem-solving category which is twice as many as assigned to any other category. 72% of the programs considered to have competition were assigned to points 2 and 3, the enhanced drill and practice categories. 71% of the programs where children enjoyed being right were assigned to point 2, the drill and practice plus graphics category. Finally, 78% of the programs where the children enjoyed the game or graphics were assigned to points 2 and 3, the drill and practice plus games or graphics categories.

Whether a program is considered recreational by the teachers or not is associated with the scale of involvement ($X^2=38.4$, $p<.001$) and the two are positively correlated ($\gamma=.44$, $p<.001$). Indeed 77% of the programs considered recreational are assigned to the three highest categories on the scale.

However, there is no statistically significant association between programs considered poor, good, very good or fun by the teachers and the scale of involvement though 58% of the programs considered to be fun are assigned to points 3 and 7, the game and drill and practice plus game categories.

Programs that require logical thought are associated with the scale of involvement ($X^2=15.6$, $p<.02$) and there is a low, positive correlation between them ($\gamma=.24$, $p<.0001$). 50% of programs requiring logical thought are assigned to point 5, the problem-solving category.
Binary profiles for the 20 programs to be analysed using MSA-I were made up using the presence or absence of the comments discussed above, except for children enjoy competition and being right, as variables. These two were excepted as they occurred for less than 5% of the programs. The results of the MSA are shown in Figure 6.1 below.

**Figure 6.1.** Overall plot resulting from MSA of teachers' and children's opinions of programs used in local primary schools.

Each number in the plot indicates the position in which the program with that profile number is plotted, both the programs analysed using MSA-I and their profile numbers are given in Table 6.2.
It can be seen that the points representing the program profiles made up of children's and teachers' opinions of the programs fall into a horseshoe shape with Brick Up and Bus Stop at one pole and Granny's Garden and Crash at the other. The horseshoe shape is indicative of a single dimension running through all the points (Kruskal and Wish, 1978). Its presence confirms that one variable, user involvement, is responsible for differences between the programs. This horseshoe is equivalent to that described in Section 5.5.2 except that the proposed level of user involvement with the programs increases in an anti-clockwise direction around the horseshoe. The programs are given in Table 6.2 in the order that they were plotted around the horseshoe, together with a description of the sort of involvement produced and the point on the proposed scale of involvement the program was assigned to.

Table 6.2. Programs used in primary schools that are representative of different levels of user involvement.

<table>
<thead>
<tr>
<th>Profile No.</th>
<th>Name</th>
<th>Program Type</th>
<th>Point on Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Brick Up</td>
<td>Drill and Practice + Game</td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Considered poor as task is confusing.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Bus Stop</td>
<td>Drill and Practice + Graphics</td>
<td>(3)</td>
</tr>
<tr>
<td>15</td>
<td>Shopping</td>
<td>Simulation - Considered poor as time limit is extremely frustrating for slower children.</td>
<td>(1)</td>
</tr>
<tr>
<td>13</td>
<td>Let's Count</td>
<td>Drill and Practice + Graphics</td>
<td>(3)</td>
</tr>
<tr>
<td>17</td>
<td>Spelling Maze</td>
<td>Drill and practice + Game</td>
<td>(4)</td>
</tr>
<tr>
<td>11</td>
<td>Fraction Snap</td>
<td>Drill and Practice + Speed Challenge</td>
<td>(2)</td>
</tr>
<tr>
<td>14</td>
<td>Shape Shoot</td>
<td>Drill and Practice + Game</td>
<td>(4)</td>
</tr>
</tbody>
</table>
Table 6.2. (cont'd)

<table>
<thead>
<tr>
<th>No.</th>
<th>Profile</th>
<th>Name</th>
<th>Program Type</th>
<th>Point on Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ambilsum</td>
<td>Drill and Practice + Score kept</td>
<td>(2)</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Watchperson</td>
<td>Problem Solving</td>
<td>(5)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Bat 'n' Ball</td>
<td>Arcade Game</td>
<td>(7)</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Snapper</td>
<td>Arcade Game</td>
<td>(7)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Artmaths</td>
<td>Creating Pictures</td>
<td>(6)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Edword</td>
<td>Creating Stories</td>
<td>(6)</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Treasure Island</td>
<td>Problem Solving + Graphics</td>
<td>(5)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Drop Socks</td>
<td>Drill and Practice + Graphics</td>
<td>(3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Children find the graphics highly amusing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Dartt</td>
<td>Simple Programming</td>
<td>(6)</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Table Test</td>
<td>Drill and Practice + Speed challenge + and Score Kept</td>
<td>(2)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Air Traffic Control</td>
<td>Simulation</td>
<td>(5)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Crash</td>
<td>Simple Programming</td>
<td>(6)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Granny's Garden</td>
<td>Problem Solving + Graphics</td>
<td>(5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- An adventure game</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.1.4) Discussion

From the MSA of children's and teachers' opinions of software shown in Figure 6.1 it can be seen that the continuum of user involvement with computer programs proposed in the earlier studies is reflected in their opinions of the programs. Again the horseshoe shape of the plot is indicative of a single dimension running through the points and from descriptions of the programs it can be seen that this dimension is the amount of involvement they can be expected to produce in a user. The level of involvement seen on the
MSA plot increases from poor quality and drill and practice programs, through computer games to creative software and illustrated problem solving programs.

The order around the horseshoe in Figure 6.1 produced by the MSA of teachers' and children's opinions of the software is very similar to the order of the programs predicted according to the proposed scale thus confirming the presence of the scale of user involvement amongst software used in schools. Even where programs have not been plotted as expected other properties related to level of user involvement may be used to explain the anomalies.

For instance, three mainly drill and practice programs, Table Test, Amblsum and Drop Socks have been plotted further round the horseshoe i.e. generating more involvement than expected. However, they all keep track of the user's score of correct answers which would present an extra challenge to the user and so involve them. Table Test also incorporates answer timing so there is another challenge to answer as quickly as possible. In Drop Socks the children find the graphics of socks falling from a washing line particularly amusing. A simulation, Shopping, is shown as being low in involvement whereas it is an illustrated problem solving program simulating a shopping trip. However, there is only a fixed amount of time available to do the shopping else the user 'misses the bus back'. Slower children who 'miss the bus' every time they use the program become increasingly frustrated at their inability to operate the program successfully. Finally, the two arcade games are plotted only half way around the horseshoe, much lower in involvement than predicted. This can be explained in that Bat 'n' Ball is only a copy of a complex arcade game with much less sophisticated use of
graphics and no use of variable difficulty levels, and Snapper is too difficult for younger children to get involved with to any great degree of success.

The results of the crosstabulation show significant correlations between the proposed scale of involvement and that children consider the programs to be poor or very good and that teachers consider the programs to be recreational. This shows good agreement between some of the users' opinions of the software and the amount of involvement they have with the software as predicted by the scale. The higher the program on the scale of predicted involvement, the better the opinions of it. More specifically, the comments made by the users; the children enjoy the challenge, the competition, being right, the game, the graphics and the program requires logical thought were found to be associated with particular points on the scale.

One problem with this survey was the fact that nearly all the programs were considered good by at least one of the respondents providing information on them. One respondent commented "They (the children) enjoy using the computer so much I don't think they would mind which program they did." However, it is to be hoped that as the novelty of using computers wears off the children will become more discriminating.

6.1.5) Conclusion

The proposed seven point scale of user involvement with educational software with involvement increasing in steps from poor quality programs, through drill and practice programs, enhanced drill and practice programs, problem solving programs and creative programs to computer games has been shown to agree well with users' opinions of the programs. There was even greater agreement between
the users' comments on particular, favourable aspects of programs and specific points on the scale. When the users' opinions of the programs failed to agree with the level of predicted involvement, it could be seen that this was either due to poor quality of the software lowering the users' opinion, or due to inclusion of an extra challenge, such as scoring, thus increasing involvement from the predicted level and consequently raising the user's opinion.

In general a child is far more likely to become involved with a program that they have a high opinion of, the high opinion being generated by recognition of the involving properties of the program. From consideration of the programs used in the survey and previous research these involving properties appear to be largely made up from challenge from the program, complexity of the program and the opportunity to control it.

6.2) Further Investigation of User Involvement According to Software Type

6.2.1) Introduction

The scale of involvement described in the previous sections was based primarily on educational software. This second experiment was set up in order to gain information on children's involvement with programs used at home as well as at school, especially the many different kinds of computer games. The final point on the scale developed and tested earlier was labelled computer or arcade games but no effort was made to distinguish between the different types of games. By studying what it is about the games that makes them more involving, in general, than educational programs it is hoped to discover more about individual components of involvement.
Previous research on computer programs and motivation to use them have indicated several potential sources of involvement. Malone (1980, 1981a and b) proposed three categories of motivation, intrinsic to the program being used, to use software. These were a challenge from the program, curiosity to see the program and a fantasy involved in the program. The challenge may consist of goals such as beating the previous high score in an arcade game or reaching the end of an adventure game and is hypothesised to depend on an uncertain outcome to the program. Curiosity is made up of sensory curiosity, stimulated by the complexity of the program's use of graphic effects such as animation and colour, and cognitive curiosity, caused by desire to find the answer or to complete the story. Fantasy involves the player identifying with their role in the game.

Other researchers (Schaffer, 1981, Bobko et al, 1984) have noted the role of complexity in motivation to use computer arcade games. Schaffer using a stepwise multiple regression to predict revenue taken by arcade machines found that novelty, fantasy and display movement (three forms of complexity) together with user control predicted 53% of the variation in revenue. Two of the three dimensions found in video games by Bobko et al using multidimensional scaling techniques are forms of complexity, dimensionality and graphic quality, the third was destructiveness.

Again a questionnaire survey of primary school children was chosen as the simplest method of acquiring information on their involvement with computer programs. Eight questions were made up asking the children to assess the programs they knew in several
different ways in order to investigate how involved they became with the software.

6.2.2) Method

First the children's ability to rate programs was assessed using seven and eight year olds from the two first schools that had been attended regularly, in order to observe children using microcomputers, throughout the studies described in this thesis.

Ten pairs of children were introduced to a new program, allowed to play it several times and then were asked to rate how much they liked it on a four point scale. However, the children were not very discriminatory, 85% of the children used the highest rating indicating that if they were assessing a single program they were likely to rate it as good whatever it was like. In order to make the idea of rating clearer smiling faces and not so happy faces were used to illustrate the rating scale which was also increased to five points to include a neutral midpoint. Four more pairs of children were asked to rate both the new program and their favourite program using this scale, however, only one child used the negative side of the scale. Therefore, the points of the scale were revised to go from not at all through not much, some and quite a lot to lots and lots and the smiling faces redrawn appropriately. Five pairs of children rated three programs quite happily using this scale and only 53.3% of the ratings were in the highest two categories.

The scale chosen, together with eight questions to assess the children's involvement with the programs used, were printed on a question sheet as shown in Appendix 6.1. These question sheets were completed by all the primary schoolchildren who took part in the experiment on involvement and learning described in Chapter Seven.
together with any others present when the experiment was taking place. The children were asked to answer the questions for all the programs they used by entering the name of the program beneath the point on the scale indicating their answer. When, rarely, the children knew more than five or six programs they were asked to choose one that represented each group of similar programs. The children were also asked to include programming and word processing if they had used such software. Only a few of the children had difficulty filling out the form in which case a more able child was asked to read the questions to them and/or enter their answers.

6.2.3) Results

In all the questionnaire sheets were filled in by 373 children from nine local primary schools, 199 boys and 174 girls, whose ages ranged from 5 to 12 years with a mean of 8.39 years. The number of computer programs or games known by any one child ranged from 1 to 17 with a mean of 3.78.

Information was received for 1372 programs, though, as many children knew the same programs, this reduced to 420 different programs of which 307 were games, 95 were educational programs and the others were word processing, business, data handling, graphics or sound effects software and programming. Many of the programs were extremely similar, the only difference being the scenario of the game or the subject being taught, so they were reduced to 31 different types. These are listed in Table 6.3 on the following pages together with the frequency with which they occurred.
Table 6.3. Types of programs known by primary school children.

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Programming</td>
<td>36</td>
</tr>
<tr>
<td>e.g. BBC BASIC</td>
<td></td>
</tr>
<tr>
<td>2) Word processing</td>
<td>6</td>
</tr>
<tr>
<td>e.g. Wordstar</td>
<td></td>
</tr>
<tr>
<td>3) File handling</td>
<td>16</td>
</tr>
<tr>
<td>e.g. Factfile</td>
<td></td>
</tr>
<tr>
<td>4) Business software</td>
<td>3</td>
</tr>
<tr>
<td>e.g. Lotus 1,2,3</td>
<td></td>
</tr>
<tr>
<td>5) Graphics</td>
<td>7</td>
</tr>
<tr>
<td>e.g. Paintbrush</td>
<td></td>
</tr>
<tr>
<td>6) Sound effects</td>
<td>5</td>
</tr>
<tr>
<td>e.g. Sounds</td>
<td></td>
</tr>
<tr>
<td>7) Drill and Practice</td>
<td>122</td>
</tr>
<tr>
<td>e.g. Amblsum</td>
<td></td>
</tr>
<tr>
<td>8) Illustrated drill and practice</td>
<td>270</td>
</tr>
<tr>
<td>e.g. Dropsocks</td>
<td></td>
</tr>
<tr>
<td>9) Drill and practice with game</td>
<td>40</td>
</tr>
<tr>
<td>e.g. Brick Up</td>
<td></td>
</tr>
<tr>
<td>10) Tutorial</td>
<td>27</td>
</tr>
<tr>
<td>e.g. Eureka</td>
<td></td>
</tr>
<tr>
<td>11) Educational simulation</td>
<td>35</td>
</tr>
<tr>
<td>e.g. Survival</td>
<td></td>
</tr>
<tr>
<td>12) Problem solving</td>
<td>10</td>
</tr>
<tr>
<td>e.g. Watchperson</td>
<td></td>
</tr>
<tr>
<td>13) Illustrated problem solving</td>
<td>92</td>
</tr>
<tr>
<td>e.g. Treasure Island</td>
<td></td>
</tr>
<tr>
<td>14) Educational adventure</td>
<td>125</td>
</tr>
<tr>
<td>e.g. Granny's Garden</td>
<td></td>
</tr>
<tr>
<td>15) Fruit machine simulation</td>
<td>10</td>
</tr>
<tr>
<td>e.g. Fruit Machine</td>
<td></td>
</tr>
<tr>
<td>16) Simulation of a traditional game</td>
<td>35</td>
</tr>
<tr>
<td>e.g. Video Checkers</td>
<td></td>
</tr>
<tr>
<td>17) Simulation of rifle shooting</td>
<td>4</td>
</tr>
<tr>
<td>e.g. Quackers</td>
<td></td>
</tr>
</tbody>
</table>
Table 6.3. (cont'd)

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>18) Simulation of a 'plane or a submarine</td>
<td>14</td>
</tr>
<tr>
<td>e.g. Ace</td>
<td></td>
</tr>
<tr>
<td>19) Shoot 'em up game (movement in 1 plane)</td>
<td>78</td>
</tr>
<tr>
<td>e.g. Space Invaders</td>
<td></td>
</tr>
<tr>
<td>20) Shoot 'em up game (movement in two planes)</td>
<td>42</td>
</tr>
<tr>
<td>e.g. Defender</td>
<td></td>
</tr>
<tr>
<td>21) Game allows 2D control, restricted movement</td>
<td>55</td>
</tr>
<tr>
<td>e.g. Pacman</td>
<td></td>
</tr>
<tr>
<td>22) Game allows 2D control, free movement</td>
<td>61</td>
</tr>
<tr>
<td>e.g. Frogger</td>
<td></td>
</tr>
<tr>
<td>23) Ladders and levels game</td>
<td>43</td>
</tr>
<tr>
<td>e.g. Chuckie Egg</td>
<td></td>
</tr>
<tr>
<td>24) Platforms game</td>
<td>38</td>
</tr>
<tr>
<td>e.g. Jet Set Willy</td>
<td></td>
</tr>
<tr>
<td>25) 2D control of racing car or motorbike</td>
<td>36</td>
</tr>
<tr>
<td>e.g. Checkered Flag</td>
<td></td>
</tr>
<tr>
<td>26) 3D control of plane, spaceship or man</td>
<td>30</td>
</tr>
<tr>
<td>e.g. Blackhawk</td>
<td></td>
</tr>
<tr>
<td>27) 2D or 3D control of sportsman or fighter</td>
<td>38</td>
</tr>
<tr>
<td>e.g. Way of the Exploding Fist</td>
<td></td>
</tr>
<tr>
<td>28) Text adventure game</td>
<td>14</td>
</tr>
<tr>
<td>e.g. Colossal Adventure</td>
<td></td>
</tr>
<tr>
<td>29) Illustrated adventure game</td>
<td>32</td>
</tr>
<tr>
<td>e.g. Hacker</td>
<td></td>
</tr>
<tr>
<td>30) Arcade and adventure combined game</td>
<td>39</td>
</tr>
<tr>
<td>e.g. Elite</td>
<td></td>
</tr>
<tr>
<td>31) 3D Maze escape games</td>
<td>9</td>
</tr>
<tr>
<td>e.g. Monster Maze</td>
<td></td>
</tr>
</tbody>
</table>

The number of program types known by the children ranged from 1 to 10 with a mean of 3.37.

The number of programs known, and the number of different types of programs known were tested for association with the gender of the user. No significant association was found between gender and number.
of programs known but gender was found to be associated ($\chi^2 = 13.59$, p<.02) with number of different types known. Boys knew a significantly greater number of different types of programs. The sample was then broken down into age groups to see whether this difference in program use between sexes extended over the whole age range. The resulting values for association between gender and program use, tested using chi-square, are tabled below.

Table 6.4. Values of $\chi^2$ testing for association between gender and program use for different age groups of primary schoolchildren.

<table>
<thead>
<tr>
<th>Age</th>
<th>Number of programs known</th>
<th>Number of different types known</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;= 7</td>
<td>.62</td>
<td>7.01</td>
</tr>
<tr>
<td>8</td>
<td>4.28</td>
<td>7.05</td>
</tr>
<tr>
<td>9</td>
<td>5.94</td>
<td>6.54</td>
</tr>
<tr>
<td>&gt;= 10</td>
<td>13.44*</td>
<td>12.08*</td>
</tr>
</tbody>
</table>

* p<.01

The children's age was not found to be associated with the number of programs known but is associated with the number of program types known ($\chi^2 = 32.8$, p<.001), older children knowing more. Reading and writing ability was not associated with amount of software known however, both intelligence and mathematics ability were associated with number of programs known ($\chi^2 = 14.1$ p<.03 and =15.5, p<.02 respectively) but not with the number of different program types known. More intelligent children and those who were better at maths knew more programs.

The mean results for the children's answers to the eight questions eliciting their opinions of each program type are shown in the table in Appendix 6.2. These were recoded and used as profiles...
for each program type for multivariate statistical analysis using MSA-I (Lingoes, 1973). MSA is described in detail in Sections 5.2 and 5.3, the plots resulting from the MSA of children's opinions of program types are shown in Figures 6.2 and 6.3.

Figure 6.2. Overall plot for two dimensional MSA of primary school children's involvement with different program types

The numbers indicate the positions in which the profiles for the program types are plotted. They refer to the list of types given in Table 6.3.

The MSA plot is shaped like a horseshoe, very similar to the ones described in Chapters Five and Six. The programs can be seen to increase in involvement as one moves anti-clockwise around the horseshoe from profiles 7, 6 and 15 to 14.
Figure 6.3. Individual plots produced by MSA for each of the eight questions contributing to the profile of the program type analysed.

The contributions of the individual questions to the overall plot can also be immediately seen for liking the program type, wanting to do the program again, not wanting to stop, and finding the program exciting. These increase in the same anti-clockwise fashion as the horseshoe. For both amount learned from and level of interest in the program type, involvement increases linearly from the right side of the plot to the left indicating that these are closely related. Amount of concentration on the program type increases diagonally across the plot from bottom right to top left. Thus the horseshoe of involvement followed by like, do again, stop doing and exciting is produced by the combination of concentrate, learn from and interest in. Amount of difficulty with program type is more complex, as the program gets too difficult involvement is reduced so the most difficult programs are plotted at a middle level.
of involvement. The same process occurs at the lower end of the horseshoe where more difficult programs are plotted at a lower point of involvement than easier ones.

The relationship between difficulty and the other questions was further investigated by plotting the mean response of the children to each of the other questions about their involvement with the programs against the difficulty level that they assigned the programs to. The resulting graph is shown in Figure 6.4 on the next page.

The graph shows that, except for learn from and find exciting, all the responses to the questions increase with the first four levels of difficulty and then fall or slow their rate of increase at the highest level of difficulty. Thus involvement can be seen to increase with difficulty until a point where the program becomes too difficult after which involvement falls as it is impossible for a user to become involved with a program that cannot be operated successfully. The amount the children consider that they learn from a program increases throughout with difficulty, they appear to believe that the harder the program was the more they must have learnt from it. Excitement peaks earlier with level of difficulty than the other variables, it appears that it is the first aspect of involvement to disappear with increased difficulty. However, it rises again possibly with excitement generated by attempting that which was previously thought impossible.
Figure 6.4. Mean responses to questions used to assess involvement with plotted against perceived difficulty of programs.
6.2.4) Discussion

The results show that all the primary school children in the survey were familiar with microcomputers, knowing on average at least three different kinds of programs. The programs they knew could be classified into 31 groups, 17 different kinds of games, 8 types of educational software and 6 different software tools. Boys tended to know more different types of programs than girls.

The MSA of the questionnaire results for each type of program showed the now familiar horseshoe that indicates one dimension running through the programs and it is concluded that this is the facet of involvement originally discussed in Chapter Five. Involvement increases from drill and practice programs, through other educational programs, through simple and very complex games, through arcade games and software tools, to educational adventures. This provides further evidence to corroborate the scale of involvement discussed earlier in this chapter.

When the program types used in this survey are assigned to their equivalent points on the original scale of software according to potential for user involvement, the points can be seen to be positioned all the way around the horseshoe of involvement. However, creative software and arcade games do not separate from each other as envisaged from the scale. Also, the highest point on the horseshoe of involvement is occupied by educational adventure games. This also occurred in the first MSA of teachers' and children's opinions of educational software. Therefore, a further point must be added to the scale of involvement, one for adventure games which had previously been assigned to problem solving programs. However, as adventure games are not usually designed with young children in
mind, children in the age group studied in this survey find normal adventure games too complex and are less likely to become involved with them. The highest level of involvement is therefore shown with educational adventure games that have been designed for their level of comprehension.

The revised scale of software according to expected user involvement including an additional level for educational adventure games is shown in Table 6.5 below. The table also gives examples of the programs that are assigned to each point on the scale together with their profile numbers as plotted in Figure 6.2 and shown in Table 6.3.

Table 6.5. Revised scale of software types according to potential for user involvement.

<table>
<thead>
<tr>
<th>Software Type</th>
<th>Profile Nos.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Poor quality programs</td>
<td>6</td>
</tr>
<tr>
<td>2) Drill and practice programs</td>
<td>7</td>
</tr>
<tr>
<td>3) Illustrated drill and practice programs</td>
<td>8</td>
</tr>
<tr>
<td>4) Drill and practice programs with a game</td>
<td>9</td>
</tr>
<tr>
<td>5) Problem solving programs</td>
<td>13</td>
</tr>
<tr>
<td>6) Creative software</td>
<td>1,2,3,5</td>
</tr>
<tr>
<td>7) Computer arcade games</td>
<td>19 to 27</td>
</tr>
<tr>
<td>8) Educational adventure games</td>
<td>14</td>
</tr>
</tbody>
</table>

* In general, the children found the sound effects software, such as making zapping or pinging noises or getting the computer to "say" the user's name to be extremely limited and disappointing.

In the overall MSA plot, shown in Figure 6.2, it can be seen that nearly all the arcade games are plotted very closely together indicating extreme similarity in their effects on the user.
Therefore, the hypothesis that investigating the differences between arcade games would assist in the study of involvement was not supported.

From the individual plots for each of the questions that together generated the overall MSA just discussed, it can be seen that the questions assessing involvement interact with one another. The right to left horizontal movement increasing in interest and amount learnt from can be combined with the upward and leftward diagonal movement of increasing amount of concentration to produce the anti-clockwise movement of like, want to do again, want not to stop and excitement. The inclusion of want to stop doing, a question asking the opposite to like and want to do again, proved to be very useful in ensuring that the children had considered all the questions on the sheet and broke up any tendency towards a response set.

The differences between the points on the scale of software according to user involvement could be attributed to three of the components of intrinsic motivation discussed in previous research on motivation to use computer games. These were challenge and graphic complexity taken from Malone's (1980, 1981 a and b) theories and user control suggested by Schaffer (1981). The points on the scale are listed below with the potential contribution to involvement of each of these three factors.

1) Poor quality programs - There is no challenge to operate a program full of errors, nor successful control if the program fails to run properly nor any opportunity to observe the level of complexity.
2) Drill and practice programs - There is the challenge of getting the answers right and possibly scoring points for doing so making a high score to beat at another attempt. However, the user is not in control, it is the computer that decides what questions to ask and what answers to reward and with no graphics, there is no complexity.

3) Illustrated drill and practice programs - Again there is challenge but no user control. However, the use of graphics increases the complexity and stimulates curiosity in the user.

4) Drill and practice programs with a game - The games are usually illustrated so there is complexity as well as challenge. There is additional challenge from the goal of winning the game and also control since, in the game, the user is in control of the game piece. However, the games are nowhere near as sophisticated as published arcade games, and are usually external to the learning process.

5) Problem solving programs - These have challenge to complete the problem or problems and to reach the successful outcome of the program and more often than not they are illustrated which provides complexity. More importantly, the user is in control as they work out the solution to the problem and the three involving aspects are integral to the learning process unlike in 4) where they are usually provided as rewards for the right answer.

6) Creative software - The user has a great deal of control in operating software tools to create material such as graphics, essays and programs. There is the challenge of operating it successfully and the user operates at their chosen level of complexity. There is no definite end to these programs and the user may become totally involved in controlling the computer.
7) Computer arcade games - The user is in control of the game piece, there is challenge from high score tables and the level of complexity created by fast moving graphic effects is programmed to change with ability thus providing a continuous challenge. Again there is not usually an end to these programs so the user may become totally involved with or "addicted to" the game.

8) Educational adventure games - There is a strong challenge to reach the end of the adventure, the user is in control making the decisions for and solving the problems in order to move on. The illustrations provide complexity making the user eager to see all the possible situations. As in 5) all the involving aspects are integral to the concepts being learnt.

The other aspects of intrinsic motivation mentioned (Malone, 1980, 1981a and b) such as fantasy and cognitive curiosity do not vary so obviously between the software groups.

The increase of involvement with difficulty, shown in the graph in Figure 6.4, until a peak after which involvement falls follows the inverted U shaped curve proposed by Berlyne (1960) for perceptual complexity and curiosity. Curiosity increases with complexity until a point after which it falls. Difficulty like complexity provides a challenge to the user which increases until the task becomes too difficult when the challenge becomes impossible to take up and involvement falls.

6.2.5) Conclusion

The facet of involvement has been found to occur in home computer games as well as educational software. However, arcade type games were found not differ significantly from each other in involvement generated. Therefore, the programs used in the survey
fitted well with the scale of software according to potential user involvement originally tested in Section 6.1. However, it was found necessary to include a separate point on the scale for educational adventure games at the highest level of involvement.

The differences between the level of involvement of the user produced by software at different points on the scale can be explained in terms of three factors suggested by previous research into motivation to use computer games. These are challenge from the program to the user, opportunity for the user to control the program and curiosity in the user generated by the complexity of the program. Further investigation of the effects of these factors on involvement with computer software and on learning from it is reported in Chapters Seven and Eight.

It was found possible to assess user involvement with programs using self reports of users' opinions of computer programs. Involvement appeared to be closely related to the concepts of liking a program, wanting to do it again and not to have to stop using it, and finding it exciting. Being interested in a program and concentrating on it both differed slightly from these concepts but their combination could produce them. Interest in a program was also closely related to how much was considered to be learnt from it. Lastly, reported difficulty was found to relate to involvement in a different way to the other variables since less involvement occurs if a program is found to be either too difficult or too easy.
"There is clearly considerable scope for more sophisticated programming of computer games, and a desperate need for experimental studies of their effectiveness."

- T. O'Shea and J. Self (1983)

Learning and Teaching With Computers
7.1) Introduction

In Chapters Five and Six the level of involvement of an individual with the software they were using was found to vary widely according to the type of software. A deep involvement is the result of increased motivation to use the software produced by aspects of the software itself as opposed to external motives. This motivation, intrinsic to the activity being carried out, was first noted by Koch (1956) who suggested that when a person engages in an intrinsically motivated activity they are fully absorbed in and committed to that activity. Intrinsic motivation has been the subject of much previous research which has been found to be applicable (Malone 1980, 1981a and b) to computer software.

Malone's work and other psychological theories relating to involvement with computers have been discussed in detail in Section 3.3. In summary Malone proposed three categories of intrinsic motivation: challenge, curiosity, and fantasy. Both his and other research provides support for the categories of challenge, goals set by the software, and curiosity, stimulated by the complexity of the software but the role of fantasy is less clear. It is proposed that fantasy would be more appropriately considered as a way of increasing complexity of a game and so should be considered under curiosity. Other research on intrinsic motivation has focussed on the concept of control or causation.

Lepper (1985), in a discussion on the motivational issues of the use of microcomputers in education, considers that these three hypotheses of intrinsic motivation caused by either challenge, complexity or control have developed as the result of historically distinct research traditions. Each approach has been developed
independently of the others and has produced its own research paradigms which has made comparative research difficult. However, Lepper suggests that the microcomputer will provide an ideal laboratory where variables relevant to each of these traditional models can be manipulated and the effects on a common measure of intrinsic motivation studied. In line with this suggestion, it was decided to investigate how the depth of involvement engendered in the user by being in control of, the challenge of or the complexity of an educational microcomputer game could affect learning from the game.

It has long been a general belief that the more a student is involved with or committed to a task the more they will learn from it. Snelbecker (1982) states most of the research on teacher effectiveness shows that improved learning occurs when the student is constructively involved in the learning process. Cobb (1972) notes a positive relationship between attentive classroom behaviour and academic achievement. Saloman (1983) argues that learning is strongly influenced by the amount of mental effort invested by the learners in processing the material to be learnt. This argument is based on research into memory and cognition (Craik and Lockhart, 1972, Brown, 1975, Kintsch, 1977) which supports the hypothesis that deeper cognitive processing is related to improved long term memory of material, recall of conceptual information and transfer to new material. Tobias (1982) notes that the primary determinant of whether an instructional approach will be effective is the degree to which it increases student absorption levels. Bloom (1976) summarises a number of studies that found that achievement in a variety of academic learning tasks was positively related to
interest in the tasks. In two of the studies carried out with American college students (Anderson, 1973 and Ozcelik, 1974) both overt (level of attention displayed) and covert (amount of relevant thinking reported) measures of involvement were taken. They found positive correlations ranging from .5 to .66 between level of involvement and gain in achievement.

In a study on American high school students taking social studies classes Laffey (1982) found that achievement, measured by tests of subject matter, was significantly related to the following four measures of involvement; teacher rating of student's level of involvement and participation ($r^2 = .33$), number of assignments not completed ($r^2 = .28$), number of days absent ($r^2 = .22$) and student's self report of feeling involved ($r^2 = .1$).

However, previous research on ego-involvement and learning shows conflicting results. Alper (1946) found that American college students performed worse at a task constructing sentences from randomly arranged phrases and remembered fewer sentences when the experimental set up was designed to be ego-involving than when it was set up informally. Though, in this experiment, Alper, perhaps, goes over the top in order to ensure ego-involvement. She has accomplices doing better than the subject at the experiment and an attractive female in the room to heighten the subject's embarrassment at failing, as well as telling the subjects that the experiment was an intelligence test for Army Officer training.

Kausler (1951) compared two groups of American college students on the DuBois-Bunch learning test, the first group's answer booklets were entitled Learning Test and the second group's were entitled University Intelligence Test (ego-involved condition). He found that
the performance of the ego-involved subjects was significantly better \((p<.05)\) than that of the second group. However, in a repeat of this experiment with high school seniors Shedd and Angelino (1952) found that the subjects in their ego-involved condition did significantly worse than the others. The nonego-involved subjects were told that the task and not them was being assessed whereas the others were told that their school had asked for a measurement of their intelligence to be placed on their permanent record. They conclude from this and the previous experiments that there is an optimum level of ego-involvement after which performance and learning fail to increase with involvement and begin to deteriorate.

It is concluded from previous research that there is, in general, a positive relationship between involvement and learning though stress caused by extreme pressure on the involved ego may result in poor performance. The following experiment was set up to compare the effects of involvement due to control, challenge and complexity on learning from a computer game.

