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# A Personal Construct Theory Based Method for Questionnaire Development: A Field Test with Teacher Attitudes Towards Educational Computing

Laura Ruth Winer

A Thesis

in

The Department

of

Education

Presented in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy at Concordia University
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## ABSTRACT

A Personal Construct Theory Based Method
for Questionnaire Development:
A Field Test with Teacher Attitudes
Towards Educational Computing

Laura Ruth Winer, Ph.D.
Concordia University, 1986

This research examined the effects of learning different programming languages, specifically BASIC and Logo, on teacher attitudes towards the uses of computers in education. These two languages are the most common within education and are purported to differ significantly on both technical and philosophical grounds. Attitudes toward innovations are important in their success or failure. Given that the "language" experience in teacher-training courses can be expected to influence teacher attitudes towards computers, the choice of programming language should be examined. Useful standardized attitude assessment instruments did not exist, and established development procedures for such instruments are prone to experimenter bias and subjectivity. A unique method based on Personal Construct Theory for producing a contextually-relevant and meaningful questionnaire was developed. This method allows a researcher to develop a questionnaire for mass data collection which has as its base constructs derived from a sample of

the target population. A field test on teacher attitudes towards fifteen different uses of computers was conducted in which ratings were collected from 122 teachers at the beginning of a course in one of the two languages, and 119 at the end. No differential effects of programming language on attitude were found, although there were some differences between the two language groups, and over time. Recommendations regarding teaching programming within teacher-training programs are given. The use of Personal Construct Theory for questionnaire development is described in detail, and guidelines for the method's use in situations other than the one described here are given.

## SOMMAIRE

Une méthode d'élaboration de questionnaires basée sur la théorie des construits personnels de Kelly: Une application à la mesure de l'attitude des enseignants face aux utilisations pédagogiques de l'ordinateur

Le but de cette recherche est d'étudier les effets de l'apprentissage de différents langages de programmation, notamment BASIC et Logo, sur l'attitude des enseignants face aux applications pédagogiques des ordinateurs. Les langages BASIC et Logo sont les plus populaires dans le monde de l'éducation, et on croit généralement qu'ils ont des fondements philosophiques et techniques bien différents. On sait que le succès ou l'échec d'une innovation dépend en grande partie de l'attitude des gens envers cette innovation. Comme l'expérience d'un enseignant avec un langage pendant sa formation peut influencer son attitude vis-à-vis l'ordinateur, le choix d'un langage de programmation doit être fait avec soin. Non seulement il n'existe pas d'instrument de mesure valable des attitudes, mais encore, les procédures établies de développement de tels instruments sont elles-mêmes sujettes au biais et à la subjectivité de l'expérimentateur. Dans cette recherche on a cherché à développer une méthode originale, basée sur la théorie des construits personnels de Kelly, pour produire un questionnaire significatif et adapté au contexte. Cette

méthode permet au chercheur de développer un instrument de recueil de données, qui est basé sur des construits élaborés par un échantillon de la population-cible. Une étude sur le terrain, portant sur les attitudes des enseignants vis-à-vis de quinze utilisations différentes de l'ordinateur, a été conduite auprès de 122 enseignants au début d'un cours sur un des deux langages, et 119 après huit semaines. Les résultats n'ont montré aucune différence significative attribuable à l'apprentissage de l'un ou l'autre des deux langages choisis, bien qu'il y ait eu des différences entre les deux groupes au départ. Des différences entre le test administré au début des cours, et celui administré après, sont également apparues dans l'ensemble des deux groupes. Le chercheur tire de l'étude des recommendations sur la formation à l'apprentissage d'un langage par les enseignants. Il décrit en détail l'utilisation de la théorie des construits personnels de Kelly pour le développement d'un questionnaire, ainsi que des lignes directrices pour l'application dans des situations différentes de celle de son application ici.

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LRW

To the memory of my mother,

Harriet Herzog Winer.

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# CHAPTER 1

## INTRODUCTION

This dissertation began with what seemed at the time to be a very straightforward question, "Does the programming language learnt by teachers following courses in educational computing affect their attitudes towards uses of the computer in education?" Curriculum decisions have been and are being made without an answer to this question; it therefore seemed to be one worth the trouble of answering. From that point on, however, very few things were straightforward.

Within computer science in general, not just educational computing, programming languages inspire factional allegiances to rival any partisan activity. It seemed to this researcher that there was a serious danger of responding to the emotional arguments, or taking rational arguments out of context. Particular concerns of education had to be assessed, and emotion tempered with reason.

Attitude was a logical place to start, given the acknowledged importance of attitude in any process of innovation or change (Havelock, 1973). After identifying teacher attitudes towards different uses of microcomputers in education as the index of determining the influence of programming, the choice of an evaluation technique had to be made. The debate over qualitative vs. quantitative approaches is not new and will no doubt long