The computer game to be used in the proposed experiment on involvement and learning was an educational simulation designed to teach children what to do in case of a domestic fire. A prototype had been developed earlier by the author as a feasibility study for the Fire Research Unit (FRU) in the Department of Psychology at Surrey University. The package of interacting programs, named VESTA, was completed for the experiment and a second version using simpler language developed for use by young children. As it was designed to be used in schools VESTA runs on the standard BBC Micro B and it comes on a single disk for ease of use. A complete listing of the programs that make up VESTA is given in Appendix 7.4.
VESTA begins with a written introduction setting the scene before the fire is discovered. The player or players are staying at a friend's house where they are woken in the middle of the night by strange noises and a funny smell. They are sent downstairs to investigate and the computer displays the scene which greets them and a short description of the situation. When they have read the description, it changes to a menu of options that they can take at this point. When they press the number of their chosen option the scene changes to display the results of this action and another set of options. This sequence continues until dependent upon their actions the player escapes safely or is injured by the fire. The player's goal is not only to escape safely but to rescue other children from the fire. By being able to make decisions and see their effect children see and learn what they should do in this situation.

The domestic fire scenario and choice of actions available to the players were developed from previous research by the FRU using interviews and questionnaires with people involved in fires (Canter, 1985). From these the acts and sequences of acts that people made during a fire were extracted and used as the basis for this fire training aid.

The use of VESTA in schools has been evaluated (Powell and Canter, 1986) in terms of its value as a teaching device and its appeal to potential users. Use of VESTA under supervision was compared with a presentation by the Fire Brigade Schools Liaison Officer (SLO) using audiovisual aids in local Middle schools. A questionnaire was given to assess the children's fire safety knowledge before and after using VESTA or seeing the presentation.
Initial analysis of the data revealed marked baseline differences in the responses to the before questionnaire. Therefore, each of the 60 subjects who used VESTA was matched for age, sex and before responses with a subject who saw the presentation. When the two groups were compared there was a statistically significant improvement in the fire safety knowledge of the group that had used VESTA but a smaller improvement for those who saw the SLO's presentation was not significant. The group who used VESTA also completed a questionnaire on their attitudes towards VESTA. Overwhelmingly, the children enjoyed using VESTA, found it easy to use, considered that they learnt a lot from it, preferred it to the usual fire safety lessons and wanted to use it again.

In order to investigate involvement with microcomputer programs, six versions of VESTA were developed each lacking or providing one or more of the hypothesised determinants of involvement. These are control, challenge and complexity and their roles in determining involvement were discussed at length in Sections 3.2 and 3.3. This idea of investigating people's reactions to elements of a computer program by setting up different versions with or without the variables being investigated was based on Malone's (1980, 1981a and b) original experimental work where he was successful in getting young children to assess the version they saw and compare it to another program.

The element of control was easily removed from the simulation by omitting the menus of options available to the user, on pressing the space bar to indicate they had finished reading the description the subjects were moved immediately on to another scene and its description. Two routes were fixed in this way one indicating what
the player should do and the other what they should not do. Sensory curiosity engendered by the complexity of the program was removed by presenting the simulation normally but without using colour graphics to illustrate the scenes. Challenge was provided in the form of a high score table presented at the end of the simulation, the running total being kept in a corner of the screen, points were given for correct moves and taken away for useless or dangerous moves.

The different versions were:-

1) Fixed route through house, no graphics, no scores (no control, complexity or challenge)
2) Fixed route through house, graphics, no scores (complexity, no control or challenge)
3) Choice of routes, no graphics, no scores (control, no complexity or challenge)
4) Choice of routes, graphics, no scores (control, complexity, no challenge)
5) Choice of routes, no graphics, scores (control, challenge, no complexity)
6) Choice of routes, graphics and scores (control, challenge and complexity)

It was decided not to use fixed routes with the version with scores, since this would mean that the score would also be fixed and so it would not provide a challenge.

It is hypothesised that the presence of the three variables, control, complexity and challenge will significantly increase the amount of involvement of the children with the software. This increased involvement will be recorded in the children's opinions of the software when they are asked to compare two versions of VESTA.
It is also hypothesised that increased involvement will result in increased learning and therefore, any increase in knowledge of what to do in fires measured by a questionnaire given before and after using VESTA will be dependent on the version seen.

7.2) Pilot

The experiment to be carried out in the main study was piloted by the children at two first schools that were visited regularly for two terms.

7.2.1) Method and Results of First Trial

Six children were asked to complete the questionnaire given below, then were allowed two runs through VESTA and afterwards asked to do the questionnaire again.

1) What number do you call for the Fire Brigade?
2) What sound does the school fire alarm make?
3) What can you use to put out a fire?
4) What would you do if your clothes catch fire?
5) What should you do if you find a fire in a room of your house?

It was decided to allow the children two goes on the version seen first because if they made an early mistake on their first go they would not get to explore very far which would affect their opinion of that version.

They were then allowed another go at VESTA but using a different version, lastly, they were asked to rate the different versions on the following questions using the scale discussed in Section 6.2.2.

How much did you like this program?
How much did you learn from this program?
How involved were you with this program?
How much do you want to do this program again?
Their teacher was asked to rate their learning ability to see whether this affected the results.

The actual results of the experiment are not recorded here as it was the method that was being tested and there were few subjects. The children used the computer in pairs quite happily, each pair taking 20-25 minutes to complete the experiment. They had no problems with the before and after questionnaire but had difficulty in rating the two versions and in particular did not understand being involved, the third question they were asked to rate the versions on. The children followed two separate ideas when using VESTA, the first to get everything right and the second to see what happened if they did something wrong. Three versions of VESTA were used in the experiment, they all ran well recording the subjects' routes however a bug was soon found in the high score table which affected the subjects' attitudes to that version.

The following changes were made to the experimental method as a result of this pilot. It was decided to change the way of rating the versions of VESTA seen to a direct comparison of the two. The subjects will be asked to compare the versions on a number of questions designed to assess involvement using a ratio scale in order to provide the most information. To make the information easier to collect the subjects will be asked to enter this information directly into the computer. Also the teachers found it difficult to give each child a single measure of learning ability so it was decided to ask them for separate measures of reading and writing ability and maths ability as well.
7.2.2) Method of Second Pilot

As before children were asked to fill in the questionnaire given in Section 7.2.1, were then given two goes on a version of VESTA, repeated the questionnaire and then given a third go on a second version of VESTA. Finally, they were asked to indicate on a scale displayed on the computer their answers to the following questions designed to assess their involvement with the programs. The questions are taken from the survey described in Section 6.2 and reworded for comparing programs.

1) How much more or less than the first program, did you like the second program?
2) How much more or less than the first program, did you learn from the second program?
3) How much more or less than the first program, did you want to do the second program again?
4) How much more or less than the first program, were you interested in the second program?
5) How much more or less than the first program, did you want to stop doing the second program?
6) How much more or less than the first program, did you concentrate on the second program?
7) How much more or less than the first program, were you excited by the second program?
8) How much more or less difficult then the first program, was the second program?

Three versions of VESTA, with graphics, without graphics and with high score table and graphics had been fully debugged and were used for the pilot.

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7.2.3) Results of Second Pilot

Sixteen children from two first schools completed the experiment using VESTA in pairs and taking about half an hour per pair to do so. The children's ages ranged from six to eight years and there were 12 boys and 4 girls. Their teacher's ratings of their intelligence on a five-point scale with one high and five low ranged from one to four with a mean of 2.81, ratings for maths ability scored similarly also ranged from one to four with a mean of 2.88 and for reading and writing ability ranged from one to five with a mean of 2.94.

Between the eight pairs of children they followed five separate routes, usually the correct one. The most popular alternative to the correct route was to do something known to be dangerous to see what would happen.

On the before and after questionnaire, 8 children produced the same answers, 4 children improved in their answers to the questions covered by VESTA and 2 children made more mistakes on those questions on their second go.

The ratings of the different versions on each question were collapsed into which version was preferred. The totals for each question given in Table 7.1 on the next page do not add up to 16 because sometimes the versions were considered equal.

The variables were tested for association with each other but no significant relationships were found between age, sex, school, ability, version seen and change in performance on the questionnaire. Nor between the versions seen first or second and version preferred on any of the eight questions nor between routes followed and version seen.
Table 7.1. Version preferred according to questions used to rate VESTA in pilot.

<table>
<thead>
<tr>
<th></th>
<th>With high score table</th>
<th>With graphics</th>
<th>Without graphics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Like</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Learn from</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Do again</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Interesting</td>
<td>4</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Not stop doing</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Concentrate on</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Exciting</td>
<td>5</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Difficult</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

7.2.4) Discussion of Pilot

There was not very much variation in the answers to the questionnaire nor the routes followed through the simulation. However, it should be noted that the children had had some previous experience of VESTA as they were used during its early development to check for bugs so most of them knew what they should do. The lack of association found in the results is probably due to this absence of variation.

The versions with graphics were generally preferred and were found less difficult but there was little difference between the versions with and without a high score table except for concentration. More than twice as many subjects said they concentrated more on the version without a high score table as on the version with one.

Most of the children did not include shutting the door on the fire in their answer to question 5) of the before and after questionnaire so another question was included to enquire what they
should not do to make it easier for them to remember. Some of the questions were reworded for clarity and the revised questionnaire is shown in Appendix 7.1.

However, the experiment ran well, successfully recording the results, and it was decided to continue with the main study.

7.3) Main Study

To see how the degree of involvement of a user with software created by being in control of, the challenge of and complexity of the software affects learning from the software.

7.3.1) Method

There are six versions of VESTA to be presented in pairs which makes 15 possible combinations and as the combinations need to be presented in reverse order to allow for order effects that makes 30 combinations in all. It was planned to have 10 children see each combination and these children were carefully selected so that for each combination the average of their ages was 9y ± 9m and the average of their learning and reading abilities (measured by the teachers using a five point scale) was 3 ± 0.5. This was to ensure that any resulting preference for or increase in learning from a particular version of VESTA would be independent of age and ability of the subjects.

The subjects first completed the questionnaire (shown in Appendix 7.1) on general knowledge about fires including what they should and should not do on discovering a fire at home. They were then allowed, in pairs, two goes on VESTA, the microcomputer based fire training aid used to simulate a domestic fire. After this the children were given the same questionnaire in order to assess how much they had learned from VESTA.
The children were then allowed another go on a second version of VESTA. They were asked to compare the two versions they had seen using a ratio scale displayed on the computer to answer the questions given in Section 7.2.2. These were read out loud to them as well as being displayed on the screen to aid comprehension.

The computer recorded the children's names, the routes they took through the simulation and their answers to the final questions assessing how deeply they were involved with the two versions they had to compare. Also the conversation between the pairs of children whilst doing the experiment was recorded on tape.

7.3.2) Results

Three hundred subjects from eight local first and middle schools completed the experiment. The subjects' ages ranged from five years, nine months to twelve years, three months with a mean of eight years, eleven months. Fifty-four percent were boys. Their average intelligence measured by teachers' judgements, based on the county screening test or practices for it, on a scale from 1 (highest) to 5 (lowest) was 2.7 and their average reading ability, using the same scale, was 2.8.

When allowed to choose they took a wide variety of routes through the simulation though one or two were much more popular than the others. On their first go 50% chose to go outside via the front or back doors on discovering the fire, then wake the neighbours to phone for the fire brigade and to wait outside for them. On their second go 50% immediately rescued the others in the house, went outside with them and then woke the neighbours to call the fire brigade. On their last go 42% chose this route which is the correct one. Three transcripts of the conversation between pairs of subjects
who followed typical choices of routes through VESTA are given in Appendix 7.2.

Taping the subjects' conversations was abandoned after visiting three schools because the background noise especially if the computer was stationed in an occupied classroom or corridor made the recordings nearly unintelligible.

The subjects' answers to the questionnaire, shown in Appendix 7.1, on knowledge of behaviour in fires given before and after using the first version of VESTA seen are shown in Table 7.2 on the next page.

The answers given on the first presentation of the questionnaire and any change in answers to questions 5 and 6, the questions specifically testing information provided by VESTA, were tested for association with age, sex, school, ability and version of VESTA seen using the chi-square statistic.

There was statistically significant association between the school attended and the subjects' answers to questions 2 and 3 ($\chi^2 = 22.2, p<.01$ and $\chi^2 = 47.6, p<.001$, respectively) given before using the simulation. There was no association between school and the answers to the other questions, nor to any change in answers to questions 5 and 6 over using VESTA.

Again, there was statistically significant association between the age of the subjects and their answers to questions 2 and 3 ($\chi^2 = 9.9, p<.05$ and $\chi^2 = 10.8, p<.05$) given before using the simulation. However, there was no association between age and answers to the other questions nor change in answers to questions 5 and 6 over use of the simulation.
Table 7.2 Results of before and after questionnaire on fire safety knowledge.

<table>
<thead>
<tr>
<th>Question</th>
<th>% Before</th>
<th>% After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1) What telephone number do you call for the fire brigade?</td>
<td>correct</td>
<td>95.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>97.7</td>
</tr>
<tr>
<td>Q2) What is the school fire alarm?</td>
<td>correct</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>93</td>
</tr>
<tr>
<td>Q3) What should you do if your clothes catch fire?</td>
<td>correct</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>29.7</td>
</tr>
<tr>
<td>Q4) What can be used to put 1 item out a fire?</td>
<td>1 item correct</td>
<td>44.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>34.3</td>
</tr>
<tr>
<td></td>
<td>2 items</td>
<td>43.7</td>
</tr>
<tr>
<td></td>
<td>3 &quot; &quot;</td>
<td>9.3</td>
</tr>
<tr>
<td></td>
<td>4 &quot; &quot;</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>5 &quot; &quot;</td>
<td>0</td>
</tr>
<tr>
<td>Q5) What should you do if you find a fire in a room of your house?</td>
<td>Dangerous answer</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Silly answer</td>
<td>11.3</td>
</tr>
<tr>
<td></td>
<td>No answer</td>
<td>12.7</td>
</tr>
<tr>
<td></td>
<td>1 answer correct</td>
<td>42.7</td>
</tr>
<tr>
<td></td>
<td>2 &quot; &quot;</td>
<td>21.7</td>
</tr>
<tr>
<td></td>
<td>&gt;=3 &quot; &quot;</td>
<td>6.7</td>
</tr>
<tr>
<td>Q6) What shouldn't you do if you find a fire in a room of your house?</td>
<td>Silly answer</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>No answer</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>1 answer correct</td>
<td>52.7</td>
</tr>
<tr>
<td></td>
<td>2 &quot; &quot;</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>&gt;=3 &quot; &quot;</td>
<td>1.3</td>
</tr>
</tbody>
</table>

There was no significant association between the subjects' sex and their answers given before using the simulation nor was there any association between gender and change in answers to questions 5 and 6.
The learning ability of the subjects was found to be associated only with the answers to questions 2 and 3 in the questionnaire given before using the simulation ($\chi^2=12.6, p<.01$ and $\chi^2=19.6, p<.001$). Learning ability was not associated with the change in answers to questions 5 and 6 over using the simulation. Nor was the reading and writing ability of the subjects associated with answers to the questionnaire nor the change in answers to questions 5 and 6.

The mean change in subjects' answers to question 5 over the use of the simulation is plotted against version of VESTA seen in Figure 7.1 below.

**Figure 7.1.** The mean improvement in answer to question 5 over using VESTA plotted against version seen.

In order to show the changes in the subjects' answers to question 5 more clearly, the numbers of subjects who performed better, the same or worse after using VESTA were crosstabulated with
the version seen, as shown in Table 7.3 below. There was a statistically significant association between the change (before and after using the simulation) in answers to question 5 and the version of VESTA seen ($\chi^2=29.4, p<.01$).

Table 7.3. Performance of subjects on question 5 by version of VESTA seen.

<table>
<thead>
<tr>
<th>Version</th>
<th>Did Worse</th>
<th>Same</th>
<th>Did Better</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Fixed route, no pictures</td>
<td>11</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td>2) Fixed route + pictures</td>
<td>10</td>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td>3) Choice, no pictures</td>
<td>8</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>4) Choice + pictures</td>
<td>3</td>
<td>13</td>
<td>34</td>
</tr>
<tr>
<td>5) Choice, no pictures, with score</td>
<td>3</td>
<td>12</td>
<td>35</td>
</tr>
<tr>
<td>6) Choice + pictures, with score</td>
<td>2</td>
<td>13</td>
<td>35</td>
</tr>
</tbody>
</table>

Assuming that the versions are ordered from 1 to 6 in increasing predicted user involvement they form an ordinal scale and so Kendall's Tau was calculated to test for correlation between version used and predicted involvement. A significant ($p<.001$) correlation of .25 was found indicating that the more the user was involved, the better they did. When versions 4 and 5 were swopped on the scale of predicted involvement to see whether this affected the correlation, it fell, only slightly, to .24.

In order to illustrate this crosstabulation the graph of the ratio of subjects who did better to those who did worse on question 5 against version seen is plotted in Figure 7.2 on the next page.
Figure 7.2. The ratio of subjects who did better on question 5 to those who did worse plotted against version seen.

The ratio of number of subjects who did better to those who did worse on question 5 can be seen to increase steadily from version 1 to versions 2 and 3 and makes a large jump to version 4. Then there is only a tiny increase to version 5 followed by another jump to version 6.

However, for change in answer to question 6 over the use of the simulation, the same question but negated, the version seen had no significant effect and there was no correlation between version seen
and performance on question 6. There was a slight but increasing improvement in performance over versions 2, 3, 4 and 5 to 6 but the biggest improvement was for version 1.

The results for each of the eight questions asking the children to compare the two versions of VESTA are shown in Appendix 7.3. For each of the eight questions the mean answers for the version seen first and the version seen second were compared using Wilcoxon Signed Ranks, a nonparametric test for two related samples. The signs of the means for the version seen first were reversed so the two could be compared directly. In each case except for question 2, 'did you learn more or less from the second version?’, there was a statistically significant difference between the scores for the versions seen first and second. This implies that there is an order effect, the subjects liked the second version more, learnt more from it, found it more interesting and exciting, concentrated more on it and wanted to do it again more. The subjects wanted to stop doing the first version seen more and found it more difficult. In fact the version seen first was always considered more difficult than the one seen second.

However, since it was ensured that each version was presented both first and second the results for both presentations may be averaged discounting the order effect. The means for both presentations for each version are given in Table 7.4 on the next page where a positive value indicates that overall that version was liked more, concentrated on more, found to be more interesting, exciting etc. when it was shown, and a negative value that it was liked etc. less. The actual value indicates how much more or less.
Table 7.5. Mean results of questions used to compare versions of VESTA seen.

<table>
<thead>
<tr>
<th>Question</th>
<th>Version Seen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Q1) Like</td>
<td>-8.9</td>
</tr>
<tr>
<td>Q2) Learn from</td>
<td>-3.1</td>
</tr>
<tr>
<td>Q3) Do again</td>
<td>-7.9</td>
</tr>
<tr>
<td>Q4) Interested</td>
<td>-5.15</td>
</tr>
<tr>
<td>Q5) Stop Doing</td>
<td>6.25</td>
</tr>
<tr>
<td>Q6) Concentrate</td>
<td>-5.15</td>
</tr>
<tr>
<td>Q7) Excited</td>
<td>-8.75</td>
</tr>
<tr>
<td>Q8) Difficult</td>
<td>-2.35</td>
</tr>
</tbody>
</table>

From the mean results of each of the eight questions designed to assess involvement given in the table above, except for difficulty, the versions may be ordered in increasing involvement from versions 1 to 6 with 4 and 5 in swopped positions. This is illustrated in Figure 7.3, on the next page, which shows the mean answers for each question plotted against the version of VESTA seen.

The graphs in Figure 7.3 for questions 1,3 and 4, like, do again, and interesting show a reasonably steady increase through the versions from 1 to 6. The same pattern, but reversed, occurs for question 5 wanting to stop. The means for versions 1,2 and 3 are negative (or positive in the case of question 5) indicating that the subjects did not become involved with these versions, without control and control without complexity or challenge. The means for version 5 are borderline but those for versions 4 and 6 are positive (or negative in the case of question 5) indicating that the presence
Figure 7.3. The mean results of each of the eight questions assessing involvement with VESTA plotted against version seen.
of both control and complexity are required for involvement which is enhanced if challenge is also present.

The graph for question 7, exciting, is very similar to those described above with positive means for versions 4 and 6 only but version 3 is considered less exciting than version 2 demonstrating the role of complexity in creating excitement. The graph for question 2, learn from, is also similar except that subjects consider that they learn less from version 2, with the 'exciting' graphics than version 1. This is in fact opposite to the truth shown in Figure 7.1 and Table 7.3 indicating that the subjects associate excitement with lack of learning even when increased learning occurs.

However, the graphs for questions 6 and 8, concentrate on and find difficult do not follow this pattern as versions 3 and 5, both with control but no graphics were found to be more difficult than the others and so took proportionately more concentration. The difficulty of and consequent concentration on version 5 accounts for its positive, as opposed to borderline, mean in the graph for question 2, indicating that the subjects considered they learned more from it even though they did not feel involved with it.

Finally, the graph for question 8 shows that the versions, 4 and 6, that the subjects became most involved with were of an intermediate level of difficulty compared with the others which tended to be too difficult or too easy.

In order to further investigate these results a Partial Order Scalogram Analysis (POSA) was carried out. This is a similar multidimensional analysis to the MSA described in Sections 5.2 and 5.3. POSA is however, a special case of MSA, in that the categories
of the variables making up the profiles being analysed are assumed to be uniformly ordered. In this case the profiles are made up of the subjects' performance on question 5 of the before and after questionnaire shown in Table 7.3 and their mean answers to the questions assessing involvement shown in Table 7.4 for each of the versions of VESTA seen. The order is of increasing involvement shown in increased learning from and increased preference for the different versions. Therefore, the results for wanting to stop using VESTA and the frequencies for subjects not improving over use of VESTA were reversed before being entered into the analysis.

POSA, as carried out by the POSAC computer program, both described fully by Shye and Amar (1985), produces a geometrical configuration of points that represent the profiles being analysed in two-dimensional space. The profiles are plotted so that the studied phenomenon, in this case involvement, decreases along the northeast to southwest diagonal of the plot which is termed the joint axis. The spread of profiles along the perpendicular diagonal, from northwest to southeast, termed the lateral axis is due to the scalogram being one of partial order rather than complete order. Thus the plot may be interpreted quantitatively along the joint axis and qualitatively along the lateral axis.

The resulting plot of the POSA for this study is shown in Figure 7.4 on the next page, together with the plots for each of the individual variables that make up the profiles.
plots of POSA on program profiles made up from questions assessing learning from and involvement with VESTA

OVERALL PLOT

INDIVIDUAL PLOTS

worse on Q5

same on Q5

better on Q5

like

learn from
do again

interesting

stop doing

concentrate

exciting

difficult
The way in which the versions of VESTA are plotted along the joint axis of the overall plot shows the increase in involvement with versions 1 to 6. The plot shows low involvement with versions 1 and 2, without control, a big increase in involvement with versions 4, 5 and 3, control with complexity, with challenge and without either, and a further increase in involvement with version 6, control with complexity and challenge.

The spread of the points representing the versions over the lateral axis can be interpreted with the aid of the individual plots. All of the individual plots except for difficulty and amount learnt from can be partitioned horizontally indicating that they are closely related. The plot for difficulty is partitioned vertically indicating that its role in involvement differs from the others but it can be seen to combine with them to produce the L-shaped partitions for amount learnt from. Thus the amount the subjects considered they learnt from VESTA results from a combination of preference for the version seen and how difficult it was. The L shaped plot also indicates that amount learnt from is associated with the extreme ends of the lateral axis. This can be seen as versions 2 and 3 from which the subjects considered they learnt less from than they actually did are plotted on opposite sides.

7.4) Discussion

The results show that the children's opinions of VESTA and how much they learnt from it varied widely according to the version they saw. However, from the children's conversation when using the simulation, they tended to follow only three strategies. One was to do everything correctly, the second was to find out what happened if a deliberate error was made and the third was not to do the same
things a second time. Usually the second and third strategies only occurred once the first had been worked out indicating a desire for a greater degree of complexity in the form of novelty.

Using any version of VESTA tended to make the children more aware of or remind them of what to do in case of fire. There is a general improvement when doing the fire knowledge questionnaire for the second time, some children even asked to change their first answers because they had now remembered the right one. School attended, age, ability and sex were not found to affect the answers relating to knowledge acquired from the simulation therefore, any change in these must be due only to the simulation seen. However, school attended, age and ability were found to affect answers given on the school fire alarm and what to do if one's clothes caught fire. Obviously, some groups of children had received and remembered this information, different schools or different age groups had not received this information and other children differed in ability to remember it.

Performance on the question on knowledge that could be gained from use of VESTA, what should be done on discovering a domestic fire, was found to be significantly related to the version of VESTA seen. The relationship, illustrated in Figure 7.2, shows poor performance on the versions without control, little better on the version without complexity and a large increase in performance to the versions with both control and complexity and with both control and challenge. Finally, there is another jump in performance to the version with complexity and challenge.

These results confirm the hypothesis that involvement with an educational computer game is positively related to learning from it.
Being in control of the action is most important in learning from a computer simulation or game, players pay little attention if they have no choice to make, even less if they have no pictures to look at. This supports the results of Fisher and Blackwell's (1975) experiment on the effect of control on engagement in an arithmetic task presented by computer. They found that ten year olds who were allowed to choose the number and difficulty of maths problems showed significantly (F=5.039, p<.05) more task engagement than a yoked control group.

The condition of no control but graphics is equivalent to an audiovisual presentation, an example of which has been shown (Powell and Canter, 1986) to be inferior in transmitting fire safety knowledge to the normal version of VESTA. Making the computer game more complex with the use of colour graphics to evoke curiosity in the user or adding a challenge in the form of a score to be beaten appear to have an equivalent effect on improvement of learning through increased involvement. The use of both together was found to be even more effective.

Although the increase in learning through the use of complexity was not found to be significant, this is in line with Smith and Smith's (1966) conclusion that children prefer materials that are coloured, contain action and tell an organised story but do not necessarily learn more from them.

There was no association between the second question on information provided by VESTA on what not to do on finding a fire and version of VESTA seen. This is because children appeared to find it quite easy to think of a number of valid actions that they should not make whether influenced by VESTA or not. The best results on
this question were for children who had seen version 1 from which it
has been shown that they learnt little. Since they did not acquire
the correct answer from VESTA they came up with a greater variety of
sensible alternatives.

Measures of how much the children actually considered themselves
to be involved with the different versions of VESTA were made by
asking the children to compare two versions. The first finding was
that the children's opinions were affected by the order in which
they had seen the versions. However, the presence of such an order
effect had been foreseen and it had been ensured that each pair of
versions was presented twice, the second time in reverse order so
that the results for each version could be averaged.

The means of the children's opinions, graphed in Figure 7.3,
show that they liked the three versions, control with complexity,
with challenge and with both, considered they learnt more from them
and did not want to stop doing them. They wanted to do the two
versions, control with complexity and control with complexity and
challenge, again and were interested in and excited by them. They
concentrated only on the versions that they could control and
significantly more on the version with control and both challenge
and complexity. These results confirm the increased involvement of
the user when control and either complexity or challenge are
provided in a computer program that results in the increased
learning discussed earlier. Involvement is increased still further
when both complexity and challenge are included.

However, unlike the results of how much they learned from the
simulation, the children reported themselves as more involved with
the version with control and complexity than with version with
control and challenge. They appear to have learnt more from the latter version because they found it more difficult, without illustrating graphics, and so concentrated harder on it. This is an example of involvement caused by the challenge of a high score, the children reported that they found the version without complexity and challenge even more difficult and concentrated nearly as much on it, but without the challenge learned very little from it. So though concentration may be a good measure of invested mental effort (Saloman, 1983) it does not, by itself, indicate involvement with the material.

The POSA of the results of both learning from and reported involvement with VESTA demonstrates the importance of being in control in becoming involved in a computer program. The versions without control are plotted at a low level of involvement compared with the three versions, with control only, with control and either challenge or complexity, which are plotted at a considerably higher level of involvement. The plotting of the version with control, and both challenge and complexity at an even higher level shows the effectiveness of the combination of both complexity and challenge in causing involvement.

Also the individual plots of the POSA show how the difficulty of the program is combined with indicators of involvement such as preference for, concentration on, interest and excitement in the program to produce the subjects' perception of how much they learnt from the program. This perceived amount learnt from the program appeared to be responsible for the qualitative differences between the different versions of VESTA plotted at the same level of involvement.
The results show significant differences in learning from and reported involvement with the different versions of VESTA seen. The different versions included control in the form of a choice of routes, complexity in the form of colour graphics and challenge in the form of a high score table. Therefore, Lepper's (1985) hypothesis that these three are identical, merely the result of different approaches to intrinsic motivation, cannot be correct. If they were the same then involvement would have increased steadily from versions without these attributes to those with them. Instead there is, generally, little difference between the versions without control, and a large difference between these and the other versions. However, once control is provided there does appear to be some equivalence between complexity and challenge as there is little change in involvement between the two versions with graphics and with a high score table and a jump in involvement between these and the version with both.

There are noticeable similarities between the theories behind challenge (Deci, 1975) and complexity (Berlyne, 1960). Both consider that intrinsic motivation to interact with material increases with the challenge or complexity of the material until a certain point, after which, motivation decreases as the challenge becomes too difficult to overcome or the material too complex to become involved with. Challenge and complexity are also related in that the complexity of an object provides a challenge to the potential user. Too simple a problem is no challenge and too complex a task is impossible to carry out successfully. In fact computer game programmers trade on this relationship, in order to keep players motivated they organise the game so that as the player improves they
move onto a higher level which is more complex thus providing a constant challenge to continue playing.

A final, interesting point generated by the results of this experiment is that the failure of programmed learning machines was due to lack of involvement of the learners being taught. According to the theory proposed by Skinner (1968), the learner's answer is reinforced by turning the handle to move on to the next question, thus controlling the machine. In versions 1 and 2 of this experiment, without control, the subjects did actually have to press the space bar to move on to the next frame of information, thus they did physically control the computer but the computer controlled the route they followed through the simulation. The children learned very little from these versions which are equivalent to the teaching machine suggesting that control through physical operation of a machine does not provide reinforcement for learning. Skinner also proposed that getting the question right was the most rewarding reinforcement and insisted that the questions to be used in programmed learning should be phrased so that the learner would nearly always get them right. However, according to competence theories of intrinsic motivation there would be no challenge in this so the learners would be unlikely to persist for very long. In the experiment reported in this chapter both being in control of the simulation and having an extra challenge in the simulation was found to increase involvement in the learning process and consequently improved learning occurred. In the use of a teaching machine, as designed by Skinner, there is neither true control nor challenge therefore, there is little involvement in using them and little
learning from them, consequently there was a lack of interest on the part of teachers and schoolchildren in using the machines.

7.5) Conclusion

The results of this experiment have shown that the amount of learning from an educational computer game may be significantly increased by giving the learner control over the action, and further enhanced by increasing the complexity of the game with colour graphics or providing challenge with a high score table. Animated graphics would further increase the complexity of the game but the designer should be careful not too make the game too complex for the intended user which would prevent them becoming involved. The inclusion of challenge in the form of scoring encourages involvement of the user in beating his or her classmates' score by getting more answers right and so increases learning. The inclusion of all three control, challenge and complexity is much more effective at increasing learning than any combination from the three.

The subjects were enthusiastic about learning from a computer game, increasingly preferred and were increasingly interested in versions of the game that included control, then complexity, then challenge in order of importance. From multidimensional analysis of their responses, when asked to compare versions of VESTA, and the results of tests on learning from it, it could be seen that the subjects became involved with the versions that included control and deeply involved with the version that also contained complexity and challenge. This confirmed the theories, discussed in the introduction, that intrinsic motivation to use a computer game is
caused by control, challenge and complexity and results in increased involvement with the game which improves learning from the game.

Finally, although challenge and complexity are generally considered to be separate aspects of intrinsic motivation they are related in that complexity, as well as generating curiosity as suggested in previous explanations, provides a challenge. A successful challenge consists of one or more goals that the potential user may overcome, too complex or too simple tasks do not provide very much challenge. Therefore, educational computer game designers should consider carefully the ability of the group the game is designed for and, more importantly, design the game with a variety of levels of complexity to cater for a wide range of abilities.
CHAPTER EIGHT

COMPARISON OF THEORIES HYPOTHESES TO EXPLAIN INVOLVEMENT

"Learn, compare, collect the facts!"

- I.P. Pavlov (1849-1936)

Bequest to the Academic Youth of Soviet Russia
8.1) Introduction

In Chapter Three a number of theories that might explain involvement with a computer were discussed. According to the literature there are a possible six factors that could be used to determine involvement with a computer. A short description of each follows.

The first three factors are based on research by cognitive psychologists into intrinsic motivation discussed in Section 3.2. These are involvement through a desire to control or master the computer, involvement through curiosity engendered by the complexity of the software used and involvement through responding to a challenge from the computer.

The importance of being in control of the computer was noted in the experiment described in Chapter 7 where it was found to affect significantly children's enjoyment of and learning from a computer simulation. In the case of programming computers or using them for word processing or data analysis the user is in control, employing the computer as a tool. Also in computer games the user is in control of their "piece", however, in many educational programs the only opportunity the student has for control is to choose the difficulty level if it has not been already set by the teacher.

Complexity of the software generates curiosity in the user, the user finds a too simple program boring and an over intricate one too difficult. The more curious the user is about the software the more they become involved. In all the computer uses investigated the programmer can manipulate complexity using audio and visual effects and amount of information the user needs to acquire so as to achieve the optimum curiosity of the user about the software.
The challenge that a computer program presents to the user is made up of a number of goals which may be varied during the program. Whether the goals will be achieved by the user must be uncertain in order to provide a successful challenge. Easily programmed goals are to get the highest score in a computer game or to get all the answers right in an educational program. Less obvious goals are to use word processing or business software to present reports clearly and neatly or, for a software writer, to get the program up and running. Challenge is related to complexity in that programs of different levels of complexity provide differing challenges to the potential user.

These three factors are generally considered to be three independent determinants of intrinsic motivation however, Lepper (1985) considers them merely to be the results of three different approaches to the field. He also suggests that the microcomputer could be used as a laboratory where variables relevant to each of these theories could be studied. It is hypothesised that these three approaches are closely related and would form a facet of involvement with the computer, whatever the situation it is used in.

However, other theories that might explain involvement must also be considered. Reinforcement theory has already been put forward, as discussed in Section 3.4, in explanation of involvement with computers. The student using an educational program learns that a correct answer leads to positive reinforcement and so attempts to keep answering correctly. The user feels rewarded by being able to move on to the next topic or question and so is motivated to continue using the program. If, according to Skinner (1968), the programmer makes it virtually impossible for the user to get a wrong
answer the user will continue to be positively reinforced and become highly involved with the program. Many drill and practice programs attempt to follow this theory and add to the reinforcement of getting the answer right with entertaining audiovisuals. The most common reinforcements used in computer games software are getting points for doing well and being able to play the game for longer. In other uses of the computer such as word processing or programming reinforcements could be a well presented print out or seeing the program work.

This form of reinforcement is intrinsic to the program that is being used however, the user may also be reinforced for using the computer in a number of ways that actually have nothing to do with the program being used. For instance the child might use the educational programs in order to gain the teacher's or parent's approval, or play computer games to impress or keep up with their peers and the adult might learn how to program in order to make money. This will be termed extrinsic reinforcement and considered separately from the reinforcement produced by the individual programs. Extrinsic reinforcement also follows Skinner's principles of operant conditioning where an activity will be repeated if it is seen to be rewarded. The more important the reward is to the user the more likely he or she is to become involved in using the computer.

A final factor that is hypothesised to affect an individual's involvement with computers is ego-involvement. Ego-involvement, discussed at length in Section 3.1, occurs in a computer user when the user considers the operation of the program being used to be
associated with their abilities and attitudes. As the user becomes more deeply involved with the program they come to regard using the computer as an extension of themselves. Ego-involvement occurs if a business software user believes that using the software enhances his own abilities or when a games player associates himself with his fantasy role in the game.

The aim of the following study is to see how the cognitive concepts of challenge, control, and complexity relate to each other, to compare them with the theories of ego-involvement, reinforcement and extrinsic reinforcement and to discover how much each is responsible for motivating people to use computers. It is hypothesised that the three cognitive variables control, challenge and complexity which were found in the previous chapter to affect children's preferences for versions of a computer game will be seen to be held responsible for creating involvement with computers in different situations.

This hypothesis will be compared with two others, the first with reinforcement theory replacing the cognitive variables as the explanation of involvement, i.e. testing the theory that motivation to learn is caused by reinforcement either produced immediately by the program or from other causes external to the program itself. The second hypothesis to be compared with the first replaces the cognitive explanation with ego-involvement as the cause of involvement.

These hypotheses can be combined into the following mapping sentence. The mapping sentence is used to formally relate the ideas being studied and represents a succinct statement of the research design (Brown, 1985).
The user will become involved with the computer due to

(the challenge of

(being in control of

(the complexity of

(ego-involvement with

(reinforcement produced by)

(reinforcement extrinsic to)

(play arcade games

(play adventure games

(to (write computer programs

(learn from

(analyse data or finances

In order to compare these six concepts that have been used to explain involvement a number of statements were made up describing reasons for using computers in each of the six situations mentioned where computers are commonly used. Each statement hypothesised that the reason for becoming involved with computers in that situation was due to either the control, challenge, complexity, or reinforcement of the program, extrinsic reinforcement or ego-involvement. This made 36 sentences in all which are given in the questionnaire shown in Appendix 8.1 and the respondents who completed the questionnaire were asked to indicate whether they agreed or disagreed with each statement and to what extent.

8.2) Pilot

8.2.1) Method

Statements giving reasons for involvement in different situations were made up and distributed to other members of the Department of Psychology in the form of a pilot questionnaire, a copy of which is shown in Appendix 8.1. Examples of the statements are given below.

Control - People enjoy writing computer programs because they can make the computer do what they want it to.
Complexity - People like best the graphic effects in arcade games that speed up as you get better at playing them.

Reinforcement - People like using educational programs because the programs tell them when they are right.

The respondents had to indicate how much they agreed or disagreed with each statement using a scale from 1 (maximum disagreement) to 7 (maximum agreement) and were also asked to comment on the format of the questionnaire.

8.2.2) Results

The questionnaire was completed by 20 people, 12 men and 8 women, with a mean age of 28.7 years. They were 10 students, 6 researchers, 2 directors, a secretary and a charge nurse. The mean results for the 36 statements which the subjects agreed or disagreed with using the 7 point scale are tabled below.

Table 8.1. Mean results of pilot study comparing different explanations of involvement.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Challenge</th>
<th>Complexity</th>
<th>Reinforc't</th>
<th>Ego-Involv't</th>
<th>Extr. Reinforc't</th>
<th>Ave.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educ. Programs</td>
<td>4.3</td>
<td>5.2</td>
<td>4.0</td>
<td>4.7</td>
<td>4.45</td>
<td>3.15</td>
<td>4.31</td>
</tr>
<tr>
<td>Adventure Games</td>
<td>3.95</td>
<td>5.35</td>
<td>4.8</td>
<td>3.65</td>
<td>3.85</td>
<td>2.25</td>
<td>3.98</td>
</tr>
<tr>
<td>Arcade Games</td>
<td>4.45</td>
<td>5.6</td>
<td>4.8</td>
<td>5.05</td>
<td>3.9</td>
<td>4.1</td>
<td>4.65</td>
</tr>
<tr>
<td>Programming</td>
<td>4.9</td>
<td>5.2</td>
<td>5.3</td>
<td>4.8</td>
<td>4.4</td>
<td>4.4</td>
<td>4.83</td>
</tr>
<tr>
<td>Word Processing</td>
<td>5.85</td>
<td>4.0</td>
<td>5.15</td>
<td>4.35</td>
<td>5.05</td>
<td>5.35</td>
<td>4.96</td>
</tr>
<tr>
<td>Finan. &amp; Data Anal.</td>
<td>5.7</td>
<td>4.9</td>
<td>5.1</td>
<td>4.65</td>
<td>5.45</td>
<td>5.55</td>
<td>5.23</td>
</tr>
<tr>
<td>Average</td>
<td>4.86</td>
<td>5.05</td>
<td>4.86</td>
<td>4.53</td>
<td>4.52</td>
<td>4.13</td>
<td></td>
</tr>
</tbody>
</table>
Using the Wilcoxon Signed Ranks test challenge and control were found to be significantly different from reinforcement, ego-involvement and extrinsic reinforcement but not from each other nor complexity. Complexity was found to be significantly different from extrinsic reinforcement but not from the others. Ego-involvement and reinforcement were both significantly different from extrinsic reinforcement but not from each other.

The means given in Table 8.1 were also calculated separately for respondents that had experience of using computers for the activity mentioned in the statement they agreed or disagreed with and for those who did not. The two sets of figures were compared using the Mann-Whitney test, as they were not related, and were found not to be significantly different from each other. The same was done for respondents who were interested in computers and for those who were not. Again no statistically significant difference was found between the two groups.

A Smallest Space Analysis (SSA) was also carried out on the possible motivators for computer use. SSA is a multidimensional procedure that represents the correlations between variables as points in space. It is described in detail in Section 8.3.2. The program used to perform the SSA, SSA-I (Lingoes, 1973), produced a 3 dimensional plot with a coefficient of alienation of .247 but was not easily interpreted. There was some indication in the plot of vector 2 against vector 3 of the control, challenge, complexity and ego-involvement variables lying in separate diagonal lines across the plot with reinforcement and extrinsic reinforcement also lying diagonally but in an orthogonal direction.
8.2.3 Discussion

The results show that challenge is considered to be the major reason for involvement with computers followed closely by control and complexity. However the differences are not great enough nor the SSA clear enough to be able say that they are solely responsible for involvement. The responses show that overall the subjects consider that reinforcement, both extrinsic and internal, and ego-involvement are also responsible for some involvement.

This applies to both subjects who have had experience of using computers in the situations described in the statements and to those who have not. It also applies for subjects who are interested in using computers and for those who are not. That is to say the results are independent of the subjects experience of or attitude towards computers.

However, a number of comments and suggestions were made about the pilot questionnaire which were incorporated into a revised questionnaire.

The 36 statements had been worded in this fashion, "People like/enjoy using computers in ...... situation because ......." and many found this unclear and difficult to agree or disagree with. The statements were therefore reworded in the fashion "Using computers in ...... situation is good/fun/useful because ..... " and the instructions amended to make how to answer clearer.

There was no explanation of the different uses of computers, in particular some respondents did not realise the difference between arcade and adventure games. Examples of each sort of computer use were therefore included on the revised questionnaire.
The use of "indifferent" as the mid point on the 7 point scales was inappropriate, it has been changed to "neither agree nor disagree".

Finally, many respondents had trouble remembering the points on the scale they were using and found it tiresome to turn back. The scales were therefore included on the top of each relevant page.

8.2.4 Results of piloting revised questionnaire.

The revised questionnaire, a copy of which is given in Appendix 8.2, was completed by 14 people. Their ages ranged from 21 to 46 with a mean of 29.07, there were 8 men and 6 women and they were mainly researchers (7) with 5 students, a secretary and a manager.

The mean results of how the respondents agreed or disagreed with the statements giving reasons for computer use in six different situations are tabulated below. The same 7 point scale was used with <4 for disagreement and >4 for agreement with the statements.

Table 8.2. Mean results of second pilot study using revised questionnaire comparing different theories of involvement.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Challenge</th>
<th>Complexity</th>
<th>Reinforc't</th>
<th>Ego-Involv't</th>
<th>Extr. Reinforc't</th>
<th>Ave.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educ. Programs</td>
<td>4.57</td>
<td>4.79</td>
<td>4.57</td>
<td>4.57</td>
<td>4.0</td>
<td>3.93</td>
<td>4.41</td>
</tr>
<tr>
<td>Adventure Games</td>
<td>4.43</td>
<td>5.36</td>
<td>4.79</td>
<td>4.21</td>
<td>4.0</td>
<td>3.14</td>
<td>4.32</td>
</tr>
<tr>
<td>Arcade Games</td>
<td>4.64</td>
<td>5.0</td>
<td>4.64</td>
<td>3.5</td>
<td>4.43</td>
<td>2.8</td>
<td>4.17</td>
</tr>
<tr>
<td>Programming</td>
<td>5.21</td>
<td>5.0</td>
<td>4.93</td>
<td>4.57</td>
<td>4.43</td>
<td>3.64</td>
<td>4.63</td>
</tr>
<tr>
<td>Word Process'g</td>
<td>5.5</td>
<td>4.07</td>
<td>4.64</td>
<td>4.57</td>
<td>5.14</td>
<td>5.5</td>
<td>5.07</td>
</tr>
<tr>
<td>Fin. &amp; Data</td>
<td>4.64</td>
<td>4.7</td>
<td>5.07</td>
<td>4.93</td>
<td>5.5</td>
<td>5.57</td>
<td>5.07</td>
</tr>
<tr>
<td>Average</td>
<td>4.83</td>
<td>4.82</td>
<td>4.77</td>
<td>4.39</td>
<td>4.58</td>
<td>4.1</td>
<td></td>
</tr>
</tbody>
</table>
Again the respondents agree most with control and challenge followed closely by complexity being responsible for reinforcement but the differences are not great enough to be conclusive.

There was high agreement with statements on ego-involvement and extrinsic reinforcement being important for business users i.e. word processing and financial or data analysis, but little agreement with them being important in the other situations.

An SSA was carried out on these results but there was nothing that could be clearly interpreted, however in the 3D plot, for vectors 2 and 3, there was a possible division between ego-involvement, extrinsic reinforcement, challenge and control.

No further comments were made about the revised questionnaire and it was decided to go ahead and use it for the main study.

8.3) Main Study

8.3.1) Method

The questionnaire to be used in the main study was piloted and its format revised as described in Section 8.2. 200 copies of the final version of the questionnaire, shown in Appendix 8.2, were handed to students at Surrey University to be completed and returned through the internal mail.

Examples of the statements used to test people's agreement or disagreement with possible reasons for using computers are given below.

Control - Writing computer programs is enjoyable because the programmer can make the computer do what he or she wants it to.

Complexity - Playing arcade games is fun because of the graphic effects that speed up as you get better at playing them.
Reinforcement - Educational programs are good because they tell the user immediately when they are right.

The results were analysed using Smallest Space Analysis (SSA), (Lingoes, 1973) which produces a geometric representation of the correlations between variables in 2 or 3 dimensional space. In this case the variables are the measures of how much the subjects agreed or disagreed with the statements postulating reasons for becoming involved with computers. They are plotted in such a way that the closer together the points representing the statements are the greater the correlation between the statements.

8.3.2) Results

Seventy-four questionnaires were returned of which two had been defaced giving a return rate of 31%.

The respondents ages ranged from 17 to 49 years with a mean of 21.26 and 40.3% were female and 59.7% male. Fifty-eight were undergraduates, 5 were postgraduates, 4 were employed, 3 were managers and 2 were unemployed.

The mean results of how the respondents agreed or disagreed with the statements giving reasons for computer use in six different situations are shown in Table 8.3 on the next page. The same 7 point scale as used in the pilots was used to indicate level of disagreement and agreement.
Table 8.3. Mean results of main study comparing different theories of involvement.

<table>
<thead>
<tr>
<th>Chall.</th>
<th>Ctrl</th>
<th>Complex</th>
<th>Ego-inv't</th>
<th>Rein-force't</th>
<th>Extr.</th>
<th>Ave.</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edu. Progs.</td>
<td>5.11</td>
<td>4.38</td>
<td>4.63</td>
<td>3.5</td>
<td>4.58</td>
<td>2.27</td>
<td>4.08</td>
</tr>
<tr>
<td>Adven. Games</td>
<td>5.1</td>
<td>4.32</td>
<td>4.57</td>
<td>4.53</td>
<td>4.38</td>
<td>2.64</td>
<td>4.26</td>
</tr>
<tr>
<td>Arcade Games</td>
<td>5.11</td>
<td>4.43</td>
<td>4.33</td>
<td>4.33</td>
<td>4.42</td>
<td>2.9</td>
<td>4.25</td>
</tr>
<tr>
<td>Progr- amming</td>
<td>5.1</td>
<td>5.31</td>
<td>4.67</td>
<td>4.64</td>
<td>5.64</td>
<td>3.56</td>
<td>4.82</td>
</tr>
<tr>
<td>Word Proc.</td>
<td>4.14</td>
<td>5.78</td>
<td>4.75</td>
<td>5.28</td>
<td>4.85</td>
<td>5.25</td>
<td>5.01</td>
</tr>
<tr>
<td>Fin. &amp; Data</td>
<td>4.72</td>
<td>4.61</td>
<td>5.08</td>
<td>5.07</td>
<td>4.88</td>
<td>5.57</td>
<td>4.99</td>
</tr>
<tr>
<td>Ave.</td>
<td>4.88</td>
<td>4.81</td>
<td>4.67</td>
<td>4.56</td>
<td>4.79</td>
<td>3.7</td>
<td>199</td>
</tr>
<tr>
<td>S.D.</td>
<td>.39</td>
<td>.6</td>
<td>.25</td>
<td>.63</td>
<td>.47</td>
<td>1.39</td>
<td></td>
</tr>
</tbody>
</table>

A Smallest Space Analysis (SSA) was carried out on the results of how much the respondents agreed or disagreed with the statements giving potential reasons for involvement with computers. The SSA is a non-metric multidimensional procedure which operates upon the rank order of the correlation matrix derived from correlating all of the statements with each other. It finds an n-dimensional space such that the rank of the distances between points representing the statements in that space has a maximal relationship to the rank of the correlation coefficients. The strength of this relationship is measured by the coefficient of alienation which, in this case, was .23 for three dimensional space showing a fairly good fit between the ranks of the correlations between the statements and their geometric representation. The actual procedure used for the SSA was
SSA-I (Lingoes, 1973) and the correlation coefficient used was Kendall's Tau(c) as the data was ordinal.

The SSA produced three plots, using views from three angles orthogonal to each other to represent the three dimensional plot on paper. These angles are termed vectors and the plots for vectors 1 against 2, vectors 1 against 3 and vectors 2 against 3 are shown in Figures 8.1 a), b) and c) respectively. Each plot is repeated to demonstrate two possible ways of dividing the plots into regions as described below. The numbers labelling each point in the plots refer to the number of each statement in the questionnaire shown in Appendix 8.2.

By examining the positions of the points representing the statements on each plot, it can be seen that the statements have been grouped by the SSA into separate regions both for the different reasons given for involvement and for the different situations where computers were used. For instance statements numbers 3, 9, 10, 21, 27 and 30 all proposing challenge as the reason for involvement with computers are grouped on the right hand side of the plot showing vectors 1 against 2 (Figure 8.1 a.) and on the lower right of the plot showing vectors 1 against 3 (Figure 8.1 b.). Also statements mentioning computer use in financial or data analysis, numbers 10, 11, 14, 15, 20 and 34, are found to be grouped on the bottom right of Figure 8.1 a) and on the middle and upper left of Figure 8.1 c).

Thus Figure 8.1 shows how the plots may be divided into regions for both the facets in original mapping sentence, the different reasons proposed for involvement and the situations where the computer is used. This division can be seen in each of the three orthogonal views of the plot. The erratic outlines to the regions in
Figure 8.1. Resulting plots of SSA on subject's opinions on involvement with computers showing regions for theory of involvement (A) and computer use (B).

a) A1-challenge A2-control A3-complexity A4-ego-involvement A5-reinforcement A6-extrinsic reinforcement

b) B1-educational B2-adventure games B3-arcade games B4-word-processing B5-programming B6-financial/data analysis software

c) no division into regions
the plots are due to "noise" in the data, possibly caused by
disagreement between some of the subjects on the importance of the
proposed reasons for involvement or the lack of a clear distinction
between some of the statements giving the different reasons,
however, the overall indications are clear.

A conceptual ordering of these regions may be predicted from the
principle of contiguity, which states (Brown, 1985) that items which
are more similar in their conceptual definitions will be more
similar empirically. More similar items have greater correlation
coefficients and are therefore plotted more closely together forming
contiguous regions. The inverse relationship between distance in the
spatial plot and similarity also applies to these regions, which in
this case contain the points representing statements grouped
according to the causes of involvement the statements propose. In
Figures 8.1a) and b), there is greater similarity between regions
labelled A1 and A2, containing statements proposing challenge and
control respectively, than between regions A1, challenge, and A3,
the statements proposing complexity. The greater the distance, the
less the similarity and thus an order amongst these regions is
implied with increasing distance between them. The partitioning of
the SSA of people's attributions of the causes of involvement shown
in Figure 8.1 demonstrates that the reasons given for involvement
are ordered conceptually from challenge, through control,
complexity, ego-involvement and reinforcement to extrinsic
reinforcement.

Thus the results do not support the original hypothesis, that
control, challenge and complexity would, together, be held
responsible for creating involvement. Since reinforcement, both
extrinsic and intrinsic, and ego-involvement appear as contiguous regions on the same plot as regions for control, challenge and complexity, they must also be considered by the subjects to be responsible for causing involvement. However, the arrangement of the regions shows that there is an order to these theories. Had the plots represented the original hypothesis the points representing the statements that were based on reinforcement theory or ego-involvement would have been scattered randomly over regions for control, challenge and complexity. If the subjects had not agreed with the original hypothesis that control, challenge and complexity were responsible for involvement then the points representing statements containing these concepts would also have been plotted randomly.

In the third plot shown in Figure 8.1 c) no regions can be found for the reasons proposed to explain involvement however, there is a clear radial division into contiguous regions for each situation where a computer may be used. In this case no order may be predicted between regions as they are not separate, all the regions (except that for programming) share a common origin where the distance between every region and every other is the same. Thus the partitioning represents qualitative rather than quantitative differences between the groups, however, the circular sequence in which the regions are plotted may be important. Although six situations where a computer may be used were presented in the original statements only five separate angular regions occur as the region for programming is contained entirely within the region for word processing.
Two facets have so far been described, as demonstrated by the plots shown in Figures 8.1 a), b) and c), reason for involvement and situation where the computer is used. However, the plots are two dimensional representations of three dimensional space taken from orthogonal viewpoints and should also be considered in combination with each other. Facets have certain lawful roles (Levy, 1985) and the combination of an ordered, axial facet and a radial facet is termed a cylindrex. This is illustrated in Figure 8.2 on the next page where it is shown how a cylinder viewed from three orthogonal angles could produce the plots shown in Figure 8.1. When the cylinder is looked at from its "side" (views a and b) planar regions for the reasons making up the axial facet of involvement can be seen but these disappear when the cylinder is looked at from its "end" (view c) as they overshadow one another. In the case of the radial facet of situation of computer use, at least two of the angular regions can be seen in both the views of the cylinder from its "side" as they form wedge shapes that run through the whole cylinder. Where the wedges overshadow one another, which depends on the viewing angle, the situations are mixed, however, when viewing the cylinder from its "end", all six situations occur plainly.

8.4) Discussion

The results show that people with a wide range of experience in using computers do not consider that explanations drawn from cognitive theory, reinforcement theory or ego-involvement theory can explain user involvement with computers, but that involvement is the result of a combination of the explanations given by these theories. The mean results of the subjects' level of agreement with each of the theories put forward to explain involvement vary only from 4.56
Figure 8.2. Schematic view of cyllindrex of user involvement with computers.

a) Vectors 1 against 2

b) Vectors 1 against 3

c) Vectors 2 against 3
to 4.88, except for extrinsic reinforcement (3.7), showing that the subjects tended to agree slightly with all the theories. Opinion of the role of extrinsic reinforcement varied widely, from 2.27 to 5.57, according to the possible reinforcements mentioned in the original statements. There are many extrinsic reinforcements available to computer users in each of the six situations mentioned and, though the ones chosen for the experiment were the ones most often mentioned in the literature for that situation, the reinforcements chosen for business uses such as data analysis or word processing were considered by the subjects to be far more important than the others.

The SSA also showed that all six of the proposed theories combined in an ordered fashion in the explanation of involvement. Therefore, the original hypothesis that involvement with computers was created by challenge from the software, together with being in control and complexity of the software is revised to include the concepts of ego-involvement and reinforcement from both the software and external sources. Thus, there are six determinants of involvement with computers, each of which was found to occur in all six situations where it was proposed that a computer may be used.

The SSA demonstrates that a three dimensional model may be used to explain involvement with computers. The proposed model is a cylindrex, made up of two facets, situation where the computer is used and reasons for user involvement with the computer. The former is the radial, or polarising, facet that divides the cylindrex into its six elements around the axis of the cylinder at each level of the latter, axial facet, that divides the cylindrex into its six elements along the axis of the cylinder.
The radial facet, situation where the computer is used, divides the cylindrex into the six situations where, in the statements, it was proposed that a computer may be used. As this radial division does not change with the reason given for user involvement, it exists throughout the cylindrex, the six possible determinants of user involvement with the computer occur in the same order in each of the proposed situations. However, as the region for programming, unlike the other situations, is not separate but contained within another region, word processing, it cannot be considered as a separate situation where a computer is used but to be a special case of using the computer to write with. Both programming and word processing are using the computer in a creative fashion, to produce material according to one's own ideas.

The sequence in which the situations where a computer may be used occur around the radial facet can provide useful information on how people view the different situations where a computer is used. The most apparent change in the software around the sequence is change in the type of control offered to the user. Educational programs are seen to offer little or no control to the user, the student may be allowed to control the difficulty level of the problems set by the program but often this is set by the teacher. In adventure games the player may choose the route taken but usually has few options and is not seen as actually being in control of the game. Arcade games allow the user total control over what happens in the game but no opportunity to alter the game itself. However, programming and word processing software allow the user to control not only the software but to create and control a further item such as a screen display or an essay. With financial and data analysis
programs the user is not only controlling software and manipulating data but also enhancing their managerial capabilities. Thus the different types of software or situations where a computer is used are viewed by the subjects as different ways of exercising control over the computer.

This same sequence can be seen in Table 8.3 which gives the mean values of level of agreement of the subjects with the theories of involvement being compared in each situation. People were least likely to agree with the reasons put forward for becoming involved in educational programs and most likely to agree with those explaining involvement with word processing and financial or data analysis software. Thus the sequence starts with educational programs, moves through adventure and arcade games, through word processing and programming to financial or data analysis software. Since mean values do not necessarily follow the order shown in the SSA which is based on correlations this is confirmation of the importance of the sequence and the issue of control in computing.

The axial facet, determinant of user involvement, is orthogonal to the radial facet, situation where the computer is used, and therefore, involvement is independent of type of computer use. The involvement facet comprises challenge, control, complexity, ego-involvement, reinforcement and extrinsic reinforcement. These fall into a simple order whose direction may be confirmed by referring to the mean levels of agreement of the subjects with each of these theories which are given in Table 8.3. The order amongst the theories explaining involvement is the same whatever situation the
According to the overall means the subjects agreed most with challenge as an explanation for involvement and least with extrinsic reinforcement. Therefore, the order of the elements of the axial facet of the cylindrex extends from challenge to extrinsic reinforcement and is the same as that of the overall means except for reinforcement. This order results from the relative importance of each theory in the explanation of involvement and consequent depth of involvement that is predicted by each theory. Any teacher will be able to confirm the deep involvement of students in a task that they feel provides challenge compared to the shallow involvement of students who are completing a task for reward or to avoid punishment. The anomaly of the high overall mean for reinforcement but its low position in the order of explanations can, therefore, be explained in that reinforcement does not create any great depth of involvement but people agree strongly with its role in causing involvement.

The following examples show how the theories determining involvement may combine in an order indicating increasing importance in creating involvement or increasing depth of involvement.

The student first uses an educational program for an extrinsic reason such as being told to do so by a teacher, he or she is then reinforced by the program feeding back information on their progress and so they become ego-involved in the outcome of the program. If the level of complexity of the program is appropriate to the student's ability and, more importantly, the student feels that they are in control, the student responds to the challenge to continue to
operate the program by becoming totally involved in its use. In this way the involvement of the user deepens as they move through the different categories of involvement.

Once introduced to the game, the player of an arcade game is involved mostly in the challenge of attaining the goals set by the game and in controlling it successfully to get it to reveal its levels of complexity. Involvement also occurs through immersion of the player's ego in the game, entering its fantasy, however, any activity once sustained for a period loses its original attractions and so the player is rewarded for his or her continuing commitment with points for doing well. Finally, the player may continue to play for reasons extrinsic to the game itself such as impressing their peers with their ability. In this way the different categories of involvement demonstrate their relative importance in the creation of involvement.

The results of this study, that people do not consider explanations based on reinforcement to be as important in creating involvement as those based on cognitive theories or involving the ego, support Allport's (1943) original suggestion, discussed in Section 3.4, that reinforcement is secondary to ego-involvement. Reinforcement theory only becomes important in the generation of learning if ego-involvement in the learning task has not occurred. Ego-involvement results from responding to challenge from the learning task, from successfully controlling the task and from curiosity generated by the complexity of the task.

The results may also be used to explain occasions when a program user deliberately follows a path that leads to negative reinforcement such as setting the difficulty level too high or, as
noted in Section 7.4, failing to escape from the fire in VESTA. Neither of these can be explained satisfactorily by Skinner's or Loftus and Loftus' theories of motivation to use computer programs based on reinforcement theory. Both of these cases are examples of cognitive involvement overriding reinforcement, in the first instance, the player is responding to the challenge in the greater difficulty of the program and in the second, the player is seeking greater graphic complexity in the form of novel pictures.

The cylindrex formed by the combination of a radial facet containing areas where involvement may occur and an axial facet of increasing depth of involvement is not a novel concept in the field of involvement. Levy (1979), discussed in Section 3.1 postulated a cylinder as the representation of interrelationships amongst items of political involvement. In both her model and the one presented here the radial facet represents "areas of life", in her case these were political issues and in this case they are situations in which a computer is used. Levy, however, divided the axial facet into two modalities, cognitive and instrumental, and proposed that its order extended from strong instrumental involvement such as discussion of political issues to weak cognitive involvement such as being interested in political issues.

It is possible to divide the axial facet of the model presented here in the same way since the concepts of challenge, control and complexity are all cognitive theories and reinforcement is instrumental in nature. Although the connection between the task being learnt and its reinforcement may include intervening cognitive variables not considered by Skinner, the reinforcement itself is always a demonstrable act. This might be an experimenter providing
food, a teacher providing praise or a computer program providing points or a move onto the next level. The presence of cognitive variables, such as experience or expectancies, as postulated in learning theories such as Tolman's purposive behaviorism (Hill, 1985) and Rotter's social learning theory (Rotter, Chance and Phares, 1972) does not change but rather complements the essentially instrumental nature of reinforcement. It is more difficult to include ego-involvement in this model, however, it can be considered to be part of the affective modality not mentioned by Levy.

The order of the axial facet of involvement has been shown in this study to extend from deep involvement attributed to cognitive behaviour, through ego-involvement to shallow involvement attributed to instrumental behaviour. This is in direct opposition to Levy's view that instrumental behaviour indicates strong involvement and cognitive behaviour weak involvement. However, her analysis gives attending lectures as demonstrating cognitive involvement and discussion at home as demonstrating instrumental involvement. Attending a lecture is surely more indicative of strong involvement than home discussions. Also Levy is concerned with overt demonstration of involvement rather than consideration of theories behind its causes though it is interesting to note that both may be considered from the point of view of behavioral modalities.

The idea that involvement occurs as a hierarchy according to behaviour modality observed, that is to say from shallow involvement demonstrated by instrumental behaviour, through affective behaviour to deep involvement in cognitive behaviour, may be used in a reinterpretation of the differences between active and traditional learning. For this discussion cognitive should be taken to mean the
roles of control, challenge and complexity in generating behaviour and not just "thinking" behaviour in general.

Explanations of involvement of the student in traditional learning rely heavily on reinforcement theory as applied to education by Skinner (1968). Behaviour in the instrumental modality is most easily observed which is why it figures so predominantly in the early connectionist theories of learning that Skinner developed his theories from. These theories were also based on work with animals and were thus necessarily confined to the explanation of instrumental behaviour. However, the research reported here shows that this form of involvement through reinforcement is superficial and unnecessary if affective involvement occurs. The easy observability of instrumental behaviour would also account for the high agreement of subjects with the statements attributing involvement with computers to reinforcements from the programs when reinforcement was low in their priority of explanations.

In active learning the student is directly experiencing the learning task and so becomes ego-involved with its outcome. This deeper involvement may be increased further by selecting the complexity level of the task to invoke the student's curiosity and to make sure the goals set by the task provide a challenge thus ensuring cognitive involvement. Finally, the student must be in control, or feel that they are in control, of the task for cognitive involvement to occur.

Thus we may expect high involvement in active learning methods and shallow involvement in traditional learning methods and, since it has been shown in Chapter Seven that more learning occurs with
higher involvement, it may be concluded that active learning is the more successful method.

The explanations of involvement that form the axial facet of the cylindrex may also interact in other ways than the simple order discussed above and are even dependent upon one another. Skinner (1968), when discussing mechanical teaching machines, states that successful control i.e. operating a handle to move on to the next question is reinforcing. Producing the successful outcome of an act i.e. successfully being in control is also considered to be ego-involving (Nuttin, 1973). It should be noted that both Skinner and Nuttin state that control must be successful which depends on the complexity of the program. If a program is too complicated, the user will not be able to work out how to control it and will not become involved. In arcade games, if the player manages to successfully control the game, he or she is reinforced by moving to a more complex level. Complexity is also closely related to challenge, if a program is too simple or too complex it will not provide a challenge to the user. So rather than considering these theories as separate aspects of motivation and learning it can be seen that they should be considered as an interwoven network that results in involvement in learning tasks and consequent learning. Extrinsic reinforcement also provides motivation to learn but with a wider application than the other variables being discussed.

Thus the results support Lepper's (1985) original hypothesis that control, challenge and complexity are not incompatible theories of intrinsic motivation. However, they are not, as he suggests, merely the result of different approaches to researching the same variable but are separate variables that are inextricably related.
In the experiment on involvement and learning described in Chapter Seven challenge and complexity were found to be related, now control may be included with them.

8.5) Conclusion

The original hypothesis that the cognitive variables of control, challenge and complexity would be held responsible for creating user involvement with computers has been rejected. When students were asked to compare it with explanations for involvement derived from reinforcement theory and the concept of ego-involvement, no single theory was held to determine involvement. Instead involvement was considered to depend on a combination of these theories which is illustrated by the mapping sentence given in Section 8.1.

Two facets of user involvement with computers were found to exist, determinant of involvement and situation of computer use, together they formed a three-dimensional model of involvement, a cylindrical structure termed, according to facet theory, a cylindrex. The six factors that determine involvement, listed in the first facet of the mapping sentence, formed a simple order, from challenge to extrinsic reinforcement, along the axis of the cylindrex, one of decreasing effect in the generation of involvement. The second facet contained the different situations, listed in the mapping sentence shown in Section 8.1, where this involvement might occur, orthogonal to the first, it divides the whole cylindrex into angular segments for each situation.

This composite model of involvement, developed from subjects' attributions of how people become involved with computers, demonstrates an hierarchy of theories of involvement according to
the depth of involvement with a computer program they explain. The theories occur in the same order in the hierarchy whether the computer is used for entertainment, for education or as a tool. Superficial involvement with the computer may occur as the result of extrinsic reinforcements, if the program itself provides further reinforcement, involvement may deepen. Thus shallow but definite involvement is generated instrumentally by reinforcement. Deeper involvement occurs if the user becomes ego-involved, behaving affectively towards the computer program. Involvement of the user is deepest, however, when cognitive factors of challenge from the program, being in control of it and curiosity about its complexity level are present. Therefore depth of involvement of the computer user is seen to be related to the modality of their behaviour.

This work on involvement with computers may be applied to other situations where involvement occurs, for instance in learning. It has been shown in Chapter Seven that involvement is important for learning. The concept that involvement is strongest when created by cognitive factors, can be deepened through the ego and maintained by reinforcement is just as relevant to learning history from a textbook or to learning how to drive a car as to learning how to play computer games. It is also applicable to the different methods of active and traditional learning which attempt to involve the student through approaches based, respectively, on cognitive and reinforcement theories. The results presented here show that cognitive explanations are held to be responsible for creating deeper involvement and so active learning appears to be the more successful approach.
It may be concluded that the most appropriate uses of computers in learning is in running simulations and instructional games or for programming where active learning may take place. The great advantage of using computers over other active learning methods is the ease with which the complexity level of a program may be changed to ensure a constant challenge to the user to successfully control the program. Even when learning to program the student is able to create more and more complex effects.

A final suggestion is that further research into this model is required, in this experiment only one example, usually the most obvious, has been given for each determinant of involvement in each situation. Whereas different challenges, and different ways of providing complexity or reinforcements for the individual situations should really be tested to see whether the structure of the model holds. Also, the model is based on research into people's attributions of involvement, further work is required on actual measures of involvement that can be taken while the subject is engaged in an activity such as interacting with a computer.
CHAPTER NINE

INDIVIDUAL PROPERTIES THAT AFFECT INVOLVEMENT WITH COMPUTERS

"Who can control his fate?"

- William Shakespeare (1564-1616)

Othello
9.1) Introduction

Earlier research reported in this thesis has concentrated on exploring differences in an individual's involvement with computer software caused by aspects of the software itself. However, it was felt that it was important to include an investigation of individual properties that may influence this involvement with computers. In Section 3.5 a number of individual attributes that appeared to be related to involvement with and attitude towards computers were discussed, these were sex, age, locus of control and self-esteem. This chapter describes a study to investigate the relationship between these attributes and involvement with computers amongst university students.

It has been widely observed that men are more likely than women to have taken maths at school or to have taken up computing courses in further education and, consequently, to have made careers in computing. Boys tend to be encouraged much more than girls to take up computing, for instance, Hoyles (1985) found that approximately 80% of home computers are bought for boys. Boys also have more experience of computers in recreational settings, McClure and Mears (1984) found that, amongst American high school students, boys reported playing video games significantly more often than girls. This has also been observed in England in a recent study of microcomputer use by secondary school children (Mohamedali, Messer and Fletcher, 1986) which found that boys spent significantly more hours playing games on home computers than girls ($\chi^2 = 51.46$, $p<.001$).

In an in-depth study of sex differences in attitudes toward and involvement with computers Dambrot et al (1985) found significant
differences between the sexes. Their subjects were 559 female and 342 male, American, first year university students who answered questions on attitude towards, aptitude for and experience of computers and anxiety about, aptitude for and experience of maths. They found that men were significantly more likely to have greater computer aptitude and experience and a positive attitude toward computers (p<.01) as well as prerequisite maths ability and experience (p<.05). Attitude toward computers was found to be related to anxiety about maths, aptitude for and experience of computers. However, the differences in computer attitude and involvement between the sexes were smaller than Dambrot et al expected and they suggest this is because the subjects were college freshmen and the differences would be greater, or perhaps more engrained, at a senior or graduate level.

This difference in involvement with computers according to gender has even been reported in children as young as seven. In their study of primary schoolchildren Siann and Macleod (1985) found significant differences (p<.01) between boys' and girls' interest in computers as rated by their teachers. There was also a significant difference between the numbers of boys and girls who had computers at home.

Computing is also generally considered to be the province of the young though this has not been so deeply researched. In a study of 241 secretaries' attitudes towards word processing equipment Arndt et al (1983) found that the older subjects were significantly less likely ($\chi^2 = 16.45$, df=3 p<.001) to have used a word processor. In their study of American high school students aged between 14 and 17 McClure and Mears (1984) found that younger students liked video
games more ($\chi^2=29$, $p=.004$) and played them significantly more often ($\chi^2=28.4$, $p=.005$) than older ones.

Therefore, the first two hypotheses put forward for investigation are a) that age and b) gender will affect attitudes towards and involvement with computers. It is also hypothesised that these are not permanent divisions between individuals but rather a consequence of the rapid emergence of computing technology and its immediate spread throughout the workplace. In this thesis involvement with computers has been recorded for people of all ages and both sexes. It is proposed to gather this information together in order to gain information on the current situation in computing which may be used to test this third hypothesis, c).

From the results of earlier experiments reported in Chapters Seven and Eight it was concluded that being in control of the computer played a large part in becoming involved with it. This discovery led to investigation of the role of the concept of locus of control in involvement with computers. Locus of control was introduced by Rotter (1966) in explanation of differences between individuals in how they tend to attribute reinforcements for their actions and how this affects learning. People range from being highly internally controlled ie. are sure that they influence what happens to them to highly externally controlled ie. those who are sure that anything that happens to them is the result of fate or work by others. Previous research (Tobin and Capie, 1982, Runyon, 1973) discussed in Section 3.5 showed that locus of control is related to involvement in both academic work and one's job. Thus it may be anticipated that locus of control is also related to involvement in computing. In fact the researchers discussed below
(Coover and Goldstein, 1980, Arndt et al, 1983) have already found a low but statistically significant correlation between locus of control and attitudes towards computers or word processors.

Coover and Goldstein (1980) asked 68 American university undergraduates to complete two scales. The first measured positive attitudes to computers, how much the subject regards the computer as a tool to be utilised, and the second, negative attitudes to computers, how much the subject regards the computer as an autonomous or mind controlling entity. They also asked the subjects to complete Rotter's (1966) Internal External (IE) Locus of Control scale. Their results showed that those who were more internally controlled had a significantly more positive attitude toward computers than those who were more externally controlled (F=13.88, p<.01). Internal subjects also had a less negative attitude toward computers than external subjects but the difference was not statistically significant.

Arndt et al (1983) carried out a questionnaire study of subjects randomly selected from the secretarial staff at an American university. They received 241 replies from subjects whose experience ranged from those who used a word processor continuously in their work to those who had never used one. The questionnaire assessed the subjects' experience of word processing, their feelings toward word processors and included a locus of control scale developed by Nowicki and Duke (1974). The results showed that locus of control was related to how reluctant a secretary felt towards using a word processor. Externally controlled individuals were significantly more reluctant to use the equipment and less curious about it. Also, for secretaries with experience of word processing locus of control was
related to curiosity and anxiety, internals being significantly more curious and less anxious about word processing.

However, other research has shown that the original concept of locus of control put forward by Rotter (1966) is not a simple continuum. Levenson (1972) proposed that Rotter's IE scale was multidimensional and in studies, both with normal subjects and psychiatric patients (1972, 1973), she found two definite dimensions; control by powerful others and control by fate or gods. She also found evidence for a possible third dimension of control by oneself. This was further investigated by Reid and Ware (1974) who measured the locus of control of 167 university students and used factor analysis to reveal the same three dimensions.

In the light of this research, Coover and Goldstein (1980) carried out a second experiment with 65 subjects. They again measured American university students' positive and negative attitudes toward computers but used Levenson's scale to measure their locus of control for the three dimensions. The results confirmed their hypothesis that those with positive attitudes who regard the computer as a tool to be used would score high on internal control of oneself and low on the other two dimensions. However, they had also proposed that those with negative attitudes would regard the computer as a powerful other and so score high on the control by others dimension and low on the others. This second hypothesis was not confirmed, the only dimension for which they found a statistically significant difference between people with positive and negative attitudes towards computers was internal control ($F=9.14$, $p<.01$).
From this research it appears that this dimension, control of oneself or internal control, of the original locus of control scale is the one most related to involvement with computers. It may be described in terms of reinforcement, from Rotter's (1966) original theory, as a continuum which ranges from highly internal individuals who attribute reinforcement for their actions to their abilities to highly external individuals who attribute reinforcements to external causes. Thus Rotter's theories are based on behaviourist theories of learning such as those proposed by Skinner (1938). However, it was shown in Chapter Eight of this thesis that the cognitive concept of control was more likely to be held responsible for creating involvement with computers than reinforcement. Therefore, the dimension of internal control may be better considered as the extent to which an individual believes that they are in control of their lives. People range from high internal control, those who believe they are in control, to high external control, those who believe they are controlled by outside influences.

This leads to the fourth hypothesis of this chapter, d), that control by oneself or internal control will affect attitude to and use of computers. If a person believes they are in control and, as discussed in earlier chapters, being in control of a computer is rewarding, then they will be happy with using a computer. However, if a person believes that they are not in control of themselves being placed in control of a computer will be unsettling and lead to conflicting emotions.

The final attribute hypothesised to affect a user's involvement with computers is self-esteem, hypothesis e). The higher a person's self-esteem the more likely they are to believe that they would be
able to cope happily with using a computer. People tend to see
operating a computer as a highly skilled task and those with
negative self images are unlikely to believe they have the requisite
skill or even the ability to learn it. Burns (1979) puts forward a
reciprocal relationship between self-esteem and academic attainment,
success raises or maintains self-esteem while self-esteem influences
performance. This cycle can be either beneficial or destructive to a
person's self-esteem. Since computing is usually introduced as an
academic subject people with low self esteem do not take it up for
fear of failing. As William James (1890) said "With no attempt there
can be no failure;" (p313).

In order to test these theories the following experiment was
developed and carried out. The questionnaire format was chosen as
the simplest way of getting information from the sample population.
It is also the instrument chosen most often for measuring locus of
control and attitudes.

A questionnaire was devised to assess individuals' involvement
with computers by asking them to describe their attitudes towards
computers and how much experience they had of using computers. The
questionnaire included the following locus of control and self-
estee m scales.

The locus of control scale used was the Internal Locus of
Control Index (Duttweiler, 1984) chosen because it was designed to
measure specifically control by oneself and not control by others or
fate. The latter two were not hypothesised to be related to computer
use. Duttweiler's scale was preferred to both Levenson's scale for
internal control used by Coover t and Goldstein (1980) and the forced
choice scale that Reid and Ware (1974) developed. Levenson, herself,
(1973) found her scale to be unreliable and forced choice is generally unpopular with subjects. Also it is difficult to ascertain whether the relationship between each pair of items in the forced choice is the same twelve years later when some of the words may have gained new meanings.

The self-esteem scale used was Rosenberg's Self-esteem Scale (Rosenberg, 1965), chosen because it was short and its use has been well established. This is a ten item Guttman scale developed for ease of administration that has been proven to measure an unidimensional continuum ranging from very high to very low self-esteem.

9.2) Pilot Study

The questionnaire described in Section 9.1 was first piloted using members of the Department of Psychology as subjects. A copy of the questionnaire is given in Appendix 8.1.

9.2.1) Method

The questionnaire included questions on age, sex and occupation, a 28 item scale for measuring internal locus of control (Duttweiler, 1984), a 10 item scale to measure self-esteem (Rosenberg, 1965), six questions on computer use, and seven on attitude towards computers. It also contained 36 statements giving possible reasons for enjoying using computers, the design and analysis of which are discussed in Chapter Eight. It was handed to the subjects for completion and comment.

9.2.2) Results

The questionnaire was completed by 20 people, 12 men and 8 women, whose ages ranged from 16 to 44 with a mean age of 28.7 years. They were 10 students, 6 university researchers, 2 directors,
a secretary and a charge nurse.

Their scores on the Internal Locus of Control (LOC) Index ranged from 71 to 130 with a mean of 106.2, the higher the score the more the subject is internally controlled. The scores on the self-esteem measure ranged from 0 to 6 with a mean of 1.85, the higher the score the less self-esteem the subject has.

Thirteen of the respondents had access to a computer both at work and at home, 6 had access to a computer at work only and one had access at home only. The number of uses made of computers ranged from 2 to 9 out of a possible 12 with 5 and 6 making up 50% of the replies.

Correlations between the internal locus of control and self-esteem scores were calculated with the demographic and computer attitude and use data using Kendall's Tau as the data were non-parametric. Most of the correlations were not statistically significant at \( p < .05 \) but those that were are tabled below.

**Table 9.1. Correlations between attitudes toward computers, internal locus of control and self-esteem in the pilot study.**

<table>
<thead>
<tr>
<th></th>
<th>Tau((\alpha))</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal LOC</td>
<td>Self Esteem</td>
<td>-.47</td>
</tr>
<tr>
<td></td>
<td>Being scared of</td>
<td>-.48</td>
</tr>
<tr>
<td></td>
<td>using a computer</td>
<td></td>
</tr>
<tr>
<td>Internal LOC</td>
<td>Being in danger</td>
<td>-.33</td>
</tr>
<tr>
<td></td>
<td>of computers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>taking over</td>
<td></td>
</tr>
<tr>
<td>Self Esteem</td>
<td>Interested in</td>
<td>.4</td>
</tr>
<tr>
<td></td>
<td>computers</td>
<td></td>
</tr>
<tr>
<td>Self Esteem</td>
<td>Want or wanted</td>
<td>.37</td>
</tr>
<tr>
<td></td>
<td>to know how to</td>
<td></td>
</tr>
<tr>
<td></td>
<td>use computers</td>
<td></td>
</tr>
</tbody>
</table>

The rest of the correlations are given in the table in Appendix 9.1.
9.2.3) Discussion and revision of questionnaire

The results of the pilot show a good correlation between low internal control and being scared of or in danger from computers which supports hypothesis d). They also show correlation between low self-esteem and interest in computers which is opposite to the one predicted in hypothesis e). These results were encouraging, if unexpected, and it was decided to continue with the study.

A number of comments and suggestions were made about the pilot questionnaire which were incorporated into the revised questionnaire shown in Appendix 8.2.

The questions on computer use "in the past" were unclear as some respondents were not sure as to when "in the past" was. The question was therefore reworded to inquire if the respondent has used computers more frequently than they do now and if so, how often and for how long.

There was no explanation of the different uses of computers, in particular some respondents did not realise the difference between arcade and adventure games. Examples of each sort of computer use were therefore included on the revised questionnaire.

The use of "indifferent" as the mid point on the 7 point scales was inappropriate, it was therefore changed to "neutral" on the computer attitude questions.

Many respondents had trouble remembering the points on the scale they were using and found it tiresome to turn back. The scales were therefore included on the top of each relevant page.

Finally, the order of the scales within the questionnaire was changed so that the easy to answer questions on computer use came
first progressing to the more difficult ones on locus of control and self concept.

The revised questionnaire was then given a second pilot.

The revised questionnaire was completed by 14 people. Their ages ranged from 21 to 46 with a mean of 29.07, there were 8 men and 6 women and they were 7 university researchers, 2 students, 3 postgraduates, a secretary and a manager.

Their scores on the Internal Locus of Control Index ranged from 93 to 136 with a mean of 111.2, the higher the score the more the subject is internally controlled. The scores on the self esteem measure ranged from 0 to 5 with a mean of 1.57, the higher the score the less self-esteem the subject has.

Four of the respondents had access to a computer both at work and at home, 7 had access to a computer at work only and 3 had no access at all. The number of uses made of computers ranged from 2 to 9 out of a possible 12 with 2, 3 and 4 making up 50% of the replies.

The internal locus of control and self-esteem scores were correlated with the answers to the demographic and computer attitude and use questions, however again most of the correlations were not statistically significant. Therefore, the results for questions that were included in the same wording in both the original pilot and the revised questionnaire were combined and correlated with each other using Kendall's Tau. This produced a sample size of 34 and the statistically significant correlations (p<.05) are tabled on the next page.
Table 9.2. Correlations between attitudes towards computers, internal locus of control and self-esteem resulting from pilots of the original and revised questionnaires.

<table>
<thead>
<tr>
<th></th>
<th>Tau(c)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal LOC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self Esteem</td>
<td>-.44</td>
<td>.001</td>
</tr>
<tr>
<td>Scared of using a computer</td>
<td>-.3</td>
<td>.014</td>
</tr>
<tr>
<td>Access to a computer</td>
<td>.36</td>
<td>.008</td>
</tr>
<tr>
<td>Interested in computers</td>
<td>.34</td>
<td>.008</td>
</tr>
<tr>
<td>Want to know how to use a computer</td>
<td>.43</td>
<td>.001</td>
</tr>
</tbody>
</table>

The rest of the correlations are given in the table in Appendix 9.2.

No suggestions were made about the revised questionnaire and it was decided to go ahead with the main study.

9.3) Main Study

9.3.1) Method

The questionnaire was piloted and its format revised as described in Section 9.2 until the final version shown in Appendix 8.2 was found to be acceptable. 200 copies were printed and handed to students at Surrey University to be completed and returned through the internal mail.

Correlations between the results of the questionnaire were calculated using the Statistical Package for Social Sciences. The coefficient used was Kendall's Tau(c) as it could not be assumed that the data was normally distributed. Smallest Space Analysis (SSA) (Lingoes, 1973) was then used to analyse the correlations between all the questions including those that made up the locus of control and self-esteem scales. SSA, described in detail in Section
8.3.2, performs a multidimensional statistical analysis that produces a geometric representation of the correlations between variables in two or three dimensional space. Points representing the variables are plotted in such a way that the closer they are together, the greater the correlation between variables. The way in which these points can be grouped into regions may be used to interpret the results.

9.3.2) Results

Seventy-four questionnaires were returned of which two had been defaced giving a return rate of 31%.

The respondents ages varied from 17 to 49 years with a mean of 21.26, 29 were female and 43 male. 58 were undergraduates, 5 were postgraduates, 4 were employed, 3 were managers and 2 were unemployed.

Age was not related to any of the other variables except for occupation. Seniority in occupation, graded on the scale unemployed, student, postgraduate, employed, manager, was found to correlate at the $p<.05$ level with age ($\gamma =.33$), worry as to the danger of computers taking over ($\gamma =-.17$), internal locus of control ($\gamma =.16$) and self-esteem ($\gamma =-.21$).

Using chi-square sex was found to be associated only with computing experience ($\chi^2=7.0$, $p=.03$) and interest in computers ($\chi^2=8.93$, $p=.01$). The actual percentages are shown in Table 9.3 on the next page.
Table 9.3. Sex differences in frequency of computer use and interest in computing.

<table>
<thead>
<tr>
<th>Computer Use</th>
<th>Men (%)</th>
<th>Women (%)</th>
<th>Interest in Computers Men (%)</th>
<th>Women (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than monthly</td>
<td>27.9</td>
<td>38.0</td>
<td>Not interested</td>
<td>65.1</td>
</tr>
<tr>
<td>monthly to weekly</td>
<td>44.2</td>
<td>58.6</td>
<td>Neutral</td>
<td>7.0</td>
</tr>
<tr>
<td>everyday</td>
<td>27.9</td>
<td>3.4</td>
<td>Interested</td>
<td>27.9</td>
</tr>
</tbody>
</table>

The respondents' experience of computers given by their access to and frequency of use of computers is shown in Table 9.4 below.

Table 9.4. Types of access to and frequency of use of computers.

<table>
<thead>
<tr>
<th>Access</th>
<th>%</th>
<th>Computer Use</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>16.6</td>
<td>None</td>
<td>5.6</td>
</tr>
<tr>
<td>At work</td>
<td>37.5</td>
<td>&lt; once a year</td>
<td>9.7</td>
</tr>
<tr>
<td>At home</td>
<td>15.3</td>
<td>&lt; monthly</td>
<td>16.6</td>
</tr>
<tr>
<td>At home and at work</td>
<td>30.6</td>
<td>monthly</td>
<td>16.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>weekly</td>
<td>33.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>everyday</td>
<td>18.1</td>
</tr>
</tbody>
</table>

The number of different uses the subjects made of a computer ranged from 0 to 11 with 4, 5 and 6 being made most often.

The respondents used all the points on the seven point scale ranging from definitely not (1) through neutral (4) to very much indeed (7) in indicating their attitudes towards computers, the mean answers to each question are shown in Table 9.5 below.

Table 9.5. Mean response to questions on attitude towards computers.

| Q1) | How interested are you in computers ?       | 4.46 |
| Q2) | How much do you want, or did you want       |      |
|     | to know how to use a computer ?             | 5.0  |
| Q3) | How much do you like using, or the          |      |
|     | idea of using a computer ?                  | 4.71 |
| Q4) | How much do you think that the user          |      |
|     | is in control of the computer ?             | 5.97 |
Table 9.5 (cont’d)

Q5) How scared are you of using a computer ? 2.57
Q6) How much are you in favour of the introduction of computers into your work ? 5.51
Q7) How much do you think that we are in danger of letting computers take over ? 3.57

The respondent's scores on the Internal Locus of Control (LOC) Index ranged from 71 to 130 with a mean of 102.6 and their scores on the self-esteem scale ranged from 0 to 6 with a mean of 1.53. A high score on the internal locus of control index indicates high internal control but a high score on the self-esteem scale indicates low self-esteem.

These variables were correlated with each other and attitudes to and experience of computing, the results that were statistically significant ie. $p < 0.05$ are reported below.

Internal locus of control was found to correlate with computing experience ($\gamma = 0.24$), number of uses made of a computer ($\gamma = 0.18$), interest in computers ($\gamma = 0.18$), like using computers ($\gamma = 0.21$), belief that the user is in control of the computer ($\gamma = 0.2$), being scared of computers ($\gamma = -0.33$) and self-esteem ($\gamma = -0.44$).

Self-esteem (measured in opposite direction to the other variables) was found to correlate with access to a computer ($\gamma = -0.17$), computing experience ($\gamma = -0.26$), number of uses made of a computer ($\gamma = -0.25$), interested in computers ($\gamma = -0.2$), like using computers ($\gamma = -0.18$), belief that the user is in control of the computer ($\gamma = -0.2$), being scared of computers ($\gamma = 0.41$) and in favour of the introduction of computers ($\gamma = -0.17$).
The rest of the correlations between answers to the questions on computer experience and attitudes are given in Table 9.6 below.

Table 9.6. Correlations between attitudes towards computers and computing experience.

<table>
<thead>
<tr>
<th></th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of access to</td>
<td>.34</td>
<td>.2</td>
<td>.2</td>
<td>.21</td>
<td>-.32</td>
<td>.27</td>
<td>-.19</td>
</tr>
<tr>
<td>Frequency of use</td>
<td>.47</td>
<td>.25</td>
<td>.29</td>
<td>.13*</td>
<td>-.34</td>
<td>.33</td>
<td>-.16</td>
</tr>
<tr>
<td>No. of uses made</td>
<td>.32</td>
<td>.21</td>
<td>.2</td>
<td>.07*</td>
<td>-.27</td>
<td>.31</td>
<td>-.17</td>
</tr>
<tr>
<td>Q1</td>
<td>X</td>
<td>.65</td>
<td>.71</td>
<td>.16</td>
<td>-.45</td>
<td>.38</td>
<td>-.26</td>
</tr>
<tr>
<td>Q2</td>
<td>X</td>
<td>.6</td>
<td>.23</td>
<td>-.46</td>
<td>.43</td>
<td>-.32</td>
<td></td>
</tr>
<tr>
<td>Q3</td>
<td>X</td>
<td>.12*</td>
<td>-.41</td>
<td>.33</td>
<td>-.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q4</td>
<td>X</td>
<td>-.3</td>
<td>.17</td>
<td>-.37</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q5</td>
<td>X</td>
<td>-.3</td>
<td>.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q6</td>
<td>X</td>
<td>-.23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p >.05 therefore correlation not statistically significant.

The results of the SSA for 3 dimensions are shown in Figure 9.1 on the next page, though only the plot for vectors 2 against 1 is shown, the same pattern occurs in the plot for vectors 3 against 1. The coefficient of alienation giving the goodness of fit between the plot and the original correlations is .23. The points indicated by numbers on the plot represent the questions with those numbers in the questionnaire shown in Appendix 8.2.
Figure 9.1. SSA of correlations between questions on involvement with computers, internal locus of control and self-esteem.

The SSA produces a geometric representation of the data so that the distance between each point on the plot is inversely related to the amount of correlation between the variables the points represent. It can be seen that points representing all the questions except for scared of using computers and in danger of computers taking over (both negative attitudes towards computers) lie in one large group, showing that they are related to each other and inversely related to a negative attitude towards computers. The points representing other questions on attitudes toward computers (all positive) form a small group within this large group and close to them are the questions on computer use. The points representing questions that form the self-esteem scale also form another small
group within the large group. The close grouping shows that they are highly related to each other. The questions from the internal locus of control scale are not so closely related to each other since the points representing them spread over most of the large group that also contains age and occupation. However, since this large group also contains the points representing positive attitude to computers, computer use and self-esteem all of these are related to internal locus of control.

Thus the SSA shows a close relationship between positive attitudes towards computers and experience of and use of computers and between these variables and self-esteem and internal locus of control. Individuals with high self-esteem and those who are more internally controlled make greater use of computers and are more likely to hold a positive attitude to them. All these variables are negatively related to both being scared of computers and being in danger of computers taking over which are themselves closely related.

The subjects were then selected according to sex, whether they were a student or employed and whether they had made few (<5) or many uses of a computer. SSAs were carried out for each of these subject groups and the resulting plots were compared to see whether these affected the relationships between internal locus of control, self-esteem and attitude to computers.

The plot resulting from the SSA for men was similar to that for the overall SSA but, in the one for women, computer experience and positive attitudes towards computers were more widely spread within the group made up of these and locus of control and self-esteem questions. This indicates a less strong connection between computer
experience and positive attitudes toward computers but these variables are still related to locus of control and self-esteem.

The SSA plot for students was similar to the overall one except that age was plotted close to the negative attitudes towards computers indicating that older students were more likely to be scared of computers. The SSA plot for subjects with jobs was also similar to the overall SSA plot except that again age was close to negative attitudes and that computer use and experience was spread widely through the locus of control group. This indicates that for those in employment computer use and experience is more related to internal locus of control than attitude towards computers.

The plot resulting from the SSA for subjects who made many uses of computers was very similar to that for the overall SSA. However, the plot for those who made few uses of computers showed the group of positive attitudes to be much more widely spread and next to rather than within the computer experience, locus of control and self-esteem group which itself was also more widely spread. Age was also plotted close to negative attitudes to a computer. This shows little connection between locus of control, self-esteem, and positive attitudes to computers but locus of control and self-esteem were related to computer use and experience.

9.4) Discussion

The first hypothesis of this chapter, a), that age would be related to involvement with computers was supported by the SSAs of the results for undergraduates and for subjects with little experience of using computers. These show age plotted close to negative attitudes towards computers such as being scared of using them and worry about being in danger from computers taking over. The
older the students were the more likely they were to be scared of using computers and so are less likely to become involved with them. However, the hypothesis is not supported by the SSA for subjects with a lot of computing experience. Therefore, it appears that once initial apprehension about using computers has been overcome there is no difference between older and younger users but people are more anxious about learning to use computers.

Sex was found to be associated with interest in and experience of computers supporting the second hypothesis, b). A greater proportion of men than women were either interested or not interested in computers but women were much more likely to be indifferent to an interest in computers. Many more men than women, 28% to 3%, used computers on a daily basis indicating greater experience with their use and a greater likelihood of becoming involved with them.

The following results were collected together from studies reported in earlier chapters of this thesis in support of hypothesis c), that the difference between the sexes in involvement with computers will not be permanent. In Section 6.2.3 it was shown that it is only as children reach ten years or over that any difference in involvement with computers is seen. The number of programs known by each sex and the number of different types of programs known were compared for primary schoolchildren grouped by age. Only for the 10-12 year olds was there a significant association between sex and number of programs or number of different program types known. When older children were surveyed as reported in Section 4.2.3, a significant association was found between gender and frequency of computer use at school, use of a home computer and number of
computer languages known for 14, 15, 16 and 17 year olds.

It therefore appears that girls go through a period at the start of adolescence where they do not share the same enthusiasm as boys for computing or maths which may leave them with a lasting indifference to computers. This also supports Dambrot et al's (1985) suggestion that rather than having a biologically or socially determined lack of interest in computers girls do not enter computing as they do not have the prerequisite qualifications. The period in which girls show a lack of interest in maths and computing unfortunately coincides with the one when major exams are taken and career choices made. However, when today's primary schoolchildren become teenagers, girls will have already had several years experience with computers and so it may be expected that the differences in computer use according to gender will no longer occur. Further research is required to assess the situation in several years time in order to confirm this hypothesis.

The fourth individual attribute hypothesised to be related to involvement with computers was internal locus of control, hypothesis d). This was supported by the results which showed internal locus of control to be positively related to experience of computers, interest in computers and liking using computers and negatively related to being scared of using a computer or belief that one is in danger from them. Also, the more internally controlled individuals are more likely to believe that the user is in control of the computer. When the subjects were split into subgroups this relationship between internal locus of control, experience of computers and favourable attitudes towards them held for men, women, students, those with jobs and those with a lot of computing
experience. For those with little computing experience internal locus of control was related to the amount of use they had made of computers but not to attitudes toward computers.

Coovert and Goldstein (1980) hypothesised that people with an internal locus of control have positive attitudes towards computers because they regard them as a tool to be utilised, whereas people with an external locus of control have negative attitudes towards computers because they regard them as a powerful other. However, the results of this experiment do not support this idea that two dimensions of locus of control are responsible for differences in involvement with computers. Measuring locus of control using only the internal control dimension was found to show that people with low internal control, i.e. those with a more external locus of control, have negative attitudes towards computers and less experience in their use. Thus it may be concluded that it is the dimension of internal control that affects an individual's involvement with computers.

The importance of internal control in involvement can be explained from the results of the studies reported in Chapters Seven and Eight of this thesis where it was found that being in control of the computer was a significant factor in becoming involved with it. Individuals with high internal control believe that any results they achieve are due to their actions and are more likely to be involved with computers as they provide an attractive opportunity to exercise their control. They are then rewarded by successful control or, if unsuccessful, consider the faults to be on their side and attempt to remedy them until successful control is achieved. However, individuals with low internal control do not consider the results
they achieve to be consequent upon their actions and so when using a computer will consider the machine to be in control. Therefore, they are more scared of entering into an interaction with computers and so are unlikely to become involved with them and to regard them negatively. If a person does not believe that they are in control of the computer then it is unlikely that being placed in control will be rewarding and may lead to uncomfortable internal conflicts.

This idea of the user controlling the computer versus the computer controlling the user was noted by Papert (1980) when he advocated the use using LOGO, a programming language designed for education, in preference to the drill and practice software typically used. If, as Papert suggests, drill and practice software causes the computer to 'program' or control the user then, according to the above discussion of internal locus of control, people with external control will be happy using drill and practice whereas internally controlled people will not. This is indeed what Wesley, Krockover and Hicks (1985) discovered, when comparing internals and externals on computer aided instruction (CAI) and instruction from text, they found that externals favoured the CAI mode and there was no difference between modes for internals. Chandler (1984) also notes the change in locus of control from within the program being used to within the user according to the type of software being operated. However, he does not consider it to be a dichotomy like Papert but rather a continuous variation from tutorials where the program is in control through games, simulation games, experimental simulations and content free tools to programming languages where the user is controlling the computer.
Subject's occupation was also found to be related to internal locus of control. However, as the plot for the SSA of students only was very similar to the overall one, it may be concluded that the reported relationship between locus of control, computing experience and attitudes towards computers discussed here is not dependent on job involvement as suggested in section 3.5.3.

The last aspect hypothesised to affect an individual's attitude towards and experience of using computers was self-esteem, e). High self-esteem was found to be related to both positive attitudes to computers and high involvement with computers, and low self-esteem to being scared of computers supporting the hypothesis. The opposite results of the pilot reported in section 9.2.2 may be explained in that nearly all the subjects were university employees with easy access to a computer. Only those with low self-esteem were interested in, or wanted to know how to use computers, those with high self-esteem had already found out how to use them and now regarded them as nothing more than a familiar tool.

The results confirm the common observation that those with low self-esteem fail to get involved with or learn about a subject, in this case the use of computers, because they believe that they will be unable to cope. However, Burns (1979) states that the self concept is stable from preadolescence onwards and as computers are introduced to younger children it is to be hoped that they will gain familiarity with computers before low self-esteem prevents them from approaching them later. As familiar tools they will not be subject to the concept that people have to be clever to use them.
Finally, an interesting relationship was noted between locus of control and self-esteem. The positive correlation between them corroborates Burns' (1979) armchair analysis of the relationship between the concepts and supports Bellak's (1975) results where externals produced a lower self evaluation on verbal memory tasks. However, Rotter (1966) states that those who believe they are responsible for the successes they achieve (internals) are more likely to work harder at tasks and so are more likely to gain a positive self concept. Thus high self-esteem is actually a result of having a highly internal locus of control.

9.5) Conclusion

Four attributes of the individual were found to be related to their attitude to and consequent involvement with computers. These were age, sex, internal locus of control and self-esteem however, the relationship is not so strong for those who have had little experience of computers.

It may be concluded that differences in how people of different ages and with different levels of self-esteem view computers are caused by the rapid introduction of computers throughout society. Older people and those with low self-esteem are less likely to want to learn how to use the new technology and so are less susceptible to becoming involved with it. Also that differences in how people of different sexes view computers are caused by associating computing with maths and science. However, it is suggested that, as young children who have used computers in school and at home for a variety of purposes, grow up the differences in individual attitudes towards computers caused by these attributes will gradually disappear.
The most interesting result of this study is the low but definite correlation between the internal dimension of locus of control and involvement with computers. This may be explained using the concept of locus of control as a continuum of belief in individual control from people who locate control of their actions internally to those who believe that their actions are controlled by external sources. Since being in control of the computer is a major factor in motivation to use it an individual's belief as to the source of control of their actions affects the level of their involvement with a computer. If a person does not believe that they are in control then they cannot become involved in the control of a computer in such tasks as programming or playing a computer game. However, in the case of rigid drill and practice software the computer appears to be in control and so externally controlled people would be more likely to become involved in using computers in this way.

This last finding has great potential for those who employ people in the field of computing or for those who advise on people's careers. On gaining an idea of whether a subject has high or low internal control then it would possible to assess their suitability for training as a computer programmer. For instance it could be seen whether they would enjoy programming or whether they would prefer data entry. Teachers would be able to assess how their students would react to the different types of computer based instruction. This would also be applicable in other learning situations with externally controlled students being happiest with traditional learning methods and internally controlled students with active learning methods.
Finally, it is also possible that by teaching psychiatrically disturbed people with suitable software to learn to enjoy being in control of a microcomputer they might start to internalise their locus of control. Once this learning is transferred to other situations it would be an important step on the road to recovery.
"Conclusions don't have any special status, they are, themselves, staging posts on the road to further enquiries."

- Bryan Magee (September 1987)

In a discussion on Plato's philosophy broadcast by BBC TV
10.1) Introduction

The conclusions that can be drawn from the studies exploring the concept of involvement with computers, described in the earlier chapters of this thesis, are presented in this chapter together with the original aims of the research. This is followed by a discussion of how the results of the research may contribute to the psychology of learning and motivation, the design of educational software and educational practice.

10.2) Summary of the Conclusions of the Thesis

The first aim of the research, carried out after the literature had been reviewed, described in Chapters Two and Three, and the area of proposed research surveyed, described in Chapter Four, was to clarify the question of high motivation to use microcomputers and relate it to an overall concept.

In order to fulfil this aim facets taken from the literature relevant to interaction with educational software were used to describe microcomputer programs. Six facets, challenge from, curiosity about, fantasy within and interaction with the software, mode in which information is presented and type of learning involved were used. They were divided into the following categories:- challenge from fixed or variable goals, sensory or cognitive curiosity, intrinsic or extrinsic fantasy, external or internal interaction, visual, verbal or symbolic mode and verbal/visual information, intellectual, cognitive or motor skills learning.

Profiles were made up for one hundred, randomly selected, educational and games programs using the above categories. Multivariate statistical analysis of the profiles demonstrated that all of the above facets except mode of information presentation
could be represented by an overall facet of level of involvement with the software. The assignment of the software to the relevant categories was confirmed by the results of a second experiment, a sorting task. Eight subjects had to sort descriptions of software, selected to give a wide range of possible involvement, into the categories given above. The results showed that the software fell into six separate groups that varied along a single dimension, level of user involvement.

This division of software into separate types according the amount of involvement that could be expected when using the different programs was investigated further in order to realise the second aim of the research. This was to find out how involvement was related to the different types of software used in schools and at home. A scale of user involvement was proposed where the amount of potential involvement with a microcomputer program ranged from little or none with poor quality programs that were difficult to operate to a maximum with arcade type games. At intermediate levels there was some involvement with drill and practice programs which increased if they included graphic effects and increased even further if they incorporated a game. Problem solving programs provided even more potential for involvement followed in turn by software used to create material such as word-processing or graphics programs and, finally, involvement reached a peak with arcade type computer games.

These different software groups were used to form a seven point scale of software potential for user involvement. This scale was tested with data collected in an earlier survey of computer use in local primary schools and was found to agree with both the
children's opinions of the programs and the teachers' specific comments on the programs. The concept of a scale of software types was further explored in a study questioning 373 primary schoolchildren about the programs they used at home as well as at school.

This produced 420 different computer programs that could be reduced to 31 separate software types including 15 different types of arcade games. The children's opinions of the different software types were analysed using multivariate statistical techniques and were again found to vary along a single dimension, that of user involvement. However, the many different types of arcade games did not differ significantly from each other in level of user involvement produced and so the results of this experiment corroborated the seven point scale developed earlier except in one point. Educational adventure games, originally included with problem-solving programs, were found to create extremely high involvement and were therefore included as a separate group forming an eighth point at the top of the scale.

Software properties that might be related to involvement were investigated for the third aim of the research, to discover how becoming involved with a computer program affected learning from it. From the literature on intrinsic motivation and involvement, and observation of properties of the different types of software discovered in earlier experiments, involvement was hypothesised to depend on three variables. These were the size of the challenge offered by the software, the extent to which the user was in control of the software and the level of the complexity of the software.
These properties were varied in an experiment to test their effects on involvement with and learning from an educational computer game.

Six different versions of the educational computer game, a simulation designed to teach children what to do on discovering a fire at home, were developed. The properties hypothesised to create involvement were systematically varied between the versions using colour graphics to provide complexity, a high score table to provide challenge and a choice of routes through the simulation to provide control. Three hundred children, divided into 150 pairs matched for age and ability, played two of the six versions and compared them on questions designed to assess differences in involvement with the two versions. They also completed a questionnaire on fire safety knowledge before and after playing the first version. The children became involved with all the versions where they were allowed to control their route through the simulation and their involvement deepened when both complexity and challenge were present. Being in control of the program was also shown to cause a significant increase in learning from it and the presence of complexity or challenge, or especially the inclusion of both, further enhanced learning.

Since this experiment it is interesting to note that Malone and Lepper, whose work has been referred to throughout this thesis, have joined forces and in a recently available publication combine their theories to produce a taxonomy of intrinsic motivations for learning (Malone and Lepper, 1987). In this they stress the importance of control, an issue previously neglected by Malone, thus supporting the results of this experiment.
Also recently, the Home Office has distributed copies of VESTA, the microcomputer simulation written by the author and used in this experiment, to each of the Fire Brigades in England and Wales for assessment of its use in fire education in schools. Should it be received favourably it would mean that the research for this thesis has already produced a valuable microcomputer based learning aid.

The three software properties found to create involvement in the above experiment were compared with other theories used to explain involvement with computers in fulfillment of the fourth aim of the research, the discovery of the properties of software that produce involvement in the user. In all six theories were compared, the first three, discussed above, were explanations of involvement through control, through challenge and through complexity and were taken from the literature on intrinsic motivation. The second two possible explanations were taken from an opposing point of view, that of reinforcement theory. These postulate that an individual becomes involved with computers either because he is rewarded by the program, for example, with points or free games for doing well, or because of goals or rewards extrinsic to the actual software. The latter might be approval from a teacher, admiration from peers or consideration of a lucrative career. The final explanation was based on a concept that formed most of the original work on involvement, that of ego-involvement. A user becomes ego-involved with software if they associate themselves with the subject or results of the program being used so immersing their egos in the software.

In order to compare these hypotheses as to the causes of involvement seventy-two university students were asked to indicate how much they agreed or disagreed with explanations for becoming
involved with the computer in a variety of situations. Explanations for becoming involved with the computer in each of the following situations, educational programs, word-processing, programming, financial or data analysis software, playing arcade games or adventure games, were taken from each of the above hypotheses. The results showed that, rather than one or more of the above explanations being held to be responsible for involvement at the expense of the others, all the theories could be combined to produce a composite model of involvement. In each of the situations where a computer could be used, involvement was produced by control and complexity of, challenge and reinforcement from, and ego-involvement in the software together with external reinforcements.

However, according to the subjects' attributions of how people become involved with computers, a simple order exists amongst these theories. The cognitive factors of challenge, control and complexity created the deepest involvement, ego-involvement occurs if the user becomes affectively involved and reinforcements create shallow, instrumental involvement. This order of explanations of involvement is the same whether the computer is used for games, for education or as a tool. Thus the model of user involvement with computers combines the two separate hypotheses as to the causes of involvement, first discussed in Chapter Three. In the first, the individual is cognitively active in becoming involved and, in the second, the individual is involved instrumentally through behavioural reinforcements.

The final aim of the research was to determine properties of the individual that make them more or less susceptible to the engrossing aspects of operating a computer. In order to investigate these the
seventy-two university students were also asked to complete a questionnaire to assess their attitudes towards and experience of using computers, their locus of internal control and their level of self-esteem.

The results showed that both locus of control, measured using the internal dimension as opposed to dimensions of control by others or control by fate, and self-esteem were related to involvement with computers. Individuals with a highly internal locus of control had a more positive attitude towards and more experience of using computers and were therefore more likely to become involved with computers than those with an external locus of control. It was concluded that this was due to the importance of being in control of the computer in becoming involved with it. An individual with a more external locus of control does not believe that they are in control of themselves, therefore they would be unhappy about being put in control of a computer and would not become involved with it. Individuals with high self-esteem, as well as having greater confidence in their ability to use a computer, are more likely to have an internal locus of control and so will become involved with a program more easily than those with low self-esteem.

Gender was found also to be related to involvement with computers. In earlier studies it had been found that once children reached the age of eleven or twelve boys demonstrated more use of and knowledge of computers and software than girls. This difference persisted amongst the adult students however, no theory as to the reason for this has been conclusively proved. Since amongst younger children there is no difference between the sexes in involvement
with and experience of computers, it may be expected that in the future these differences will disappear.

Finally, during the course of the research many other conclusions were noted about the disappointing response to the introduction of computers to schools. This is mostly due to the physical difficulties found in many schools in using the computer. Examples are having to keep the new, expensive tools locked away or guarded, teachers who have received little or no training in the use of the computer and who are too anxious about their ability to use it, and the government's subsidy of the purchase of the computer but not that of peripherals such as disk drives or printers which make its use so much easier. The vast bulk of available software that merely transfers drills of little educational merit from the classroom on to the computer does nothing to encourage teachers in the use of the computer.

10.3) Contributions of the research to theories of motivation and learning

The research reported in this thesis based on originally separate theories of intrinsic motivation, of reinforcement, of ego-involvement and learning has shown that they can be reconsidered using a new approach, that of involvement. The concepts are related in that motivation to perform an activity, produced intrinsically or through reinforcement, creates involvement with it. Increased involvement with an activity, for example, using an educational computer simulation, was found to result in increased learning from the activity. The discovery of a facet of involvement underlying both motivation to use and learning from computer software, and
incorporating theories related to both, is an important contribution to research in this field.

The concept that separate theories appropriate to both motivation and learning are in fact inextricably related to each other, and can be used to produce a composite model of involvement, forms a new outlook for the psychology of learning and motivation. This model combines cognitive drive theories of responding to challenge, need to explore complexity, and the desire to control together with the concept of the ego and behaviourist theories based on the importance of reinforcement.

However, it was shown that people held reinforcements to be responsible for creating only shallow involvement with computers, this involvement is considered to deepen if the ego becomes involved and is deepest when created by cognitive factors. This hierarchy may be usefully related to the modality of the behaviour expressed by the user for instrumental behaviour is demonstrated in responding to a reinforcement, affective behaviour in involving the ego and cognitive behaviour in desiring to control, to explore or to take up a challenge.

This approach may be used to explain differences in the behaviourist and cognitive outlooks on the study of motivation and learning which have hitherto resulted in separate theories. Even previous combinations of these two concepts, for example, Tolman's purposive behaviourism (Hill, 1985) and Rotter's social learning theory (Rotter, Chance and Phares, 1972), rely on the importance of instrumental reinforcements merely inserting cognitions mediating the reinforcements. For the instrumental nature of reinforcement means that it is easily observed and by concentrating on
reinforcement to the exclusion of all else behaviourists such as Skinner have missed the role played by cognitive factors. They have also ignored the role played by the ego for, as Allport (1943) noted, the experiments that reinforcement theory was developed from took place upon animals. However, behaviourism should not be dismissed as simplistic and irrelevant as Sprague (1981) does for reinforcement plays an important part in involvement. It can be used to involve a user in a task, even if only superficially, and thus creates opportunities for deeper involvement to occur.

This research supports the theories of cognitive psychologists such as Piaget (1952) and Bruner (1966) who stressed the importance of being cognitively active in learning using the concepts of control, curiosity and challenge. However, these three concepts, though related, were considered by the subjects to be separate which refutes Lepper's (1985) hypothesis that they were the results of different experimental approaches. Deep involvement of an individual with an activity is formed primarily through challenge which is a desire to achieve the goals set by the activity, then a desire to be in control of the activity and, finally, desire to explore the complexity of the activity. For this sort of involvement to occur the individual's ego must be immersed in the activity.

The results of this research have considerable import for the debate on active versus traditional learning for being in control of an activity such as using an educational computer game was found to have a significant effect on learning from it. In active learning tasks the student is in control or feels that they are in control whereas in traditional learning tasks the teacher is in control. Thus active learning provides opportunities for the student to
become cognitively involved whereas traditional learning effectively prevents deep involvement by not allowing control. The teacher has, therefore, to rely on reinforcements to induce involvement in traditional learning methods. Since amount of learning is related to depth of involvement, active learning tasks will be more successful in producing learning than traditional methods.

It was also found that the concept of locus of control is relevant to learning from computers using both active and traditional methods. Rotter (1966) developed the idea of locus of control by including a cognitive variable, expectancy, with theories of reinforcement and learning. However, this research has shown that cognitive factors are more effective than reinforcements in involving individuals in learning tasks. It is therefore more helpful to consider locus of control as a continuum extending from individuals who locate the source of their control internally to those who believe they are controlled by external factors. Since being in control of an active learning task, using a computer simulation, was shown to be important in involvement with and learning from it externally controlled learners are at a disadvantage for they do not believe that they can be in control. However, they are more likely to learn from tasks based on traditional learning methods such as drill and practice software where the program is in control.

Finally, the research has demonstrated the usefulness of microcomputers as a field in which to research learning and motivation. Software can be created to present any kind of problem, it can be manipulated experimentally to test the effects of certain variables and can also be used to record the subject's opinions and
reactions throughout the experiment. The microcomputer itself, as well as the software, is portable and so the experiment can be taken to the subjects for ease of administration.

10.4) Contributions of the research to the design of software

The main contribution of this research to software design is in the field of educational programs, games programmers already allow control and manipulate the variables of challenge and complexity to great effect even if they have not considered the psychological principles involved. Both Jones (1980) and Malone (1980), quoted in Section 1.2, have asked what features of computer games can be transferred to educational programs to make them more interesting. The answers given by this thesis are user control, more of and a greater variety of challenge and complexity and less emphasis upon reinforcement.

At present most educational programs provide little opportunity for control by the user, perhaps offering a choice of difficulty level. The common exceptions to this are the educational adventure games, such as the immensely popular Granny's Garden, where the student is in control, making decisions and choosing their route through the adventure.

There are already several types of software where the user is in control whose potential use in education could be better exploited. For instance, writing computer programs can be used to explore mathematical concepts such as solving algebraic equations, testing rules of logic or discovering geometrical relationships. Word processors could be used for English compositions in which grammatical and spelling errors could be remedied and teacher's suggestions included with ease. Databases of historical or
sociological information can be set up and interrogated to discover trends and relationships. Finally, simulations have applications in all subjects, especially sciences, for they can be developed to illustrate virtually any topic from a chemistry experiment to getting out of a house on fire.

It is suggested that educational programmers concentrate on providing educational simulations and games where the emphasis is on controlled exploration of a topic. They will be more expensive to develop than traditional drill and practice software but will demonstrate and test the rules to be learned in a way that will involve the learner deeply in their study thus increasing interest in and learning from them. However, use of such software should still be guided by a teacher, by documentation or by the program itself to ensure that it is being used effectively.

Educational programs already provide challenge in the form of intermediate goals such as getting the answers right and in the final goal of completing the program. Displaying a high score table is a relatively simple method of setting goals such as achieving the highest score and beating a previous score. However, the most involving effects of challenge are found with variable goals, as the user becomes more skilled at the task being learnt the goals are made more difficult to attain and so a constant challenge is maintained. For instance, the effectiveness of decreasing the time available to answer each question in on increasing user involvement with programs such as Table Test was noted in Chapter Six.

It is recommended that in order to provide varying goals educational programmers ensure that each program has enough difficulty levels to maintain its challenge. Such levels do not have
to be restricted to drill and practice type software, for instance, increasing the difficulty of problems to be solved by the user during an educational simulation or adventure game will vary the challenge and maintain involvement. However, an important point to be noted is that the user must be informed of their progress towards the objective of the program by displaying the goals that they have achieved. This may take the form of the proportion of correct answers or the difficulty level they have reached and should be considered as feedback rather than opportunities for reinforcement.

The role of complexity does not appear to be so important in learning, many educational programs have limited or no graphics, however, programs with audiovisual effects are greatly preferred. Involvement with a program was shown to increase when graphics were provided in the experiment described in Chapter Seven. Graphics can also be used to illustrate concepts that would otherwise take up much of the limited space for text on a computer screen in explanation. Educational programmers have already made much of the attractions of graphics but in the role of reinforcements. However, their role in creating involvement can be seen in that children take great delight in exploring an entire simulation to see what pictures it will produce and will even get answers wrong to see the pictures supposedly providing negative reinforcement.

However, complexity is closely related to challenge and may be similarly varied to maintain involvement. Complexity may be increased by speeding up animation, by representing objects in three dimensions or by allowing them to move in more directions. It is suggested that educational programmers would do better to employ audiovisual effects in this role, incorporating them within the
topic being learnt. This would fit in with the recommended use of computers for simulations and adventure games which the learners could explore with the aid of graphics of increasing complexity.

Until now educational programmers have concentrated on producing learning through reinforcement. Positive reinforcements include displaying congratulations, being allowed to play a game, see a picture or hear a tune and negative reinforcements might be derogatory remarks often accompanied by derisory sound effects. Some programs may even include the user's name in their comments for a personal touch. However, the emphasis is always on reinforcement and, as the research reported here shows, reinforcement is not considered to produce deep involvement. This is supported by Condry (1977) in his review of experiments on self initiated versus other initiated learning. He noted that the apparent effect of providing a task-extrinsic incentive was to undermine performance of and interest in the rewarded activity. Thus there is less involvement in an activity when a reward is offered for taking part than if the activity is engaged in for its own sake. It is therefore suggested that educational programmers should abandon the use of vicarious rewards and allow controlling the software to achieve its goals to provide its own reinforcement.

In summary, educational programmers should concentrate on developing software with a graded set of challenges suitable for a variety of abilities that can be controlled by the user or allows them to feel that they are in control. They should provide opportunities for reinforcement by letting the user know as they achieve the program's goals. Audiovisuals should be included but to inform the user of their progress through the program and to
illustrate the concepts involved not as rewards external to the topic being learned. In discussions with two educational programmers, they both noted the importance of making the concepts being learned part of a game. In this way they gave the user control of the learning task and asked them to respond to a series of challenges. However, it is important for transfer of learning to other situations to inform the user of their learning objectives to ensure that they realise that they are not just playing games.

10.5) Contributions of the research to teaching practices

The first point noted about teaching with computers during the course of this research was how unnecessarily difficult it was for the teachers. They received little training and no extra time with which to familiarise themselves with the operation of the computers. The schools were reluctant to buy peripherals that would simplify the use of the computer as these often cost more than the computer itself. Organising time spent at the computer by the children and what programs they had completed was virtually impossible with tens of children to one microcomputer. In fact, in the primary schools surveyed, most use of the computer was in breaks and organised by the children themselves, treating the computer as a fun activity rather than as a learning tool. The teachers feel guilty about not using the computer because of these difficulties and therefore treat the computer as a source of anxiety thus becoming even more reluctant to use it.

Perhaps the worst aspect of computer use in primary schools was the software used which tended to be so badly written and educationally doubtful that the teachers could see no point in using it. However, the situation is changing and there are quite a few
excellent teaching programs, for instance, educational adventure games and databases, word processors and high level languages designed for use by children are all now available. The research reported in this thesis has shown that students are more likely to become involved in and learn more from such software where they are active in the learning task. However, these programs are expensive and it takes a dedicated head teacher to spend a large proportion of the school's budget on one resource. Quite often the schools rely on donations from the parents to support the computer which will mean a division in children's ability to use and gain from computers according to the affluence of the area they live in.

It is suggested that, in order to use computers in schools effectively, teachers need more training in how to use the computer and what software to use, and schools need enough money to build up a complete computing resource. This would include peripherals, at the very least a printer and a disk drive, as well as a microcomputer and suitable educational software as described in Section 10.4.

The research on the relationship between locus of control and involvement with computers is particularly relevant to education. A teacher could assess how much a student believes that they are in control and then provide them with appropriate software, programs with lots of opportunity for user control for internals and little or none for externals. Since being internally controlled has been correlated with academic achievement a teacher could attempt to change the beliefs of externally controlled students by introducing them to control over a computer and then gradually extending this to other learning processes. Once an externally controlled student
comes to believe they can control the computer they may be more ready to accept control over other life events.

The results of this research on education with computers may be transferred to other learning situations for the composite model of involvement relating challenge, control, complexity, ego-involvement, intrinsic and extrinsic reinforcement is relevant to all learning tasks. Teachers should ensure that any learning task involves a challenge to the user, that the challenge may be varied, that it contains suitable levels of complexity and that wherever possible the student should be able to control or influence some aspect of the task. Feedback is important to inform the student of how successfully they are doing the task but should not be in the form of reinforcements that become the student's reason for engaging in the task. Finally, giving a student control must not be interpreted as providing complete freedom, the student should always be guided.

10.6) Future Implications of the Research

In a thesis on research into the potential of microcomputers some mention should be made of the concept of artificial intelligence (AI). This is the study of mental faculties through the use of computational methods (Charniak and McDermott, 1985). One of the most important of these faculties is the ability to learn and much AI research has concentrated on how to program computers to 'learn'. However, AI concepts can also contribute to the use of computers in education in other ways. Several methods of applying AI to education have been suggested by Yazdani (1984). These are the use of intelligent tutoring systems, AI programming environments,
microworlds, learning by doing AI, searching databases of information and artificially intelligent programs.

An intelligent tutoring system is a computer aided learning (CAL) package enhanced with the ability to diagnose students' errors and to provide appropriate remedial action. It therefore contains a model of the student to compare with the actual behaviour of its user.

AI programming and microworlds are linked in that AI programming languages are used to build microworlds which are limited portions of the real world whose characteristics are easily understood. The most well known of the educational microworlds is the use by children of LOGO to run 'turtle graphics' and so promote their understanding of geometric and mathematical concepts (Papert, 1980).

Learning by doing AI focusses on what can be learnt by using AI programming environments to produce intelligent programs. For instance, writing a program that 'learns' to play a game such as noughts and crosses helps the student to understand learning.

The educational potential of databases of information has already been realised and software to search databases e.g. Factfile can be found in schools. However, the methods used can be improved and more easily understood by using an AI language such as PROLOG to query the database.

New methods of learning can occur through observing how artificially intelligent programs such as expert systems, programs that can behave like an experts in a particular field, operate. For instance the student can follow the program through its line of reasoning and study the information used.

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In fact an intelligent tutoring system is really an expert system replacing the teacher as the expert in providing knowledge. An expert system has two major components, a database containing the information it needs and an inference engine which operates on the information to make decisions. In an intelligent tutoring system the database would contain the model of how the student should be learning, the information to be learnt and diagnostic tests to assess actual learning. The inference engine, by comparing the student's behaviour with its stored model, assesses whether learning has taken place and the student should move on to the next task, or whether the student is making errors and should be presented with remedial information.

However this model of intelligent CAL recommended by both Yazdani (1984) and O'Shea and Self (1983) is still based on reinforcement in the form of informative feedback. It does not consider the cognitive variables, except for perhaps graphic complexity where pictures may help information transfer, that were found in this thesis to be much more effective in involving the learner in the task. The research in Chapter Seven showed user control to be very important in involving the student and so increasing learning. In the form in which it is presently being discussed, intelligent CAL does not allow user control. However, this could easily be provided by allowing the student to choose the order in which the topics to be studied are presented and the difficulty level at which to work. Allowing choice of difficulty level will also increase the challenge of an intelligent tutoring system for, by always tailoring the problems to the individual's ability, much of the challenge in attempting a more difficult task
is lost. Challenge may also be included by recording the student's performance and displaying it as a 'previous best score' when the next task is presented. Complexity, in the form of graphics, should be used as much as possible not the least because a computer screen is a poor method of displaying textual information.

Better methods of using AI techniques in education would be to continue to develop easier methods of communicating with the computer such as natural languages including speech comprehension, digital pads with appropriate overlays or ability to read handwriting and type scanners. The computer could then be used productively as a source of information (encyclopaedic databases), as an environment for discovering and testing theories (programming in microworlds), and as a medium for producing work (word-processing or graphics packages). Intelligent computers could be more usefully used in managing learning, directing topics to be studied according to the student's ability and providing the resources for doing so.
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Appendix 4.1. Copy of the questionnaire used to survey computer use in local primary schools.

MICROCOMPUTERS IN PRIMARY SCHOOLS

This questionnaire contains six pages, the first page asks for some general information about what computing equipment is available and the rest are identical and ask about the software used. Five of these pages have been included, if you have less than ten programs please complete a side for each program used and if you regularly use more than ten programs please choose the ten that are used most often.

We are interested in both educational programs and games but not in computer languages such as BASIC or LOGO or in data processing programs.

Some points to note are:-

Brief answers only are required.

The description of the software should give its purpose and an outline of what the program does.

A device used to enter information could be, for example, a joystick, a light pen, a mouse or a graphics tablet.

Ways in which a program is used in class could be, for example, in demonstration like an electronic blackboard, interacting with individual or groups of pupils or with the teacher operating the computer for the class.

If you consider that your answers need further explanation please feel free to include additional sheets of paper.

Q 1.1) How many computers are there in your school and what are they?

Q 1.2) What peripherals do you have for the computer(s) e.g. cassette recorder, disk drive, printer etc.?

Q 1.3) If you have more than one computer are they networked at all?
Q 2.1) Program Title

Q 2.2) Description

Q 2.3) Who is it produced or written by? __________________________

Q 2.4) Is it on disk or tape? ________________

Q 2.5) Which computer does it run on? __________________________

Q 2.6) Is it considered to be educational or recreational?

Q 2.7) How are graphics and sound used?

Q 2.8) Is another device apart from the keyboard used to enter information and if so what is it?

Q 2.9) How is the program used with the class?

Q 2.10) How often is the program used? __________________________

Q 2.11) What do the children think of the program?

Q 2.12) What is your opinion of the program?
Appendix 4.2. Table of the most popular programs in local primary schools.

This appendix gives the programs that were considered to be very good by the children, or the teacher and those that had details on them returned by more than three schools.

<table>
<thead>
<tr>
<th>Program</th>
<th>Publisher</th>
<th>No. of replies</th>
<th>No. thought v. good by children</th>
<th>No. thought v. good by teachers</th>
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<td>0</td>
</tr>
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<td>0</td>
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<td>1</td>
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## Appendix 4.2. Table of the most popular computer programs in local primary schools. (cont'd)

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<th>No. thought v. good by children</th>
<th>No. thought v. good by teachers</th>
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<td>3</td>
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<td>0</td>
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**Appendix 5.1. Table of programs used in the further investigation of the preliminary model of user involvement.**

This appendix gives the names of the programs used in the second study reported in Chapter Five together with the numbers of the profiles they are associated with as shown in Figure 5.4 and Table 5.1. It also gives the profile number shown in Figure 5.1 if the program also appeared in the first study. Not all the programs appeared in both studies because the ones in the first study were chosen randomly and the programs in the second study were selected on the results of the first. The programs are shown in order of increasing involvement.

<table>
<thead>
<tr>
<th>Profile number shown in Fig 5.4</th>
<th>Profile Number shown in Fig. 5.1</th>
<th>Program Name</th>
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<td>13</td>
<td>Water Relations in Plant Cells</td>
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<td></td>
<td></td>
<td>Hours</td>
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<td>10</td>
<td>21</td>
<td>Balance Your Diet</td>
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<td>17</td>
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<td>2</td>
<td>9</td>
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<td></td>
<td>Bank/Notes</td>
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<td>4</td>
<td></td>
<td>Angles/Navigate</td>
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<td>3</td>
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<td>12</td>
<td>27</td>
<td>Sir Francis Drake</td>
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<td>Lost City</td>
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<td>22</td>
<td>30</td>
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</table>
Appendix 6.1. Question sheet used to collect children's opinions of programs.

1. How much did you like the program?
   - not at all
   - not much
   - some
   - quite a lot
   - lots and lots

2. How much did you learn from the program?
   - not at all
   - not much
   - some
   - quite a lot
   - lots and lots

3. How interested were you in the program?

4. How interested were you in the program?

5. How much did you want to stop doing the program?

6. How much did you concentrate on the program?

7. How excited were you by the program?

8. How difficult was the program?
Appendix 6.2. Table of mean results of questions assessing different program types.

This appendix gives the mean results of the eight questions used to assess primary schoolchildren's involvement with the different types of programs found.

<table>
<thead>
<tr>
<th>Type</th>
<th>Like</th>
<th>Learn</th>
<th>Do</th>
<th>Interested</th>
<th>Stop</th>
<th>Concentrate</th>
<th>Exciting</th>
<th>Difficult</th>
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289
Appendix 6.2. Table of mean results of questions assessing different program types (cont'd).

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<th>Like</th>
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<th>Do again</th>
<th>Interested</th>
<th>Stop doing</th>
<th>Concentrate</th>
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Appendix 7.1. Questionnaire used to assess fire safety knowledge before
and after using VESTA.

Questions to be given before and after using the fire training aid. There
is more than one answer to the last three.

1) What telephone number do you call for the Fire Brigade?

999

2) What is the school fire alarm?

Bell or whistle (according to school)

3) What should you do if your clothes catch fire?

Roll on the ground

4) What can be used to put out a fire?

Water, sand, foam, blankets, CO₂ etc.

5) What should you do if you find a fire in a room of your house?

Get everyone out
Call the fire brigade

6) What shouldn't you do if you find a fire in a room of your house?

Open the door
Try to fight the fire
Appendix 7.2. Transcripts of three typical conversations during use of VESTA.

Nearly half the conversations between children using VESTA were taped but most of these were uninterpretable due to the background noise of the classroom and so taping was abandoned.

1) Two boys -8 yrs old on their first and second goes.

Ex: Are you happy?

B1: Yup!

Ex: You've just been woken up in the middle of the night

B1: Yes.

Ex: You smell smoke, and go downstairs to see what is happening

B1: (reading) Smoke is coming through the dining room door. Type 1 to open the door, 2 to go upstairs, 3 to leave by the front door, 4 to leave by the back door.

Go upstairs!

Ex: (to B2) Do you agree with him?

B1: Do you agree? 2 to go up because they're rescuers, to the children, go on read it. (reading) Type 2 to go upstairs.

Ex: (to B2) What do you want to do?

B1: Because we need to get them out, get the children out.

B2: How do you know there's a fire?

Ex: You see smoke is coming out from the dining room door, but you can open the door to see.

B1: No! I wouldn't do it.

B2: I'd go back upstairs.

B1: Shall I just put 2? (reading) Upstairs there is no smoke, press space bar.
B2: (reading) Press 1 to get dressed, press 2 to look for your

B1: It says get dressed or look for your favourite toys. Get dressed!

Ex: Well, what about 3?

B1 + B2: Type, get the children up ! 2, no 3.

B1: Your turn next.

Ex: Go on, read it, what does it say? (reading) You can now help

the children. Some smoke is coming into the room.

B1: Ohh!

Ex: You are in the room with the children. So what are you going to
do now? You can type 1 to leave the room with the children or type

2 to wait by the window.

B2: Leave the room with the children.

B1: (reading) The smoke is now thick on the landing, press space

bar.

1 no 2 to get downstairs.

B2: Have we got the children?

B1: Yup!

Ex: It says go downstairs with the children.

B1 + B2: 2!

B1: Your turn next.

(reading with assistance from Ex) You did well in getting the
children and leaving the house immediately. Now you can get your

neighbours to call the Fire Brigade.

Ex: Well done, you got everyone out quickly. Do you want another go?

B1: Yes please.

B2: All right.

Ex: You see smoke coming out through the dining room door.
B1: Type 1 to open the dining room door.
B2: 2!
Ex: You can do the same thing or what you wanted to do last time.
B1: Type 3 to leave by the front, no, not that. 4 to leave by the back
B2: But we haven't got parents.
Ex: No, there's two other children in the house, it's the same as before.
B1: Get the children, do you want to get the children?
B2: But we'll do it all over again.
B1: Let's try a different one then. 2 to go back upstairs, I'd do 2.
B2: All right.
B1: You go first this time.
B2: 1, no.
B1: (reading) Upstairs there is no smoke. What would you do next?
All: Type 1 to get dressed, 2 to look for your favourite toys, 3 to get the children up.
B2: Get the children up.
B1: 3, I'm going to get dressed first.
B2: Why?
B1: There might be some smoke up top, huh, I'll get the children up, 3.
B1+B2: (reading) You can now help the children. Some smoke is coming through the door.
B1: Press space bar. It's your go. (reading) 2 to wait by window, 1 to leave with the children.
Ex. What would happen if you waited by the window?
B1: It would just come up.
B1+B2: (reading) The smoke is now thick on the landing. Type 1 to go in bedroom, 2 to go downstairs with the children.
B1: What are you going to do if you go into the bedroom.
Ex: I don't know, you can type 1 if you want and see.
B2: O.K.
B1: (reading) Smoke is coming into your room, press space bar. Type 1 to try to escape, 2 to open the window, 3 to shut the door.
B2: To escape, press 1
B1: The smoke from the fire is now so thick that you cannot breathe
B1+B2: You and the children were badly hurt in the fire. Ohh!
Ex: You wasted time by wandering in the other rooms.
B1: We shouldn't have done that then.
Ex: You must go upstairs and try and get everyone out.
2) Two girls - 7 years old on their first go.
G1+G2: (reading) Smoke is coming through the dining room door. Score 30 points, press space bar.
Ex: You have to decide what you are going to do next.
G1: Call the Fire Brigade.
Ex: That's not one of the options.
G2: Open the dining room door, no, go back upstairs, leave by the front door, leave by the back door.
G1: Leave by the front door 'cos that's nearest.
G2: No, try something daring like opening the dining room door.
G1: No! Leave by the front, back door.
Ex: (to G2) Do you agree, what do you want to do ?
G2: Back door.
G1: Right then leave by the back door, do we type that in ?
All: 4, 4
G2: (reading) It is very dark outside there is no one around.

G1+ G2: (reading) What would you do next, to get the neighbours up, to go back into the house.

G1: Get the neighbours up.

G2: I'd go back into the house.

G1: No! Get the neighbours.

Ex: Remember the house is burning down you don't want to run around wasting time.

G2: Nicola! I didn't agree with you.

G1: (reading) The neighbours can now

G1+G2: (reading) call the Fire Brigade on their telephone.

G1: 50 points now!

G1+G2: (reading) Dial 999 and ask for the Fire Brigade.

G2: What do you think, go back into the house.

G1: 2

G2: Wait for the Fire Brigade.

G1+G2: 2, 2, 2

G2: I have

G1: There's a fire in their house.

G2: No, that's ours.

G1: Eeaaah! Look! (at their score)

Ex: What did you forget?

G2: Children, go back into the house for the children.
3) Two boys -8 years old on their second go having spoilt their first by misusing the keyboard.

Ex: Same as before. Space bar.

B1+B2: (reading) Smoke is coming through the dining room door.

Ex: Remember to tap the keys this time and not

B1: Remember not to press that. Type 1 to open

B2: No?

B1: Type 1 to open the dining room door.

B2: No!

B1: Yes, then, 'cos we can see what happens, 1, return.

Ex: Don't press return!

B1: (reading) Flames and thick smoke burst out into the hall. This is going to be really exciting! Type 1 to fight the fire, 2

B2: No!

B1: 2 to get upstairs.

B2: No.

B1: 3 to leave by the back door.

B2: Back door because the front door's just there.

B1: Leave by the back door, 3, yes?

B2: O.K.

B1: (reading) Outside the house it is very dark, there is no-one around.

Help.

B2: Now what do we do?

B1: (reading) Score 10 points, press space bar. What do we do now?

Go back into the house, wait for the Fire Brigade, get the neighbours.

B2: Get the neighbours, umm.
B1: No.

B1+B2: Let's go back into the house.

Ex: You want to go back into the house?

B1+B2: Yes.

Ex: Why?

B2: No, let's get the neighbours.

B1: No!

Ex: All right both of you let's discuss this, why do you want to go back into the house?

B1: Because we might save the children.

B2: We could try getting the others out.

Ex: What about why do you want to go to the neighbours?

B1: Well, because they've a telephone, we could call the Fire Brigade. But that would waste time and the house would burn down.

B2: Yeah, we could try.

B1: Yes

B2: I think we should press 1, don't you?

Ex: Don't press return.

B2: The smoke from the fire is now so thick

B1+B2: Oh no!

Ex: That was really silly, you opened the door, you let the fire out and then you went back to look and see what damage you'd done. You burnt the house down and didn't get any points that time.
Appendix 7.3. Mean results for questions used to compare the two different versions of VESTA seen.

The mean results of the eight questions that the subjects used to compare the two versions of VESTA they used are shown below in matrix form. The averages of the scores taken from the ratio scale used (-20 to +20) to answer the questions for the version seen first are entered in the rows and those for the version seen second in the columns. A positive score indicates that the version seen second was liked more, more learnt from it, more interesting etc. and a negative score that it was liked less, less learnt from it, less interesting etc. than the first one.

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Q2- Learnt more from 1st/2nd?

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Q3- Want to do 1st/2nd again more?

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Q4- Is 1st/2nd more interesting

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Q5- Want to stop doing 1st/2nd more?

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Q6- Concentrate more on 1st/2nd?

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First 5 -1.0 -4.2 -.1 5.2 X -.8 -.2

Ave. -3.4 -2.6 3.8 4.6 3.4 7.3

Q7- 1st/2nd more exciting?

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Q8 - 1st/2nd more difficult?

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Appendix 7.4. Listing of the programs that make up VESTA

VESTA

VESTA is made up of thirteen programs that call each other according to the routes selected by the user. Twelve are simply numbered one to twelve and the last provides a summary of the route and displays the high score table.

PROGRAM ONE:-

5REM
6REM
7REM
10REM"ONE"
20A%=0
30 MODE1
35IFB%=1THENPROCcont
40REM
50REM
60REM
80INPUT"Do you want a new file";A$
90IFA$="""N"ORA$="""n"THENPROCcont
92ONERRORGOTOD1200
94*DE."hst"
96ONERROROFF
100INPUT"Results file name";name$
105Z=OPENOUT"TEMP":PRINT$Z,name$;CLOSE$Z
110X=OPENOUTname$
120Y=OPENOUT"hst"
140CLS
150REM
152REM
155REM
160PRINT:PRINT "VESTA - A FIRE TRAINING AID"
165REM
170PRINT:PRINT
180PRINT$X,"!"
190S%=30
200B%=0
210INPUT"What is your name ";n$
220PRINT$X,n$
250PRINT$Y,n$
260CLOSE$Y
270PRINT:PRINT
280 PRINT"Do you want information (Type Y for yes, N for no) ?"
290A$=GET$
300 IFA$="""Y"ORA$="""y"" THEN330
310 IFA$="""N"ORA$="""n"" THEN500
320 PRINT "Type Y or N only";GOTO 280
330PRINT:PRINT:PRINT"Do you want sound (Type Y for yes, N for no) ?"
340A$=GET$

304
350 IF A$ = "Y" OR A$ = "Y" THEN N% = 1: GOTO 330
360 IF A$ = "N" OR A$ = "n" THEN N% = 0: GOTO 330
370 PRINT "Type Y or N only": GOTO 330
380 CLS
390 PRINT TAB(15); "VESTA"; PRINT
400 PRINT TAB(10); "A FIRE TRAINING AID": PRINT
410 PRINT: PRINT "You are staying with two other children": PRINT "in a friend's house."
420 PRINT: PRINT: PRINT "There is no telephone in the house": PRINT: PRINT: PRINT "but the neighbours have one."
430 PRINT
440 PRINT: PRINT "You wake up in the middle of the night."
450 PRINT: PRINT "There is a funny smell and you can hear": PRINT "noises."
460 PRINT
470 PRINT: PRINT "You go downstairs to look."
480 IF N% = 1 THEN PROC1b
490 IF N% = 0 THEN PROCspace
500 REM CALLS NEXT PROGRAM IN SEQUENCE
504 REM
506 REM
510 REM PROCEDURE TO PLAY TUNE
520 FOR N = 1 TO 2
530 SOUND 3, -10, 61, 5
540 SOUND 3, 0, 69, 2
550 SOUND 3, -10, 61, 5
560 SOUND 3, -10, 81, 10
570 SOUND 3, 0, 89, 2
580 SOUND 3, -10, 81, 10
590 SOUND 3, 0, 89, 2
600 NEXT N
610 REM
620 FOR N = 1 TO 2
630 SOUND &103, -10, 89, 5
640 SOUND &102, -10, 61, 5
650 SOUND &103, 0, 89, 2
660 SOUND &102, 0, 69, 2
670 SOUND &103, -10, 89, 5
680 SOUND &102, -10, 61, 5
690 SOUND &103, -10, 97, 10
700 SOUND &102, -10, 81, 10
710 SOUND &103, 0, 89, 2
720 SOUND &102, 0, 89, 2
730 SOUND &103, -10, 97, 10
740 SOUND &102, -10, 81, 10
750 SOUND &103, 0, 89, 2
760 SOUND &102, 0, 89, 2
770 NEXT N
780 FOR N = 1 TO 2
790 SOUND &103, -10, 109, 15
800 SOUND &102, -10, 89, 5
810SOUND &2,0,89,2
820SOUND &2,-10,89,5
830 SOUND &2,-10,97,10
840SOUND &3,0,89,2
850SOUND &3,-10,109,15
860SOUND &2,0,89,2
870SOUND &2,-10,97,10
880SOUND &3,0,89,4
890SOUND &2,0,89,2
900NEXTN
910F0RN=1 TO2
920SOUND &103,-10,109,5
930SOUND &102,-10,109,15
940SOUND &3,0,89,2
950SOUND &3,-10,101,5
960SOUND&3,-10,97,10
970SOUND &2,0,89,2
980SOUND &3,0,89,2
990SOUND &2,-10,109,15
1000SOUND &3,-10,97,10
1010SOUND &3,0,89,2
1020SOUND &2,0,89,4
1030NEXTN
1040F0RN=1 TO2
1050SOUND2,-10,109,5
1060SOUND2,-10,101,5
1070SOUND2,-10,97,10
1080SOUND 2,0,89,2
1090SOUND2,-10,97,10
1100SOUND 2,0,89,2
1110NEXTN
1120PROCspace
1130ENDPROC
1134REM
1136REM Procedure to ask user to press space bar to continue
1138 REM
1140DEFPROCspace
1150VDU31,24,31
1160PRINT"Press space bar";
1170X=GET
1180CLS
1190ENDPROC
1200GOTO96
1210REM
1220REM Procedure to continue with same player
1230REM
1300DEFPROCcont
1310Z=OPENIN"TEMP":INPUT$Z,name$=CLOSE$Z
1320X=OPENUPname$;x=EXTX;PTRX=x
1330Y=OPENUP"hist";y=EXTY;PTRY=y
1340GOTO140
1350ENDPROC

306
PROGRAM TWO:
10REM "TWO"
20REM"DOMESTIC FIRE PROGRAM"
30PRINT
40REM"FIRE RESEARCH UNIT"
50REM"UNIVERSITY OF SURREY"
60PRINT
70 IF A%>=1 THEN 710

PROCEDURES TO DRAW PICTURE SHOWING FIRE STARTING
80CLS
90VDU24,10;400;1269;1022;
100VDU19,1,4,0,0,0
110PRINT:PRINT
120VDU28,0,31,39,20
130PRINT:PRINT" Smoke is coming through the dining room door."
150PROCpic1
155PROCsmoke
160PROCscore
170PROCspace
180PROCinitct

MENU OF CHOICES
190PRINT:PRINT"What would you do now?"
200PRINT
210PRINT:PRINTTAB(3);"Type 1 to open the dining room door."
220PRINT:PRINTTAB(3);"Type 2 to go back upstairs."
230PRINT:PRINTTAB(3);"Type 3 to leave by the front door."
240PRINT:PRINTTAB(3);"Type 4 to leave by the back door."
250A%=-GET-48
GO TO NEXT PROGRAM ACCORDING TO CHOICE MADE
260IF A%=-THENCHAIN"THREE"
270IF A%=2 THENA%=A%+3:CHAIN"FOUR"
280IF A%=3 THENCHAIN"NINE"
290IF A%=4 THENCHAIN"FIVE"
300PRINT:PRINT"Type 1,2,3 or 4 ONLY"
310GOTO250
320DEFPROCinitct
330PRINT€17,"HALL"
340Z=OPENOUT"FBCON"
350F=0
360PRINT€Z,F
370CLOSE€Z
380ENDPROC
390DEFPROCpic1
400REM
410GCOL0,129
420CLG
430GCOL0,0

PICTURE OF HALL
DRAW PICTURE OF HALL WITH MORE SMOKE

730PRINT:PRINT" The smoke in the hall";
740PRINT" is much thicker."
750PROCpic1
755PROCsm
760PROCms1
770PROCms2
780PROCms3
800PRINT17,"GBIH"
805S%=S%−10
810PROCscore
820PROCspace

MENU OF CHOICES
830PRINT:PRINT:PRINT"What would you do now?"
840PRINT:PRINT TAB(4);"Type 1 to open the dining room door."
850PRINT:PRINT TAB(4);"Type 2 to go upstairs."
860PRINT:PRINT
870A%=GET−48

CALL NEXT PROGRAM
880IFA%=1THENCHAIN"THREE"
890IFA%=2THENA%=A%+1:CHAIN"FOUR"
900PRINT:PRINT"Type 1 or 2 only."
910GOTO830
920END

PROCEDURES TO DRAW SMOKE

930DEFPROCms1
940FORN=1TO15;R=35+INT(RND(1)*35+1)
950X=400+INT(RND(1)*550+1);Y=700+INT(RND(1)*250+1)
960PROCfilcirc:NEXTN
970ENDPROC
980DEFPROCms2
990FORN=1TO10;R=35+INT(RND(1)*55+1)
1000X=400+INT(RND(1)*550+1);Y=700+INT(RND(1)*250+1)
1010PROCfilcirc:NEXTN
1020ENDPROC
1030DEFPROCms3
1040FORN=1TO8;R=35+INT(RND(1)*55+1)
1050X=100+INT(RND(1)*450+1);Y=700+INT(RND(1)*180+1)
1060PROCfilcirc:NEXTN
1070ENDPROC
1080DEFPROCsm
1090GCOL0,3
1100FORN=1TO5;R=35+INT(RND(1)*35+1)
1110X=170+INT(RND(1)*260+1);Y=880+INT(RND(1)*70+1)
1120PROCfilcirc:NEXTN
1130ENDPROC

PROCEDURES TO DRAW CIRCLES

1140DEFPROCCirc
1150LOCALx,y,1x,1y,n%
1160n%=17:step=2*PI/n%
1170cos=COS(step):sin=SIN(step)
11801x=R:1y=0:MOVEX+R,Y
1190 FORi%=1TON%
1200x=1x*cos−1y*sin

309
1210 y=1x*sin+y*cos
1220 DRAWX+x,Y+y
1230 l=x; y=y
1240 NEXT i%
1250 ENDPROC
1260 DEFPROC filcirc
1270 LOCAL x,y, lx, ly,n%
1280 n%=15; step=2*PI/n%
1290 cos=COS(step); sin=SIN(step)
1300 l=x; y=0; MOVEX+R,Y
1310 FOR i%=1 TO n%
1320 x=lx*cos-ly*sin
1330 y=lx*sin+ly*cos
1340 MOVEX,Y:PLOT85,X+x,Y+y
1350 l=x; y=y
1360 NEXT i%
1370 ENDPROC

PROCEDURES TO READ SPACE BAR AND CALCULATE SCORE
1380 DEFPROC space
1390 VDU31,24,10
1400 PRINT"Press space bar";
1410 X=GET
1420 CLS
1430 ENDPROC
1440 DEFPROC score
1450 VDU31,1,10
1460 PRINT"Score ="; S;" points"
1470 ENDPROC
PROGRAM THREE:

10REM"THREE"
20REM DOOR OPENED ON FIRE
30CLS

DRAW LOTS OF SMOKE ON HALL PICTURE
40PRINT" Flames and thick smoke burst out into the hall."
50PRINT
60GOSUB5000

SET FLAG FOR DOOR OPEN
50PROCpath

CALCULATE SCORE
80S%=S%-20:PROCscore
90PROCspace

MENU OF CHOICES
100PRINT:PRINT:PRINT"What would you do now?"
110PRINT:PRINT:PRINTTAB(4),"Type 1 to try to fight the fire."
120PRINT:PRINT:PRINTTAB(4),"Type 2 to try to get upstairs."
130PRINT:PRINT:PRINTTAB(4),"Type 3 to leave by the back door."
140PRINT:PRINT:PRINTTAB(4),"Type 4 to leave by the front door."
150A%=GET-4B

GOTO NEXT PROGRAM
160IFA%=1THENPROCffire
170IFA%=2THENCHAIN"FOUR"
180IFA%=3THENCHAIN"FIVE"
190IFA%=4THENCHAIN"NINE"
200PRINT"Type 1,2,3, or 4 only"
210GOTO100
310END

CIRCLES
320DEFFPROCfilcirc
330LOCALx,y,1x,1y,n%
340n%=14:step=2*PI/n%
350cos=COS(step):sin=SIN(step)
3601x=R:1y=0:MOVEX+R,Y
370FORi%=1TOn%
380x=lx*cos-ly*sin
390y=lx*sin+ly*cos
400MOVEX,Y:PLTOT85,X+x,Y+y
410lx=x:1y=y
420NEXTi%
430ENDPROC

SET FLAG
440DEFFPROCpath
450A#="OPENDR"
460PRINT£17,A#
470ENDPROC
480REM
490 DEFFPROCffire
510CLS
520 PRINT" You get a bucket of water from the kitchen."
530 PRINT: PRINT" But the fire is so hot you cannot go near it."
540 PRINT: PRINT: PRINT
545 PROC picff
550 S%=S%-5: PROC score
560 PROC space
570 PRINT
580 PRINT$17,"FFIRE"

MENU
590 PRINT: PRINT"What would you do now?"
600 PRINT
610 PRINT: TAB(4): "Type 1 to carry on trying to fight the fire."
620 PRINT: TAB(4): "Type 2 to leave by the back door."
630 PRINT
640 A%=GET-48

NEXT PROGRAMS
650 IF A%=1 THEN A%=A%+3: PRINT$17,"PERS"; CHAIN "SEVEN"
660 IF A%=2 THEN CHAIN "FIVE"
670 PRINT"Type 1 or 2 only"
680 GOTO 590
690 END

DRAW PICTURE OF FILLING BUCKET WITH WATER
700 DEF PROC picff
710 GCOLO,1
720 CLB
730 GCOLO,3: MOVE 10,700: DRAW 1269,700: PLOT85,10,400: PLOT 85,1269,400
770
790
800 MOVE 420,780: MOVE
820 MOVE 380,900: PLOT85,400,820: PLOT85,400,900
830 MOVE 555,900: MOVE 490,895: PLOT85,490,865: MOVE 545,900: MOVE
840 MOVE 540,905: PLOT85,540,875: MOVE 540,820: MOVE
850,900: PLOT85,560,820: PLOT85,560,900
860 MOVE 550,900: MOVE 500,840: PLOT85,500,840: PLOT85,500,840: PLOT85,520,840
870 MOVE 580,780: MOVE
880 MOVE 500,780: MOVE 500,740: PLOT85,500,740: PLOT85,440,740: PLOT85,440,685
900 MOVE 380,900: PLOT85,400,820: PLOT85,400,900
910 MOVE 555,900: MOVE 490,895: PLOT85,490,865: MOVE 545,900: MOVE
920 MOVE 540,905: PLOT85,540,875: MOVE 540,820: MOVE
930 MOVE 550,900: MOVE 500,840: PLOT85,500,840: PLOT85,500,840: PLOT85,520,840
940 MOVE 580,780: MOVE
950 MOVE 500,780: MOVE 500,740: PLOT85,500,740: PLOT85,440,740: PLOT85,440,685
970 MOVE 380,900: PLOT85,400,820: PLOT85,400,900
980 MOVE 555,900: MOVE 490,895: PLOT85,490,865: MOVE 545,900: MOVE
990 MOVE 540,905: PLOT85,540,875: MOVE 540,820: MOVE
991 MOVE 550,900: MOVE 500,840: PLOT85,500,840: PLOT85,500,840: PLOT85,520,840
992 MOVE 580,780: MOVE
993 MOVE 500,780: MOVE 500,740: PLOT85,500,740: PLOT85,440,740: PLOT85,440,685
995 MOVE 380,900: PLOT85,400,820: PLOT85,400,900
996 MOVE 555,900: MOVE 490,895: PLOT85,490,865: MOVE 545,900: MOVE
997 MOVE 540,905: PLOT85,540,875: MOVE 540,820: MOVE
998 MOVE 550,900: MOVE 500,840: PLOT85,500,840: PLOT85,500,840: PLOT85,520,840
$\text{ELLIPSES}$

880DEFPROC ellipse
890LOCAL x, y, lx, ly, n%
900n%=14: step=2*PI/n%
910cos=COS(step): sin=SIN(step)
920lx=R: ly=0: MOVE+R, Y
930FOR i%=1 TO n%
940x=lx*cos-ly*sin
950y=lx*sin+ly*cos
960MOVEX, Y: PLOT$X=x, Y+y/1.8$
970lx=x: ly=y
980NEXT i%
990ENDPROC

READ SPACE BAR, CALCULATE SCORE

1000DEFPROC space
1010VDU31, 24, 10
1020PRINT"Press space bar";
1030X=GET
1040CLS
1050ENDPROC
2000DEFPROC score
2010VDU31, 1, 10
2020PRINT"Score ="; S%; "points"
2030ENDPROC

draw smoke

5000REM
5010GCOL0, 0: X=220: Y=700: R=10: PROCfirc
5020GCOL0, 3
5030MOVE250, 470: DRAW250, 915: PLOT$X=250, 470$
5040FOR R=60+INT(RND(1)*60+1)
5050X=380+INT(RND(1)*600+1)
5060IF X<700 THEN Y=500+INT(RND(1)*600+1) ELSE Y=650+INT(RND(1)*450+1)
5070PROCfirc: NEXTN
5080RETURN

313
PROGRAM FOUR:

10REM "FOUR"
20REM 1060-LRK,2060-GUPST2,3060-GOUPOD
30  ONAXGOTD490,850,680,90,90
90REM GO UPSTAIRS!
100CLS

PROCEDURES FOR GOING UPSTAIRS

110PRINT:PRINT"Upstairs, there is no smoke."
120PRINT:PRINT:PRINT
130PROCpland
160PRINT17,"Goup"
162PROCspace

MENU

170PRINT:PRINT"What would you do next?"
180PRINT:PRINTTAB(4);"Type 1 to get dressed."
190PRINT:PRINTTAB(4);"Type 2 to look for your favourite toys."
200PRINT:PRINT:PRINTTAB(4);"Type 3 to get the children up."
210IFA%=GET-48

NEXT PROGRAMS

220IFAX%=1THENCHAIN"ELEVEN"
230IFAX%=2THENCHAIN"ELEVEN"
240IFAX%=3THENCHAIN"TEN"
250PRINT:PRINT"Type 1, 2 or 3 only."
260GOT0170
270END

DRAW PICTURE OF LANDING

280DEFPROCpland
290REMPICODFLANDING
300GCOLO,1
310CLG

320GCOLO,0:MOVE1270,400:DRAW1000,600:MOVE10,600:MOVE1000,600:DRAW1000,1100
326MOVE670,460:DRAW750,400:MOVE600,460:DRAW680,400:MOVE600,420:DRAW630,400:MOVE530,420:DRAW552,400
330VDU19,2,1;0;GCOLO,2;MOVE140,600:MOVE340,600:PLOT85,140,1000:PLOT85,340,1000:MOVE600,600:MOVE800,600:PLOT85,600,1000:PLOT85,800,1000
335GCOLO,3
340MOVE10,700:MOVE10,730:PLOT85,680,700:PLOT85,680,730
342F0RM=40T0640STEP60:MOVEN,700:MOVEN+30,700:PLOT85,N,505:PLOT85,N+30,505:NEXTN
346MOVE680,720:MOVE680,690:PLOT85,50,400:PLOT85,95,400

314

360 ENDPROC

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390 n% = 16: step = 2 * PI / n%
400 cos = COS(step): sin = SIN(step)
410 lx = R: ly = 0: MOVEX + R, Y
420 FOR i% = 1 TO n% 
430 x = lx * cos - ly * sin
440 y = lx * sin + ly * cos
450 DRAW x, Y + y
460 i% = lx, y = y
470 NEXT i%
480 ENDPROC

CIRCLES

PROCEDURES FOR STAIRS AND SMOKE

490 REM LEAVE ROOM WITH KIDS

500CLS
510 PRINT: PRINT" The smoke is now thick on the landing."
530 PRINT: PRINT: PRINT
540 PROCpland
550 PROCsmoke
560 PRINT f17, "LRK"
562 PROCscore
565 PROCspace

MENU

570 PRINT: PRINT" What would you do now?"
580 PRINT
590 PRINT: PRINTTAB(4); "Type 1 to go into your bedroom."
600 PRINT: PRINTTAB(4); "Type 2 to go downstairs with the children."
610 PRINT
620 A% = GET - 48

NEXT PROGRAMS

630 IF A% CH 01 IN" ELEVEN"
640 IF THEN A% = A% - 1: PRINT f17, "GDC" : CHAIN" SEVEN"
650 PRINT"Type 1 or 2 only"
660 GOTO 070
670 END
680 REM GO UPSTAIRS A SECOND TIME
685CLS
690 PRINT: PRINT" The smoke is now thick on the landing."
710 PRINT: PRINT: PRINT: PRINT: PRINT
720 PROCpland
725 PROCsmoke
727 PROCscore
730 PROCspace
740 PRINT f17, "GUPST2"

MENU

750 PRINT: PRINT: PRINT" What would you do next?"
760 PRINT: PRINT: PRINTTAB(4); "Type 1 to get the children up."
770 PRINT: PRINTTAB(4); "Type 2 to go into your bedroom."
780 PRINT: PRINT
790 A% = GET-48

NEXT PROGRAMS

800 IF A% = 1 THEN CHAIN"TEN"
810 IF A% = 2 THEN A% = A% + 2: CHAIN"ELEVEN"
820 PRINT"Type 1 or 2 only."
830 GOTO 750
840 END
850 REM GO UPSTAIRS ON OD
860 CLS
870 PRINT"The smoke is now so thick that it is very hard to breathe."
880 PRINT: PRINT: PRINT
890 PROCpland
900 PROCcupod
910 PROCscore
920 PROCspace
930 PRINT: PRINT: PRINT: PRINT: PRINT:"GOUGOD"
940 MENU
950 PRINT"What would you do now?"
960 PRINT: PRINT
970 PRINT"Type 1 to carry on up the stairs."
980 PRINT:"Type 2 to leave by the front door."
990 PRINT
1000 IF A% = GET-48

NEXT PROGRAMS

1010 DEF PROCcupod
1020 DEF PROCscore
1030 FOR N = 1 TO 20: X = 30 + RND(1000): Y = 500 + RND(500): R = 80 + RND(40): PROCfilcirc: NEXT N
1040 ENDPROC
1050 DEF PROCsmoke
1060 FOR N = 1 TO 20: X = 30 + RND(1000): Y = 700 + RND(300): R = 60 + RND(40): PROCfilcirc: NEXT N
1070 ENDPROC
CIRCLES

1200DEFPROCcirc
1210LOCALx,y,1x,1y,n%
1220n%=16:step=2*PI/n%
1240cos=COS(step):sin=SIN(step)
12501x=R:1y=0:MOVEX+R,Y
1260FORi%=1To$n%
1270x=1x*cos-1y*sin
1280y=1x*sin+1y*cos
1290MOVEX,Y:PLOT85,X+x,Y+y
13001x=x:1y=y
1310NEXTi%
1320ENDPROC

SCORE AND SPACE BAR

2000DEFPROCscore
2005S%=S%+5
2010VDU31,1,10
2020PRINT"Score =";S%;" points"
2030ENDPROC
5000DEFPROCspace
5010VDU31,24,10
5020PRINT"Press space bar";
5030X=GET
5040CLS
5050ENDPROC
PROGRAM FIVE:

10REM "FIVE"
20IF A<4 THEN 630
90REM GO OUTSIDE THE BACK
100CLS

CALL PROCEDURES TO DRAW OUTSIDE OF HOUSE FROM THE BACK
110PRINT:PRINT:PRINT"It is very dark outside."
120PRINT:PRINT"There is no-one around."
125PRINT:PRINT
130PROCgoutbk
135PROCtitsm
140PROCPath
142PROCscore
145PROCspace

MENU
150PRINT:PRINT:PRINT"What would you do next?"
160PRINT:PRINT:PRINTTAB(3):"Type 1 to get the neighbours."
170PRINT:PRINTTAB(3):"Type 2 to go back into the house."
180A%=GET-48

NEXT PROGRAMS

190IF A%=1 THEN CHAIN"SIX"
200IF A%=2 THEN CHAIN"TWO"
210PRINT:PRINT"Type 1 or 2 only"
220GOTO 150
230END
240REMGONEOUTSIDE

PICTURE OF OUTSIDE

250DEFFPROCgoutbk:
260GCOLOR,1:CLG
270GCOLOR,3
290GCOLOR,0:MOVE1269,900:DRAW1269,775:PLOT85,434,900:PLOT85,434,775:PLOT85,359,775:MOVE399,775:DRAW399,400:PLOT85,1269,775:PLOT85,1269,400
300GCOLOR,1
310MOVE934,520:DRAW889,520:PLOT85,934,400:PLOT85,889,400
360GCOLOR,2
370MOVE889,520;DRAW869,520;PLOT85,889,400;PLOT85,869,400;X=907;Y=455;R =3:PROCcirc
380ENDPROC

DRAW SMOKE
390DEFPROCclitsm
400GCOLO,3:FORN=1TO20:R=25+INT(RND(1)*25+1)
410X=880-INT(RND(1)*150+1):Y=600+INT(RND(1)*400+1):PROCcirc:NEXTN
415ENDPROC
420DEFPROCclotsm
430GCOLO,3:FORN=1TO20:R=25+INT(RND(1)*25+1)
440X=880-INT(RND(1)*150+1):Y=600+INT(RND(1)*400+1):PROCfirc:NEXTN
450ENDPROC

FLAG "GONE OUTSIDE"
460DEFPROCpath
470A$="GOUTBK"
490PRINT£17,A$
500ENDPROC

CIRCLES
510DEFPROCcirc
520LOCALx,y,1x,ly,n%
530n%=17;step=2*PI/n%
540cos=COS(step);sin=SIN(step)
5501x=R;ly=0;MOVEX+R,Y
560FORi%=1TOTn%
570x=lx*cos-ly*sin
580y=lx*sin+ly*cos
590DRAWX+x,Y+y
600lx=x;ly=y
610NEXTi%
620ENDPROC

CALLS PROCEDURES TO GO OUT THE BACK AFTER OPENING DOOR
630REMGO OUT BACK WITH OD
640CLS
650PRINT"Outside the house it is very dark."
660PRINT"There is no-one around to help."
670PROCgoutbk
675PROCclotsm
680PRINT£17,"GODOD"
682PROCscore
685PROCspace

MENU
690PRINT:PRINT"What do you do now?"
700PRINT
710PRINT"Type 1 to go back into the house."
720PRINT:PRINT TAB(4);"Type 2 to wait for the Fire Brigade."
730PRINT"Type 3 to get the neighbours."
740A%=GET-48

NEXT PROGRAMS
750IFAZ%=1THENAZ%=A%+3:PRINT£17,"PERS":CHAIN"SEVEN"
760IFAZ%=2THENAZ%=A%+1:PRINT£17,"WFBOD":CHAIN"SEVEN"
770IFAZ%=3THENCHAIN"SIX"
780PRINT"Type 1,2, or 3 then press RETURN only"
790QUIT0090
800END

810DEF PROC fillcerc
820LOCAL x, y, lx, ly, n%
830n%=17: step=2*PI/n%
840cos=COS(step): sin=Sin(step)
850x=R: y=0: MOVEX+R, Y
860FOR i%=1 TO n%
870x=lx*cos-ly*sin
880y=lx*sin+ly*cos
890MOVEX, Y: PLOT85, X+x, Y+y
900lx=x: ly=y
910NEXT i%
920ENDPROC

FILLED CIRCLES

2000DEF PROC score
2010VDU31, 1, 10
2020PRINT"Score ="; S%;" points"
2030ENDPROC
2040DEF PROC space
2050VDU31, 24, 10
2060PRINT"Press space bar";
2070CLS
2080ENDPROC

PROGRAM SIX:-

10REM "SIX"
20IFA%=3 THEN 560
90REM CONTACT NEIGHBOURS
100CLS

CALL PROCEDURES TO DRAW TELEPHONE
110PRINT: PRINT" The neighbours can now call the Fire Brigade on their telephone."
120PRINT: PRINT: PRINT: PRINT
130PROC contn
140PROC flag
160 PRINT"17","CON"
165PROC score
170PROC space

MENU
190PRINT: PRINT: PRINT"What would you do next?"
200PRINT: PRINTTAB(4); "Type 1 to go back into the house."
210PRINT: PRINTTAB(4); "Type 2 to wait for the Fire Brigade."
220A%=GET-48

NEXT PROGRAMS
230IFA%=1 THEN CHAIN"TWO"
240IFA%=2 THEN A%=A%+3: PRINT"17", "WFBHC"; CHAIN"SEVEN"
250PRINT: PRINT"Type 1 or 2 only."
DRAW PICTURE OF TELEPHONE

260 GOTO 190
270 END

280 DEF PROC cont
290 VDU 19, 2, 1, 0;
300 GCOL 0, 1: CLG

320 PLOT 85, 735, 400


390 GCOL 0, 3: X = 395: Y = 710: FOR R = 40 TO 70 STEP 3: PROC circ: NEXT R

400 VDU 5
410 GCOL 0, 3: MOVE 700, 920: PRINT "Dial 999": MOVE 700, 860: PRINT "and ask ": MOVE 700, 800: PRINT "for the"; MOVE 700, 740: PRINT "Fire": MOVE 720, 680: PRINT "Brigade"

420 VDU 4
430 ENDPROC

CIRCLES

440 DEF PROC circ
450 LOCAL x, y, l, x, l, y, n%
460 n% = 16: step = 2 * PI / n%
470 cos = COS (step): sin = SIN (step)
480 x = R: y = 0: MOVEX + R, Y
490 FOR i = 1 TO n%
500 x = x + cos * l * sin
510 y = y + sin * l * cos
520 DRAW x + x, Y + y
530 l = l + x + y
540 NEXT i%
550 ENDPROC
560 REM CONTACT NEIGHBOURS
570 CLS

CALL Procedures for Telephoning Fire Brigade after Opening Door
580 PRINT: PRINT" The neighbours can now call the Fire Brigade on their telephone."
590 PRINT
610 PRINT: PRINT
620 PROC pcon
630 PROC flag
650 PRINT fi 17,"CONTOD"
656 PROC score
660 PROC space
670 PRINT" What will you do now?"
680 PRINT
690 PRINT TAB(4);"Type 1 to go back into the house."
700 PRINT: PRINT TAB(4);"Type 2 to wait for the Fire Brigade."
720 A%=GET-48
730 IF A% = 1 THEN A% = A% + 3: PRINT fi 17,"PERS": CHAIN"SEVEN"
740 IF A% = 2 THEN A% = A% + 1: PRINT fi 17,"WFBOD": CHAIN"SEVEN"
750 PRINT"Type 1 or 2 only"
760 GOTO660
770 END
780 DEF PROC flag
790 X = OPENOUT "FBCON"
800 F = 1: PRINT FX; F
810 CLOSE FX
820 ENDPROC
830 CALCULATE SCORE AND READ SPACE BAR

2000 DEF PROC score
2005 S% = S% + 20
2010 VDU31,1,10
2020 PRINT"Score =" S%;" points"
2030 ENDPROC
5000 DEF PROC space
5010 VDU31,24,10
5020 PRINT"Press space bar";
5030 X = GET
5040 CLS
5050 ENDPROC
PROGRAM SEVEN:

10REM PRINTS TEXT FOR EACH FINAL SITUATION AND THEN CALLS PROGRAM EIGHT

20X=OPENIN"FBCON":INPUTX,F:CLOSEX
300NA%GOT040,100,160,240,300,350,460,560,620,720,790,900
40REMGD
50CLS
60PRINT" You did well in getting the children and leaving the house immediately."
70PRINT:PRINT" Now you can get your neighbours to call the Fire Brigade."
80S%=S%+40
90A%=1:PROC8
100REMESCWK
110CLS
120PRINT" The smoke from the fire is now so thick that you cannot breathe."
130PRINT:PRINT" You and the children were badly hurt in the fire."
140S%=S%-40
150A%=2:PROC8
160REMWFBO
170CLS
180IFF=1THENPRINT" The Fire Brigade will come soon but the fire is very bad."
190 GOTO 200
200PRINT" The Fire Brigade will not come as you have not called them."
210PRINT:PRINT" You are slightly hurt and the children are badly hurt."
220IFF=OTHENA%=3ELSEA%=4
230PROC8
240REMPERS
250CLS
260PRINT" The smoke from the fire is now so thick that you cannot breathe."
270PRINT:PRINT" You and the children are badly hurt."
280S%=0
290A%=2:PROC8
300REMWFBO
310CLS
320PRINT" The Fire Brigade will come soon but the smoke will make it hard for them to find the children."
330PRINT:PRINT" You have escaped but the children are slightly hurt."
340A%=5:PROC8
350REMWFBO
360CLS
370IFF=OTHEN410
380PRINT" The Fire Brigade will come soon."
390PRINT:PRINT" Both you and the children were rescued."
400 GOTO 430
410 PRINT "The Fire Brigade will not come as you have not called them."
420 PRINT: PRINT "You and the children are badly hurt."
430 IFF = OTHENA% = 2 ELSE A% = 6
440 IFF = OTHENS% = S% - 20 ELSE S% = S% + 10
450 PROC8
460 REM WBB
470 CLS
480 IFF = OTHEN 510
490 PRINT "The Fire Brigade will come soon but it will be hard for them to get to you in time."
500 PRINT: PRINT "Both you and the children were badly hurt in the fire."
510 GOTO 530
510 PRINT "The Fire Brigade will not come as you have not called them."
520 PRINT: PRINT "Both you and the children were badly hurt in the fire."
530 IFF = OTHENA% = 2 ELSE A% = 4
540 S% = S% - 30
550 PROC8
560 REM JMP
570 CLS
580 PRINT "The drop from the window is so big that you and the children were badly hurt."
590 S% = S% - 40
600 IFF = OTHENA% = 2 ELSE A% = 4
610 PROC8
620 REM JMP A\a
630 CLS
640 PRINT "You are only slightly hurt but the children are in danger."
650 IFF = 1 THEN 680
660 PRINT: PRINT "If you now get your neighbours to call the Fire Brigade they could be rescued."
670 GOTO 690
680 PRINT: PRINT "The Fire Brigade will come soon but it will be hard for them to get to the children in time."
690 IFF = OTHENA% = 4 ELSE S% = 2
700 IFF = OTHENS% = S% + SELSES% = S% - 5
710 PROC8
720 REM JMP A\a
730 CLS
740 PRINT "Get the children to jump out first."
750 PRINT: PRINT "You and the children are slightly hurt in the fall."
760 IFF = OTHENA% = 7 ELSE S% = 4
770 IFF = OTHENS% = S% + 10 ELSE S% = S% - 10
780 PROC8
790 REM WBB A\a
800 CLS
810 IFF = OTHEN 850
820 PRINT: PRINT "The Fire Brigade will come soon."
830 PRINT: PRINT "You and the children were rescued."
840 GOTO 880
850PRINT" The Fire Brigade will not come as you have not called them."
860PRINT:PRINT" Both you and the children are badly hurt."
870IFF=0OTHERS%=S%-20ELSES%=S%+10
880IFF=0OTHERNA%=2ELSEA%=6
890PROC8
900REMWFBA
910CLS
920IFF=0THEN960
930PRINT" The Fire Brigade will come soon."
940PRINT:PRINT" You and the children were rescued."
950GOTO980
960PRINT" The Fire Brigade will not come as you have not called them."
970PRINT:PRINT" You and the children are badly hurt."
980IFF=0OTHERNA%=2ELSEA%=4
990IFF=0OTHERS%=S%-10ELSES%=S%+5
1000PROC8
1005END

SCORE AND SPACE BAR

1008DEFFPROC8
1010VDU31,1,10
1020PRINT" You scored ";S%;" points";
1030CALL NEXT PROGRAM
1040CHAIN"EIGHT"
1050ENDPROC
5000DEFFPROCspace
5010VDU31,24,10
5020PRINT" Press space bar";
5030X=GET
5040CLS
5050ENDPROC

PROGRAM EIGHT:-

10REM "EIGHT"
11CALLS PROCEDURES TO DRAW FINAL PICTURE
20VDU24,10;400;1269;1022;
30VDU28,0,31,39,20
40DNA%GOTO50,60,70,80,90,100,110
50PROC choose:PROCsmoke:PROCengine
52PROCspace
55GOTO3000
60PROCruins:PROCambu
62PROCspace
65GOTO3000
70PROCChose:PROCflames
72PROCspace
75GOTO3000
80PROCChose:PROCflames:PROCengine:PROCambu
82PROCspace
85GOTO3000
90PROCChose: PROCsmoke: PROCCambu: PROCfengine
92PROCspace
95GOTO3000
100PROCChose: PROCflames: PROCfengine
102PROCspace
105GOTO3000
110PROCChose: PROCflames: PROCCambu
112PROCspace
115GOTO3000

DRAWS HOUSE

120DEFPROCChose
130VDU, 1, 4, 0, 0, 0
140GCOL0, 129: CLG
150GCOL0, 3
160FORN=1T010: R=18+INT(RND(1)*25+1)
170X=310+INT(RND(1)*200+1); Y=900+INT(RND(1)*100+1): PROCfilcirc: NEXTN
180X=1110: Y=930: R=70: PROCfilcirc: GCOL0, 1; X=1070: Y=940: PROCfilcirc

190GCOL0, 0; MOVE 10, 900: DRAW 10, 775: PLOT 85, 835, 900: PLOT 85, 835, 775: PLOT 85, 910, 775: MOVE 870, 775: DRAW 870, 400: PLOT 85, 10, 775: PLOT 85, 10, 400
200GCOL0, 1
210MOVE 320, 575: DRAW 380, 575: PLOT 85, 320, 400: PLOT 85, 380, 400

220VDU, 1, 2, 3, 0, : GCOL0, 2: MOVE 310, 720: DRAW 360, 720: PLOT 85, 310, 625: PLOT 85, 360, 625: MOVE 440, 720: DRAW 490, 720: PLOT 85, 440, 625: PLOT 85, 490, 625
230MOVE 440, 575: DRAW 490, 575: PLOT 85, 440, 475: PLOT 85, 490, 475

250NEXTN
260GCOL0, 2

280ENDPROC

DRAWS SMOKE

290DEFPROCsinoke
300GCOL0, 3
310FORN=1T016: R=18+INT(RND(1)*30+1)
320X=310+INT(RND(1)*110+1); Y=410+INT(RND(1)*270+1): PROCfilcirc: NEXTN
330ENDPROC

CIRCLES

340DEFPROCcirc
350LOCAL x, y, lx, ly, n%
360n%=16: step=2*PI/n%
370cos=COS(step): sin=SIN(step)
380lx=R: ly=0: MOVE X+R, Y
390FORDir%=1TDn%
400x=lx*cos-ly*sin
410y=lx*sin+ly*cos
420DRAWX+x, Y+y
430lx=x: ly=y
440NEXT1%
450ENDPROC

326
460DEF PROC filcirc
470 LOCAL x, y, lx, ly, n%
. 480 n% = 16: step = 2*PI/n%
490 cos = COS(step): sin = SIN(step)
500 lx = R: ly = 0: MOVEX + R, Y
510 FOR i% = 1 TO n%
520 x = lx * cos - ly * sin
530 y = lx * sin + ly * cos
540 MOVEX, Y: PLOT85, X + x, Y + y
550 lx = x: ly = y
560 NEXT i%
570 ENDPROC

DRAWS FLAMES
580 DEF PROC flames
590 VDU19, 3, 3; 0;
600 VDU19, 10, 3, 0, 0, 0

610 GCOL0, 3: FOR N = 1 TO 6: X = 300 + N * 30: Y = 450 + INT (RND(1) * 100): MOVEX, Y: MOVEX + 50,
Y + 110: PLOT85, X - 40, Y + 100: IF X > 400 THEN X = X + 30 + RND(60)
620 IF X < 370 THEN X = X - 30 - RND(50)
630 MOVEX, Y + 170 + RND(70): NEXT N

640 GCOL0, 2: FOR N = 1 TO 5: X = 310 + N * 30: Y = 440 + INT (RND(1) * 60): MOVEX, Y: MOVEX + 30,
Y + 60: PLOT85, X - 20, Y + 70: IF X > 400 THEN X = 20 + RND(50)
650 IF X < 370 THEN X = 20 - RND(30)
660 PLOT85, X, Y + 130 + RND(50): NEXT N

670 GCOL0, 3: FOR N = 1 TO 2: X = 330 + N * 50: Y = 440 + INT (RND(1) * 60): MOVEX, Y: MOVEX + 20,
Y + 40: PLOT85, X - 20, Y + 50: IF X > 400 THEN X = 20 + RND(30)
680 IF X < 370 THEN X = 20 - RND(30)
690 PLOT85, X, Y + 80 + RND(20): NEXT N

700 GCOL4, 3: FOR N = 1 TO 15: X = 320 + RND(150): Y = 700 + RND(300): R = 25 + RND(50): PROC
irc: NEXT N
710 ENDPROC

DRAWS FIRE ENGINE
720 DEF PROC engine
725 IF N% = 1 THEN PROC siren
730 VDU19, 2, 1, 0, 0, GCOL0, 2
740 MOVEX 650, 450: DRAW
1100, 450: PLOT85, 650, 520: PLOT85, 1100, 520: MOVEX 650, 520: MOVE 1000, 520: PLOT85, 5, 650, 570: PLOT85, 1000, 570
750 MOVEX 760, 570: DRAW 760, 660: PLOT85, 720, 570: PLOT85, 720, 660: PLOT85, 650, 570
760 X = 1000: Y = 580: R = 75: PROC filcirc
770 MOVEX 1080, 530: MOVE 1080, 550: PLOT85, 660, 700: PLOT85, 668, 720

780 GCOL0, 3: MOVEX 670, 570: MOVEX 710, 570: PLOT85, 710, 630: MOVEX 730, 640: MOVEX 730, 570: PLOT85, 750, 640: PLOT85, 750, 570
790 GCOL0, 0: X = 760: Y = 440: R = 50: PROC filcirc: X = 1000: PROC filcirc
800 ENDPROC

DRAWS AMBULANCE
810 DEF PROC ambu

327
DRAW S HOUSE IN RUINS

DEF PROC
816 IF N = 1 THEN PROC siren
820 VDU 19, 2, 1, 0, 0, 0; GCOL 0, 3
830 MOVE 780, 430; DRAW 1180, 430; PLOT 85, 780, 530; PLOT 85, 1180, 530
840 MOVE 780, 530; MOVE 800, 680; PLOT 85, 800, 530; MOVE 800, 680; PLOT 85, 1130, 530;
  PLOT 85, 1130, 680; PLOT 85, 1180, 530
850 GCOL 0, 2; MOVE 950, 555; MOVE 950, 450; PLOT 85, 990, 555; PLOT 85, 990, 450; MOVE 9
17, 520; MOVE 17, 480; PLOT 85, 1020, 520; PLOT 85, 1020, 480
860 GCOL 0, 1; MOVE 1130, 580; MOVE 1157, 580; PLOT 85, 1130, 667
870 GCOL 0, 0; X=870; Y=430; R=50; PROC circ r: X=1070; PROC circ r
880 MOVE 1080, 580; MOVE 1080, 660; PLOT 85, 960, 580; PLOT 85, 960, 660; MOVE 940, 660
  ; MOVE 940, 580; PLOT 85, 820, 660; PLOT 85, 820, 580; PLOT 85, 800, 590
890 END PROC
900 DEF PROC
910 VDU 19, 1, 6, 0, 0, 0
920 GCOL 0, 129; CLG
930 GCOL 0, 0; MOVE 10, 900; DRAW 10, 775; PLOT 85, 835, 900; PLOT 85, 835, 775; PLOT 85,
  910, 775; MOVE 870, 775; DRAW 770, 400; PLOT 85, 10, 775; PLOT 85, 10, 400
940 GCOL 0, 1; MOVE 250, 900; MOVE 550, 900; PLOT 85, 250, 750; PLOT 85, 550, 750; MOVE 2,
  70, 750; MOVE 550, 750; PLOT 85, 270, 650; PLOT 85, 550, 650; MOVE 10, 650; MOVE 270, 6
  50; PLOT 85, 510, 550; PLOT 85, 270, 550
950 MOVE 320, 560; MOVE 320, 520; PLOT 85, 480, 560; PLOT 85, 480, 520
960 MOVE 320, 520; MOVE 400, 520; PLOT 85, 320, 408; PLOT 85, 400, 408
970 GCOL 0, 0; MOVE 250, 760; MOVE 260, 790; PLOT 85, 540, 665; PLOT 85, 550, 695; MOVE 3,
  00, 555; MOVE 470, 605; PLOT 85, 340, 470; PLOT 85, 310, 510; MOVE 540, 665; MOVE 530, 6
  45; PLOT 85, 320, 750; PLOT 85, 310, 710
980 MOVE 310, 490; MOVE 305, 460; PLOT 85, 400, 430; PLOT 85, 390, 400
990 GCOL 0, 1; FOR N=590 TO
720 STEP 130; MOVE N, 720; MOVE N, 625; PLOT 85, N+50, 720; PLOT 85, N+50, 625; NE XT N
1000 FOR R=40 TO 170; STEP 130; MOVE N, 625; PLOT 85, N+50, 720; PLOT 85, N+50, 625; NE XT N
1010 FOR R=170 TO 720; STEP 550; MOVE N, 575; MOVE N, 475; PLOT 85, N+50, 575; PLOT 85, N+
  50, 475; NE XT N
1020 GCOL 0, 0; FOR R=590 TO
720 STEP 130; MOVE N, 625; DRAW N+50, 672; MOVE N+25, 625; DRAW N+25, 720; NE XT N
1030 FOR R=40 TO 170; STEP 130; MOVE N, 625; DRAW N+50, 672; MOVE N+25, 625; DRAW N+25,
  720; NE XT N
1040 FOR R=170 TO 720; STEP 550; MOVE N, 525; DRAW N+50, 525; MOVE N+25, 475; DRAW N+25,
  575; NE XT N
1050 GCOL 0, 2; FOR R=50 TO 600; STEP 550; MOVE N, 400; MOVE N+80, 400; PLOT 85, N, 560; P
  LOT 85, N+80, 560; NE XT N
1060 GCOL 0, 0
1070 FOR R=170 TO 720; STEP 180; Y=750+RND (250); R=20+RND (25); PROC circ r: NEXT N
1080 END PROC
SOUNDS SIREN FOR FIRE ENGINE OR AMBULANCE

2000 DEF PROC siren
2010 ENVELOPE 2, 2, -2, 2, 10, 20, 10, 1, 1, 0, -4, 100, 120
2020 SOUND 1, 2, 100, 125
2030 ENDPROC
3000 SOUND & 10, 0, 0, 1

3010 CHAIN "SUMUP"

5000 DEF PROC space
5010 VDU 31, 24, 10
5020 PRINT "Press space bar";
5030 X = GET
5040 CLS
5050 ENDPROC
PROGRAM NINE :-

10REM "NINE"
20IF A%>3 THEN 550
90REM GO OUTSIDE

CALL PROCEDURES FOR GOING OUT THE FRONT

100CLS
110PRINT:PRINT:PRINT"It is very dark outside."
120PRINT:PRINT"There is no-one around."
140PROCgoutft
160PRINT"GOUTFT"
162PROCscore
165PROCspace

MENU

170PRINT:PRINT:PRINT"What would you do next?"
180PRINT:PRINT:PRINTTAB(3);"Type 1 to get the neighbours."
190PRINT:PRINT:PRINTTAB(3);"Type 2 to go back into the house."
200A%=GET-48

NEXT PROGRAMS

210IFA%=2 THEN CHAIN"TWO"
220IFA%=1 THEN CHAIN"SIX"
230PRINT:PRINT"Type 1 or 2 only"
240GOTO 170
250END
260REM GONE OUTSIDE

PICTURE OF FRONT OF HOUSE

270DEF PROC goutft
280GCOLO,1;CLS
290GCOLO,3
300FORT=1 TO 15: R=18+INT(RND(1)*20+1)
310X=310+INT(RND(1)*200+1):Y=900+INT(RND(1)*100+1):PROCcirc:NEXT T
320X=1110:Y=930:R=70:PROCcirc1circ:GCOLO,1:X=1070:Y=940:PROC circ1circ

330GCOLO,0:MOVE10,900:DRAW10,775:PLOT85,835,900:PLOT85,835,775:PLOT85,910,775:MOVE870,775:DRA W870,400:PLOT85,10,775:PLOT85,10,400
340GCOLO,1
350MOVE320,575:DRAW380,575:PLOT85,320,400:PLOT85,380,400

370MOVE440,575:DRAW490,575:PLOT85,440,475:PLOT85,490,475

390NEXT N
400GCOLO,2

420ENDPROC

CIRCLES

430DEF PROC circ
LOCAL x, y, lx, ly, n%  
45n%=16: step=2*PI/n%  
46cos=COS(step); sin=SIN(step)  
470x=R: ly=0: MOVEX+R, Y  
480FOR Ix=1TO n%  
490x=lx*cos-ly*sin  
500y=lx*sin+ly*cos  
510DRAWX+lx, Y+y  
520x=x: ly=y  
530NEXT i%  
540ENDPROC  
550REM  
560CLS: PRINT" It is very dark outside."  
570PRINT: PRINT" There is no-one around."  
580PROCgoutft  
590PROCmsmoke  
600PRINT"7", "GOFOD"  
610PROCscore  
620PROCspace  
630MENU  
640PRINT: PRINT: PRINT"What would you do next?"  
650IF A% = A% + 2  
660IF A%=3 THEN CHAIN"SIX"  
670IF A%=4 THEN PRINT"SEVEN"  
680PRINT: PRINT"Type 1 or 2 only"  
690GOTO &10  
700END  
710DEFPROCmsmoke  
720GCOL0, 3  
730FOR n=1 TO 20: R=18+INT(RND(1)*20#1)  
740x=310+INT(RND(1)*100#1); Y=410+INT(RND(1)*200+1): PROCcirc: NEXT n  
750ENDPROC  
760DEFPROCcirc  
770LOCAL x, y, lx, ly, n%  
780n%=16: step=2*PI/n%  
79cos=COS(step); sin=SIN(step)  
800x=R; y=0: MOVEX+R, Y  
810FOR i=1 TO n%  
820x=lx*cos-ly*sin  
830y=lx*sin+ly*cos  
840MOVEX, Y; PLOT85, X+x, Y+y  
850x=x: ly=y  
860NEXT i%  
870ENDPROC  
880DEFPROCscore  
890VDU31, 1, 10  
900PRINT"Score ="; S%; " points"  
910DEFPROCfillcirc  
920LOCAL x, y, lx, ly, n%  
930n%=16: step=2*PI/n%  
940cos=COS(step); sin=SIN(step)  
950x=R; y=0: MOVEX+R, Y  
960FOR i=1 TO n%  
970x=lx*cos-ly*sin  
980y=lx*sin+ly*cos  
990MOVEX, Y; PLOT85, X+x, Y+y  
1000x=x: ly=y  
1010ENDPROC  
1020DEFPROCscore  
1030VDU31, 1, 10  
1040PRINT"Score ="; S%; " points"  
1050END
PROGRAM TEN:

10 REM "TEN"
20 IF A% = 3 THEN 30 ELSE 470
30 REM GET KIDS UP

PROCEDURES FOR GETTING THE CHILDREN UP

40 CLS: PRINT "You can now help the children."
50 PRINT "Some smoke is coming into the room through the door."
60 PRINT: PRINT: PRINT
70 PROCksrm
80 PROCscore
90 PROCspace
100 PRINTI17, "KSUP"

MENU

110 PRINT: PRINT: PRINT "What would you do now?"
120 PRINT: PRINTTAB(4); "Type 1 to leave the room with the children."
130 PRINT: PRINTTAB(4); "Type 2 to wait by the window."
140 A% = GET-48

NEXT PROGRAMS

150 IF A% = 2 THEN A% = A% + 4: PRINTI17, "WFBWK": CHAIN "SEVEN"
160 IF A% = 1 THEN CHAIN "FOUR"
170 PRINT: PRINT "Type 1 or 2 only"
180 GOTO 1110
190 END

PICTURE OF CHILDREN'S ROOM

200 DEFFPROCksrm
210 REMKIDSRoom
220 GCOLO, 1: CLG


LET85, 200, 582: PLOT85, 255, 550: PLOT85, 210, 582


300MOVE10, 700: DRAW10, 750: PLOT85, 270, 700: PLOT85, 270, 750: DRAW150, 775: PLOT85, 180, 800: PLOT85, 105, 800


320GCOL0, 3: X=770: Y=630: R=15: PROCcirc: R=8: PROCcirc: PLOT69, X, Y

330FOR N=1 TO 15: R=15+INT(RND(1)*25+1): X=730+INT(RND(1)*235+1): Y=400+INT(RND(1)*75+1): PROCcirc: NEXTN: 340ENDPROC

CIRCLES

350DEF PROCcirc
360LOCAL x, y, l, x, l, n%
370n%=16: step=2*PI/n%
380cos=COS(step): sin=SIN(step)
390x=R: l=y=0: MOVEX+R, Y
400FOR l%=1 TO n%
410x=l*cos-l*y*sin
420y=l*sin+l*y*cos
430DRAWX+x, Y+y
440l=x: y=l*y
450NEXT l%
460ENDPROC

PROCEDURES FOR GETTING CHILDREN IN SMOKE

470REM GETKIDSUPINSMOKE
480PRINT
490CLS: PRINT" You can now help the children."
500PRINT: PRINT" Thick smoke is coming into the room through the door."
510PRINT: PRINT: PRINT
520PROCksrm
530PROCmorsm
540PROCscore
550PROCspace
560PRINT" KSUPIS"

MENU

570PRINT: PRINT" What would you and the children do now?"
580PRINT: PRINTTAB(3): "Type 1 to leave the room."
590PRINTTAB(3): "Type 2 to wait for the Fire Brigade."
600PRINT: PRINTTAB(3): "Type 3 to jump from the window."
610A%=GET-48

NEXT PROGRAMS

620IFA%=1 THEN CHAIN"FOUR"

333
1. IF A% = 2 THEN A% = A% + 5: PRINT 17, "WBB", CHAIN "SEVEN"
2. IF A% = 3 THEN A% = A% + 5: PRINT 17, "JMB", CHAIN "SEVEN"
3. PRINT: PRINT "Type 1, 2 or 3 only"
4. GOTO 570
5. END

DRAW MORE SMOKE

680 DEF PROC morsm
690 REM MORE SMOKE KIDSROOM
700 FOR N = 1 TO 30: R = 20 + INT (RND (1) * 60 + 1)
710 X = 510 + INT (RND (1) * 580 + 1): Y = 430 + INT (RND (1) * 500 + 1): PROC fircirc: NEXT N
720 END PROC

FILLED CIRCLES

730 DEF PROC filcirc
740 LOCAL x, y, l x, l y, n%
750 n% = 15: step = 2 * PI / n%
760 cos = COS (step): sin = SIN (step)
770 1 x = R: l y = 0: MOVEX +R, Y
780 FOR 1 x = ITOn%
790 x = l x * cos - l y * sin
800 y = l x * sin + l y * cos
810 MOVEX, Y: PLOT 85, X + x, Y + y
820 1 x = x: l y = y
830 NEXT 1 x
840 END PROC

SPACE BAR AND SCORE

850 DEF PROC space
860 VDU 31, 24, 10
870 PRINT "Press space bar";
880 X = GET
890 CLS
900 END PROC
910 DEF PROC score
920 5 X = 5 + 20
930 10 VDU 31, 1, 10
940 PRINT "Score = "; S%; " points"
950 END PROC
PROGRAM ELEVEN:

10REM "ELEVEN"
20REM70=DRES 200-VALS 1000-EAA 1400-REAwk
300N%G0T040,210,940,600
40REM PROCEDURES TO GET DRESSED
50CLS
60PRINT:PRINT"You have wasted time by getting dressed."
70PROCpica
80PROCscore
90PROCspace
100PRINT£17,"DRES"

MENU
110PRINT:PRINT"What would you do now?"
120PRINT:PRINT:PRINTTAB(4);"Type 1 to look for your favourite toys."
130PRINT:PRINTTAB(4);"Type 2 to get the children up."
140PRINT:PRINT
150A%=GET-48

NEXT PROGRAMS
160IFA%=1THENPROCdandy
170IFA%=2THENCHAIN"TEN"
180PRINT:PRINT"Type 1 or 2 only"
190G0T0110
200END
210REM PROCEDURES TO GET VALUABLES
220CLS
230PRINT"You wasted time looking for your";PRINT:PRINT"favourite toys."
240PROCpica
250PROCscore
260PROCspace
270PRINT£17,"VALS"

MENU
280PRINT:PRINT"What would you do now?"
290PRINT
300PRINT:PRINTTAB(4);"Type 1 to get dressed."
310PRINT:PRINTTAB(4);"Type 2 to get the children up."
320PRINT:PRINT:PRINT
330A%=GET-48

NEXT PROGRAMS
340IFA%=1THENPROCdandy
350IFA%=2THENCHAIN"TEN"
360PRINT:PRINT"Type 1 or 2 only."
370G0T0280
380END
390D3EPROCdandy
400REM
410CLS
420PRINT"You have lost a lot of time by looking";PRINT:PRINT"for toys and getting dressed."
430PROCsm
PROCscore
PROCspace
PRINT$17,"DANDY"

PRINT: PRINT"What would you do now?"
PRINT: PRINTTAB(3);"Type 1 to try to escape by the stairs"
PRINT: PRINTTAB(3);"Type 2 to shut your door."
PRINT: PRINTTAB(3);"Type 3 to open your window."
PRINT: PRINTTAB(3);"Type 4 to get the children up."
520A%=GET-48

NEXT PROGRAMS
530IFA%=1THENA%=A%+3:PRINT$17,"PERS":CHAIN"SEVEN"
540IFA%=2THENPROC$sda
550IFA%=3THENCE"TWELVE"
560IFA%=4THENCE"TEN"
570PRINT:PRINT"Type 1,2,3 or 4 only."
580GOTO470
590ENDIFPROC

PROCEDURES FOR ENTERING OWN ROOM ALONE
600REMENTER A ALONE
610CLS
620PRINT: PRINT" Smoke is now coming into your room."
630PROCpica
635PROCsm
640PROCscore
650PROCspace
660PRINT$17,"EAA"

PRINT: PRINT: PRINT"What would you do next?"
PRINT: PRINTTAB(4);"Type 1 to try and escape by the stairs."
PRINT: PRINTTAB(4);"Type 2 to shut your door."
PRINT: PRINTTAB(4);"Type 3 to open your window."
710A%=GET-48

NEXT PROGRAMS
720IFA%=1THENA%=A%+3:PRINT$17,"PERS":CHAIN"SEVEN"
730IFA%=2THENPROC$sda
740IFA%=3THENCE"TWELVE"
750PRINT:PRINT"Type 1,2 or 3 only.";GOTO 670
760END
770DEFPPOCSda

PROCEDURES TO SHUT DOOR OF OWN ROOM
780REMSHUT DOOR A
790CLS
800PRINT: PRINT" Now smoke cannot get into the room so"
PRINT: PRINT: PRINT"easily."
810PROCpicsda
820G%=G%+10:PROCscore
830PROCspace
840PRINT$17,"SDA"

PRINT: PRINT"What would you do now?"
PRINT: PRINT
870PRINT: PRINTTAB(4);"Type 1 to wait for the Fire Brigade."
880PRINT:PRINTTAB(4);"Type 2 to jump from the window."
890A%=GET-48

NEXT PROGRAMS
900IFA%=1THENA%=A%+11:PRINT€17,"WBWA":CHAIN"SEVEN"
910IFA%=2THENA%=A%+7:PRINT€17,"JMPWA":CHAIN"SEVEN"
920PRINT:PRINT"Type 1 or 2 only":GOTO850
930ENDPROC

PROCEDURES TO ENTER OWN ROOM WITH CHILDREN
940REMRE-ENTER A WITH KIDS
950CLS
960PRINT:PRINT"Smoke is now coming into your room."
970PROCpica:PROCsm
980PROCscore
990PROCspace
1000PRINT€17,"REAWK"

MENU
1010PRINT:PRINT"What would you and the children do now?"
1020PRINT:PRINTTAB(4);"Type 1 to try and escape by the stairs."
1030PRINT:PRINTTAB(4);"Type 2 to open the window."
1040PRINT:PRINTTAB(4);"Type 3 to shut the door."
1050A%=GET-48

NEXT PROGRAMS
1060IFA%=1THENA%=A%+1:PRINT€17,"ESCKW":CHAIN"SEVEN"
1070IFA%=3THENPROCsdawk
1080IFA%=2THENCHAIN"TWELVE"
1090PRINT:PRINT"Type 1,2 or 3 only.",GOTO1010
1100GOTO01010
1110END
1120DEFPROCsdawk

PROCEDURES TO SHUT DOOR BEHIND YOU AND CHILDREN
1130REMSHUT DOOR A WITH KIDS
1140CLS
1150PRINT:PRINT"Now smoke cannot get in so easily."
1160PROCpicasd
1170S%=S%+10:PROCscore
1180PROCspace
1190PRINT€17,"SDAWK"

MENU
1200PRINT:PRINT:PRINT"What would you and the children do now?"
1210PRINT:PRINTTAB(2);"Type 1 to wait for the Fire Brigade."
1220PRINT:PRINTTAB(2);"Type 2 to open the window."
1230PRINT:PRINT
1240A%=GET-48

NEXT PROGRAMS
1250IFA%=1THENA%=A%+10:PRINT€17,"WBBAWK":CHAIN"SEVEN"
1260IFA%=2THENCHAIN"TWELVE"
1270PRINT:PRINT"Type 1 or 2 only.":GOTO1200
1280ENDPROC

DRAW PICTURE OF OWN ROOM
1290 DEFPROCpica
1300 GCOLO,1:CLG
1310GCOLO,0:MOVE554,480:MOVE570,480:PL0T85,554,400:PL0T85,570,400:MOVE692,420:MOVE708,420:PL0T85,692,400:PL0T85,708,400

337
1320 VDU19,2,1:0:;GCOLO,2:MOVE10,400:MOVE200,400:PL0T85,10,900:PL0T85,200,900:PL0T85,200,940
1330 MOVEMOVE1270,410:MOVE1270,500:PL0T85,700,410:PL0T85,700,500:PL0T85,550,480:PL0T85,550,570
1340 MOVEMOVE700,500:PL0T85,1120,570:PL0T85,1270,500
1350 GCOLO,3: X=1220:Y=570:R=90:PROCcirc: X=1170:Y=600:PROCcirc
1360 MOVEMOVE1060,570:DRAW1200,500:DRAW1200,410:MOVE950,570:DRAW1100,500:DI
1370 GCOLO,2: X=1360:R=130:Y=515:PROCcirc: R=150:PROCcirc
1380 GCOLO,0:MOVE500,700:MOVE500,950:PL0T85,1000,700:PL0T85,1000,950
1390
1400 GCOLO,3: F0R=1T07: X=650+RND(200): Y=750+RND(180): MOVEX,Y: PRINT"*": NEXTN
1410 VDU4
1420 MOVE500,825:GCOLO,1:DRAW1000,825:MOVE750,700:DRAW750,950
1430 GCOLO,2: MOVE470,970: MOVE600,970: PL0T85,470,670: PL0T85,600,670: MOV
1440 F0R=43T0587STEP26: X=N: Y=675: R=13: PROCcirc: NEXTN
1460 GCOLO,3
1470 X=164: Y=580: R=10: PROCcirc
1480 FOR=N=1T012: X=RND(250): Y=400+RND(170): R=24+RND(30): PROCcirc: NEXTN
1490 ENDPROC

CIRCLES

1500 DEFFPROccirc
1510 LOCAL x, y, lx, ly, n%
1520 n%=17: step=2*PI/n%
1530 cos=COS(step): sin=SIN(step)
1540 lx=R: ly=0: MOVEX+R,Y
1550 FOR i%=1 TO n%
1560 x=lx*cos - ly*sin
1570 y=lx*sin + ly*cos
1580 DRAWX+x: Y+y
1590 NEXT i%
1600 ENDPROC
1610 ENDPROC
1620 DEFFPROCcirc
1630 LOCAL x, y, lx, ly, n%
1640 n%=15: step=2*PI/n%
1650 cos=COS(step): sin=SIN(step)
1660 lx=R: ly=0: MOVEX+R,Y
1670 FOR i%=1 TO n%
1680 x=lx*cos-ly*sin
1690 y=lx*sin+ly*cos
1700 MOVEX,Y: PL0T85, X+x, Y+y
1710 NEXT i%
1720 ENDPROC
1730 ENDPROC

DRAW PICTURE WITH DOOR SHUT

1740 DEFFPROCpicksda
1750 GCOLO,1:MOVE10,400:MOVE300,400:PL0T85,10,1000:PL0T85,300,1000
1760 ENDPROC
1770 DEFFPROCsm
1780 FOR N=1T09: X=RND(250): Y=400+RND(170): R=30+RND(30): PROCcirc: NEXTN
SPACE BAR AND SCORE

1790ENDPROC
1800DEFFPROCspacescore
1810VDU31,24,10
1820PRINT"Press space bar";
1830X=GET
1840CLS
1850ENDPROC
2000DEFFROCscorespace
2005SS%=5%-5
2010VDU31,1,10
2020PRINT"Score =";S%;" points"
2030ENDPROC

PROGRAM TWELVE:

5REM "TWELVE"
10IFA%=3THEN70ELSE500

7OREM OPEN WINDOW A
75CLS
80PRINT:PRINT"If you have not shut the door
thick":PRINT:PRINT"smoke will come in."
87PROCscore
90PROCspacescore
95PRINT17,"OWA"

100PRINT:PRINT"What would you do next?"
110PRINT:PRINT"Type 1 to wait for the Fire Brigade."
120PRINT TAB(4);"Type 2 to jump from the window."
125PRINT:PRINT
130A%=GET-48

NEXT PROGRAMS
140IFA%=1THENA%=A%+11:PRINT17,",WFWA":CHAIN"SEVEN"
150IFA%=2THENA%=A%+7:PRINT17,",JMPWA":CHAIN"SEVEN"
160PRINT:PRINT"Type 1 or 2 only"
170GOT0100
180END

PROCEDURES TO OPEN WINDOW OF OWN ROOM

PROCEDURES FOR OPENING WINDOW WITH CHILDREN

500REMOPEN WINDOW A WITH KIDS
505CLS
510PRINT:PRINT"If you have not shut the door
thick":PRINT:PRINT"smoke will come in."
530PROCscore
540PROCspacescore
550PRINT17,"OWA"

560PRINT:PRINT"What would you and the children do now?"
570PRINT:PRINT"Type 1 to wait for the Fire Brigade."
580PRINT:PRINT"Type 2 to jump from the window."
590PRINT:PRINT
600A%=GET-48

NEXT PROGRAMS

339
610 IF A%=1 THEN A%=A%+10: PRINT$17,"WFBAWK": CHAIN"SEVEN"
620 IF A%=2 THEN A%=A%+8: PRINT$17,"JMPAWK": CHAIN"SEVEN"
630 PRINT: PRINT"Type 1 or 2 only."
640 GOTO 560
650 END

DRAW OPEN WINDOW

660 DEFPROC winda
670 GCOL(1,1): CLG
680 ENDPROC

SCORE AND SPACE BAR

2000 DEFPROC score
2005 S%=S%+5
2010 VDU31,1,10
2020 PRINT"Score ="; S%;" points"
2030 ENDPROC
5000 DEFPROC space
5010 VDU31,24,10
5020 PRINT"Press space bar"
5030 X=GET
5040 CLS
5050 ENDPROC
SUMMARY OF ROUTE AND HIGH SCORE TABLE:

10 REM SUM UP
20 DIM $#(30): DIM %$(30)
30 X=OPEN IN"FCON": INPUT X,F: CLOSE X
40 PROC chst
50 MODE 1
60 PRINT: PRINT "Do you want a summary of your route?"
70 A$=GET$
80 IF A$="Y" OR A$="Y" THEN 90 ELSE 570
90 REPEAT
100 B=PTR X17=1
110 A=BGET17
120 PTR X17=B
130 UNTIL A=33
140 PTR X17=B-1
150 REPEAT
160 PRINT
170 INPUT X17,A$

CALL PROCEDURES FOR SUMMARY

180 IF A$="GOUTBK" THEN PROC goutbk
190 IF A$="CON" THEN PROC con
200 IF A$="OPENDR" THEN PROC opendr
210 IF A$="SUP" THEN PROC sup
220 IF A$="SUPIS" THEN PROC supsup
230 IF A$="GBIH" THEN PROC gbih
240 IF A$="FFIRE" THEN PROC ffire
250 IF A$="GOU" THEN PROC goup
260 IF A$="GDUPED" THEN PROC goup
270 IF A$="GROUP" THEN PROC goup
280 IF A$="LRK" THEN PROC lrk
290 IF A$="GBOD" THEN PROC goutbk
300 IF A$="CONTOD" THEN PROC con
310 IF A$="PERS" THEN PROC pers
320 IF A$="ESCWK" THEN PROC escwk
330 IF A$="WFB" THEN PROC wfb
340 IF A$="JMB" THEN PROC jmb
350 IF A$="JMBWA" THEN PROC jmpwa
360 IF A$="WARIABLED" THEN PROC wباشر
370 IF A$="WFBOD" THEN PROC wfbh
380 IF A$="WFBH" THEN PROC wfbh
390 IF A$="WFBAWK" THEN PROC wfbwa
400 IF A$="WFBWA" THEN PROC wfbwa
410 IF A$="JMPAWK" THEN PROC jmpwa
420 IF A$="GDC" THEN PROC gdc
430 IF A$="GOUTFT" THEN PROC goutft
440 IF A$="GODFOD" THEN PROC goutft
450 IF A$="EAA" THEN PROC eaa
460 IF A$="SDA" THEN PROC sda
470 IF A$="OWA" THEN PROC owa
480 IF A$="SDAWK" THEN PROC sda
490 IF A$="OWAWK" THEN PROC owa

341
500 IFA$="REAWK" THEN PROC reawk
510 IFA$="DRES" THEN PROC dres
520 IFA$="DANDV" THEN PROC dandv
530 IFA$="VALIS" THEN PROC vals
540 UNTILE OF$=17
550 N = TIME
560 REPEAT UNTIL TIME = N + 1000
570 PRINT: PRINT
580 REM
590 REM
600 REM
610 REM
620 REM
630 REM
640 PRINT: PRINT
650 CALL FIRST PROGRAM
660 INPUT "Has everyone had a go yet"; B$
670 IF B$ = "Y" OR B$ = "y" THEN N% = 0
680 IF B$ = "n" OR B$ = "N" THEN N% = 1
700 CLOSE $0
710 CHAIN "ONE"
720 END

PROCEDURES GIVING SUMMARY
730 DEF PROC goutbk
740 PRINT "You left the house by the back door."
750 END PROC
760 DEF PROC con
770 PRINT "You went to the neighbours to ring the Fire Brigade."
780 PRINT "This was good, the Fire Brigade will come within minutes of a 999 call. They are trained to cope with fire or a suspected fire whereas you are not."
790 END PROC
800 DEF PROC sup
810 PRINT "You got the children up."
820 PRINT "This was good as you are now all together in one group"
830 END PROC
840 DEF PROC opendr
850 PRINT "You opened the dining room door."
860 PRINT "This was a bad thing to do as you fed the fire with a rush of fresh air that was full of oxygen."
870 PRINT "The fire had used all the oxygen in the room and was dying quietly until you revived it."
880 PRINT "Even if you think a fire is very small and want to get at it to put it out you must not open the door on a suspected fire."
890 END PROC
900 DEF PROC gbih
910 PRINT "You went back into the house."
920 END PROC
930 DEF PROC fire
940 PRINT "You tried to fight the fire with water. This was not a good idea as fires are very dangerous. It is the Fire Brigade's job to fight fires, they are specially trained to do so."
950 END PROC
960 DEF PROC goup
PRINT" You went upstairs."
ENDPROC

DEFPROC
PRINT" You and the children left their room."
ENDPROC

DEFPROCpers
PRINT" Finally, you persisted in staying or going close to the fire. This was not sensible you should have kept well away."
ENDPROC

DEFPROCdesc
PRINT" Finally, you tried to escape by the stairs but you left it too late, the fire had grown too big to pass."
ENDPROC

DEFPROCdesc
PRINT" Finally, you waited in the children's room for the Fire Brigade to arrive."
ENDPROC

IFF=OTENPRINT" This was not a good idea as you have not called them and cannot expect a neighbour to have woken and called them for you."
ENDPROC

DEFPROCdesc
PRINT" Finally, you jumped from the children's window."
ENDPROC

DEFPROCdesc
PRINT" Finally, you jumped from your bedroom window."
ENDPROC

DEFPROCdesc
PRINT" Finally, you waited outside for the Fire Brigade. This was silly as you havenot called them."
ENDPROC

DEFPROCdesc
PRINT" Finally, you waited outside for the Fire Brigade to arrive."
ENDPROC

DEFPROCdesc
PRINT" Finally, you waited in your room for the Fire Brigade to arrive."
ENDPROC

IFDEF=THENPRINT" This was not a good idea as you have not called them and cannot expect a neighbour to have woken and called them for you."
ENDPROC

DEFPROCdesc
PRINT" You went downstairs with the children."
ENDPROC

DEFPROCdesc
PRINT" You left the house by the front door."
ENDPROC

DEFPROCdesc
PRINT" You entered your own room."
ENDPROC

DEFPROCdesc
PRINT" You shut the door of the room."
ENDPROC

343
PRINT "You opened the window."
ENDPROC
DEFPROC creak
ENDPROC
DEFPROC cdres
PRINT "You went to your room and got dressed. This was not a good idea as you wasted valuable time."
ENDPROC
DEFPROC cvals
PRINT "You went to look for your valuables. This was not good as you wasted time that you needed to escape in."
ENDPROC
DEFPROC cdandy
PRINT "You got dressed as well as looking for your valuables. You wasted a lot of time that could have been used to escape from the fire before it got too big."
ENDPROC

DRAW HIGH SCORE TABLE AND WORK OUT PLAYER'S POSITION

LOCAL a,b,c,d
Y=OPENUP "hst"
X=EXT Y: PTR Y=X
PRINT: CY 1 S11.
PTR Y=0
A=A+1
REPEAT
INPUT: CY, Wr (A) S% (A)
A=A+1
UNTIL EOFEY
FOR I=1 TO A-2
FOR J=2 TO A-1
=S% (J-1)
=, a
N$ W) =(J: t- -. N--r- (0 -- I =c- T-
NEXT I
DU26:CLS
S', 5 7 1270 1 F, L01-8511270 1 930 -. MOVE 123-0 1980: PLOT85,50150 71 () u. PLOT85,50150
VDU: -ý. I1 12
PRINT "HIGH SCORE TABLE"
PRINT "HIGH SCORE TABLE"
PRINT: PRINT: PRINT
FOR I=1 TO A-1
IFI >12 THEN11880
VDU3,1.9 42 A- 1+40
NEXT I
NEXT I

DRAW HIGH SCORE TABLE AND WORK OUT PLAYER'S POSITION
1850VDU31,25,2*I+3
1860PRINT;S%(I)
1861GOTO1870
1870NEXTI

READ SPACE BAR

1880PROCspace
1900ENDPROC
1910DEFFPROCspace
1920VDU31,20,2B
1930PRINT"Press space bar";
1940X=GET
1950CLS
1960ENDPROC
Appendix 8.1. Pilot version of questionnaire on reasons for becoming involved with computers, attitudes towards computers, locus of control, and self-esteem.

Please complete and return this questionnaire to Jocelyn Wishart, Department of Psychology, Surrey University.

1. What is your age?
2. What sex are you?
3. What is your occupation?

Please could you read each of the following statements. Where there is a blank, decide from those given below what your normal or usual attitude, feeling or behaviour would be:

<table>
<thead>
<tr>
<th></th>
<th>Rarely</th>
<th>Occasionally</th>
<th>Sometimes</th>
<th>Frequently</th>
<th>Usually</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Less than 10% of the time</td>
<td>About 30% of the time</td>
<td>About half the time</td>
<td>About 70% of the time</td>
<td>More than 90% of the time</td>
</tr>
</tbody>
</table>

Of course, there are always unusual situations when this would not be the case, but think of what you would do or feel in most normal situations. Write the number that describes your usual attitude or behaviour in the blank in each statement.

1. When faced with a problem I _____ try to forget it.
2. I _____ need frequent encouragement from others for me to keep working at a difficult task.
3. I _____ like jobs where I can make decisions and be responsible for my own work.
4. I _____ change my opinion when someone I admire disagrees with me.
5. If I want something I _____ work hard to get it.
6. I _____ prefer to learn the facts about something from someone else rather than have to dig them out for myself.
7. I will _____ accept jobs that require me to supervise others.
8. I _____ have a hard time saying "no" when someone tries to sell me something I don't want.
9. I _____ like to have a say in any decisions made by a group I'm in.
10. I _____ consider the different sides of an issue before making any decisions.

11. What other people think _____ has a great influence on my behaviour.

12. Whenever something good happens to me I _____ feel it is because I have earned it.

13. I _____ enjoy being in a position of leadership.

14. I _____ need someone else to praise my work before I am satisfied with what I have done.

15. I am _____ sure enough of my opinions to try and influence others.

16. When something is going to affect me I _____ learn as much about it as I can.

17. I _____ decide to do things on the spur of the moment.

18. For me, knowing I've done something well is _____ more important than being praised by someone else.

19. I _____ let other people's demands keep me from doing things I want to do.

20. I _____ stick to my opinions when someone disagrees with me.

21. I _____ do what I feel like doing not what other people think I ought to do.

22. I _____ get discouraged when doing something that takes a long time to achieve results.

23. When part of a group I _____ prefer to let other people make all the decisions.

24. When I have a problem I _____ follow the advice of friends or relatives.

25. I _____ enjoy trying to do difficult tasks more than I enjoy trying to do easy tasks.

26. I _____ prefer situations where I can depend on someone else's ability rather than just my own.

27. Having someone important tell me I did a good job is _____ more important to me than feeling I've done a good job.

28. When I'm involved in something I _____ try to find out all I can about what is going on even when someone else is in charge.
Could you please indicate how much you agree or disagree with the following statements by ticking the answer that is most appropriate to the way you feel.

1. I feel that I'm a person of worth, at least on an equal plane with others.

   Strongly agree    Agree    Disagree    Strongly disagree

2. All in all, I am inclined to feel that I am a failure.

   Strongly agree    Agree    Disagree    Strongly disagree

3. I feel that I have a number of good qualities.

   Strongly agree    Agree    Disagree    Strongly disagree

4. I am able to do things as well as most other people.

   Strongly agree    Agree    Disagree    Strongly disagree

5. I feel I do not have much to be proud of.

   Strongly agree    Agree    Disagree    Strongly disagree

6. I take a positive attitude towards myself.

   Strongly agree    Agree    Disagree    Strongly disagree

7. On the whole, I am satisfied with myself.

   Strongly agree    Agree    Disagree    Strongly disagree

8. I wish I could have more respect for myself.

   Strongly agree    Agree    Disagree    Strongly disagree

9. I certainly feel useless at times.

   Strongly agree    Agree    Disagree    Strongly disagree

10. At times I think I am no good at all.

    Strongly agree    Agree    Disagree    Strongly disagree

Could you please answer the following questions by ticking the right answers.

1. Do you have or have you had access to a computer?

   At school or work    At home    None

2. How often do you use a computer at school or at work now?

   Everyday    Weekly    Monthly    Less than monthly    Never
3. How often do you use a computer outside school or work now?
   Everyday  Weekly  Monthly  Less than monthly  Never

4. How often have you used a computer at school or at work in the past?
   Everyday  Weekly  Monthly  Less than monthly  Never

5. How often have you used a computer outside school or work in the past?
   Everyday  Weekly  Monthly  Less than monthly  Never

6. Please tick each of the following activities that you have used a computer for:
   - playing adventure games
   - learning about computers
   - playing arcade games
   - creating sounds and music
   - doing educational programs
   - creating pictures or graphics
   - analysing and storing data
   - learning to program
   - word processing
   - programming as a hobby
   - using business packages
   - programming commercially

Please answer the following questions by ticking the appropriate number on the scale from 1 to 7 below.

   1  2  3  4  5  6  7
   1. How interested are you in computers?
   2. How much do you want, or did you want to know how to use a computer?
   3. How much do you like using, or the idea of using computers?
   4. How much do you think that the user is in control of the computer?
5. How scared are you of using a computer?
   1 2 3 4 5 6 7

6. How much are you in favour of the introduction of computers into your work.
   1 2 3 4 5 6 7

7. How much do you think that we are in danger of letting computers take over.
   1 2 3 4 5 6 7

Please indicate how much you disagree or agree with the following statements using the scale of 1 to 7 below.

definitely don't agree ---> indifferent ---> very much agree
   1   4   7

1. People like playing arcade games on computers because they like getting points for doing well.
   1 2 3 4 5 6 7

2. People enjoy word processing because it makes doing corrections much quicker and easier and so their work is less boring.
   1 2 3 4 5 6 7

3. People enjoy most the challenge in using a word processor to produce a well set out document.
   1 2 3 4 5 6 7

4. People like educational programs because the questions get more difficult as they get the answers right.
   1 2 3 4 5 6 7

5. Computer programmers enjoy most being able to write and debug more and more complex programs.
   1 2 3 4 5 6 7

6. People enjoy playing adventure games on computers because once they have completed one, their friends are nice to them in the hope of finding out how to do it.
   1 2 3 4 5 6 7
7. People enjoy writing computer programs because they can make the computer do what they want it to.

8. People enjoy word processing because it is easy to reorganise what they are writing at any point.

9. People like playing adventure games on computers because they want to complete the adventure.

10. People enjoy the challenge in using financial or data analysis software to show their results to their best advantage.

11. People enjoy using financial or data analysis software because they set up what needs to be done and then the computer does all the calculations.

12. People like using educational programs because the programs tell them when they are right.

13. People who write computer programs enjoy seeing them work most of all.

14. People enjoy using financial and data analysis software because it makes their work easier.

15. People play arcade games on computers because all their friends do.

16. People enjoy playing adventure games on computers because they can explore where they want.

17. People like using educational programs because it will improve their end of term grades.
18. People like using financial and data analysis software because they can do increasingly complex analyses.

1 2 3 4 5 6 7

19. People like using educational programs because they can choose how difficult to make the questions.

1 2 3 4 5 6 7

20. People enjoy seeing the results most when they use financial or data analysis software.

1 2 3 4 5 6 7

21. People who use educational programs enjoy most the challenge of trying to get all the answers right.

1 2 3 4 5 6 7

22. People like playing adventure games on the computer because it improves their problem solving ability.

1 2 3 4 5 6 7

23. People enjoy writing computer programs because they might get money for them.

1 2 3 4 5 6 7

24. People enjoy using word processors because it makes their writing look more professional.

1 2 3 4 5 6 7

25. People enjoy word processing because they get a print out of what they have written.

1 2 3 4 5 6 7

26. People like playing adventure games on computers because they like finding the treasure and other useful objects.

1 2 3 4 5 6 7

27. People who write programs enjoy most the challenge in trying to make them run.

1 2 3 4 5 6 7

28. People enjoy playing arcade games on computers because it improves their reactions.

1 2 3 4 5 6 7

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29. People enjoy writing computer programs because it helps their career.

30. People play arcade games on computers because they want to beat the high score.

31. People enjoy playing arcade games on computers because they like controlling the man, or spaceship.

32. People like word processing because they are able to do more complicated things with the text than would otherwise be possible.

33. People enjoy playing adventure games on computers because as they explore further the problems get more complicated.

34. People enjoy using financial or data analysis software because it enhances their business or research abilities.

35. People like best the graphic effects in arcade games that speed up as you get better at playing them.

36. People enjoy using educational programs because it pleases the teacher.
Appendix 8.2. Revised version of questionnaire on reasons for becoming involved with computers, attitudes towards computers, locus of control and self-esteem.

This questionnaire is part of a study that I am carrying out for a Ph.D. in the Department of Psychology. It contains questions about people's opinions of themselves and their attitudes towards computers. I would be very grateful if you would complete it and return it to me through the internal mail.

- Jocelyn Wishart, Department of Psychology, Surrey University.

1. What is your age?  
2. What sex are you?

3. What is your occupation?

Could you please answer the following questions by ticking the right answers.

4. Do you have access to a computer?  
   At school or work  At home  None

5. If you have access to a computer at school or work, how often do you use it?
   Everyday  Weekly  Monthly  Less than monthly  Never

6. If you have access to a computer outside of school or work, how often do you use it?
   Everyday  Weekly  Monthly  Less than monthly  Never

7. If you have used a computer in the past more often than you do now, how often did you use it?
   Everyday  Weekly  Monthly  Less than monthly  Never
   and for how long?

   More than a year  3 to 12 months  1 to 3 months  less than a month
8. Please tick each of the following that you have used a computer for:–

- playing arcade games e.g. Pac-man, Space Invaders, Hyper Olympics
- playing adventure games e.g. Island Adventure, The Hobbit
- doing educational programs e.g. Micromaths, Road Safety
- analysing and storing data e.g. Factfile, SPSS
- wordprocessing e.g. Wordwise, Wordstar, Locoscript
- using business or financial software e.g. Lotus 123, Delta
- learning about computers
- creating sounds and music
- creating pictures or graphics
- learning to program
- programming as a hobby
- programming commercially

Please answer the following questions by ticking or circling the appropriate number on the scale from 1 to 7 below.

1 2 3 4 5 6 7

definitely not --→ neutral --→ very much indeed

9. How interested are you in computers ?

10. How much do you want, or did you want to know how to use a computer.

11. How much do you like using, or the idea of using computers ?

12. How much do you think that the user is in control of the computer ?

13. How scared are you of using a computer ?

14. How much are you in favour of the introduction of computers into your work ?

15. How much do you think that we are in danger of letting computers take over ?
Please could you read each of the following statements. Where there is a blank ____, decide from those given below what your normal or usual attitude, feeling or behaviour would be:

1. Rarely
2. Occasionally
3. Sometimes
4. Frequently
5. Usually

Less than 10% of the time
About 30% of the time
About half the time
About 70% of the time
More than 90% of the time

Of course, there are always unusual situations when this would not be the case, but think of what you would do or feel in most normal situations. Write the number that describes your usual attitude or behaviour in the blank in each statement.

16. When faced with a problem I _____ try to forget it.
17. I _____ need frequent encouragement from others for me to keep working at a difficult task.
18. I _____ like jobs where I can make decisions and be responsible for my own work.
19. I _____ change my opinion when someone I admire disagrees with me.
20. If I want something I _____ work hard to get it.
21. I _____ prefer to learn the facts about something from someone else rather than have to dig them out for myself.
22. I will _____ accept jobs that require me to supervise others.
23. I _____ have a hard time saying "no" when someone tries to sell me something I don't want.
24. I _____ like to have a say in any decisions made by a group I'm in.
25. I _____ consider the different sides of an issue before making any decisions.
26. What other people think _____ has a great influence on my behaviour.
27. Whenever something good happens to me I _____ feel it is because I have earned it.
28. I _____ enjoy being in a position of leadership.
29. I _____ need someone else to praise my work before I am satisfied with what I have done.

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30. I am _____ sure enough of my opinions to try and influence others.

31. When something is going to affect me I _____ learn as much about it as I can.

32. I _____ decide to do things on the spur of the moment.

33. For me, knowing I've done something well is _____ more important than being praised by someone else.

34. I _____ let other people's demands keep me from doing things I want to do.

35. I _____ stick to my opinions when someone disagrees with me.

36. I _____ do what I feel like doing not what other people think I ought to do.

37. I _____ get discouraged when doing something that takes a long time to achieve results.

38. When part of a group I _____ prefer to let other people make all the decisions.

39. When I have a problem I _____ follow the advice of friends or relatives.

40. I _____ enjoy trying to do difficult tasks more than I enjoy trying to do easy tasks.

41. I _____ prefer situations where I can depend on someone else's ability rather than just my own.

42. Having someone important tell me I did a good job is _____ more important to me than feeling I've done a good job.

43. When I'm involved in something I _____ try to find out all I can about what is going on even when someone else is in charge.

Could you please indicate how much you agree or disagree with the following statements by ticking the appropriate number on the scale below.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>Agree</td>
<td>Disagree</td>
<td>Strongly disagree</td>
</tr>
</tbody>
</table>

44. I feel that I'm a person of worth, at least _____ on an equal plane with others.

45. All in all, I am inclined to feel that I am a failure. 1 2 3 4
Please indicate how much you disagree or agree with the following statements using the scale of 1 to 7 below. If you haven't got experience in using a computer for the activity mentioned in the question please put down what you think would be the case for those who have.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>Agree</td>
<td>Disagree</td>
<td>Strongly disagree</td>
</tr>
</tbody>
</table>

46. I feel that I have a number of good qualities. 1 2 3 4
47. I am able to do things as well as most other people. 1 2 3 4
48. I feel I do not have much to be proud of. 1 2 3 4
49. I take a positive attitude towards myself. 1 2 3 4
50. On the whole, I am satisfied with myself. 1 2 3 4
51. I wish I could have more respect for myself. 1 2 3 4
52. I certainly feel useless at times. 1 2 3 4
53. At times I think I am no good at all. 1 2 3 4

1. Getting points for doing well is most of the enjoyment in playing arcade games. 1 2 3 4 5 6 7
2. Writing is more enjoyable with word processor because it makes doing corrections much quicker and easier. 1 2 3 4 5 6 7
3. Producing a well set out document with a word processor is a challenge. 1 2 3 4 5 6 7
4. Educational programs are good because the questions get more difficult if the user gets the answers right. 1 2 3 4 5 6 7
5. Being able to write and debug more and more complex programs is the interesting part of computer programming. 1 2 3 4 5 6 7
6. Knowing the solution to an adventure game is fun because others are friendly in the hope of finding it out. 1 2 3 4 5 6 7
7. Writing computer programs is enjoyable because the programmer can make the computer do what he or she wants it to. 1 2 3 4 5 6 7
1. definitely don't agree --> neither agree --> very much agree
nor disagree

8. Word processing is good because it is easy
for the user to reorganise what they are
writing at any point.

9. Adventure games are fun because of the
challenge in completing the adventure.

10. Using financial or data analysis software
to show their results to their best advantage
is a challenge.

11. Using financial or data analysis software is
fun because the user sets up what needs to be
done and then the computer does all the calculations.

12. Educational programs are good because they
tell the user immediately when they are right.

13. Seeing the program work is the best part about
writing computer programs.

14. Financial and data analysis software is
useful because it makes the user's work easier.

15. People play arcade games on computers because
all their friends do.

16. Adventure games are interesting because the
user can decide how to explore the game
environment.

17. Educational programs are good because their
users will improve their end of term marks.

18. Financial and data analysis software is good
because the user can do increasingly complex
analyses.

19. Educational programs are fun because the user
can choose how difficult to make the questions.

20. Seeing the results is the best part of using
financial or data analysis software.

21. Educational programs are enjoyable because
of the challenge in trying to get all the
answers right.

22. Adventure games are good because they
improve the user's problem solving ability.
14 definitely don't agree --> neither agree --> very much agree
nor disagree

23. Writing computer programs is fun because the programmer might get money for them.
   1 2 3 4 5 6 7

24. Word processors are useful because they make the user's writing look more professional.
   1 2 3 4 5 6 7

25. Getting a print out of what has been written is the good part about word processing.
   1 2 3 4 5 6 7

26. Finding the treasures is the enjoyable part of playing adventure games.
   1 2 3 4 5 6 7

27. Writing programs is fun because of the challenge in trying to make them run.
   1 2 3 4 5 6 7

28. Arcade games are good because they improve the player's reactions.
   1 2 3 4 5 6 7

29. Writing computer programs is good because it helps with a career.
   1 2 3 4 5 6 7

30. People play arcade games because they want to beat the high score.
   1 2 3 4 5 6 7

31. Being in control of the man, or spaceship and making it do what you want is the fun part of playing arcade games.
   1 2 3 4 5 6 7

32. Word processing is good because writers can do more and more complicated things with their text.
   1 2 3 4 5 6 7

33. Adventure games are fun because as the user explores further the problems get more complicated.
   1 2 3 4 5 6 7

34. Financial or data analysis software is useful because it enhances the user's business or research abilities.
   1 2 3 4 5 6 7

35. Playing arcade games is fun because of the graphic effects that speed up as you get better at playing them.
   1 2 3 4 5 6 7

36. People use educational programs because it pleases the teacher.
   1 2 3 4 5 6 7

Thank you for completing the questionnaire.
Appendix 9.1. Table of correlations between attitudes towards and experience of computers from results of the pilot questionnaire.

<table>
<thead>
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<th>Interest in</th>
<th>Want to know how to use</th>
<th>Like using</th>
<th>User in control</th>
<th>Scared of intro.</th>
<th>In favour of intro.</th>
<th>In danger of being taken over</th>
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<td>.25</td>
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<td>.7*</td>
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* p < .05
Appendix 9.2. Table of correlations between attitudes towards and experience of computers from combined results of first and second pilot studies using original and revised questionnaires.

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* p < .05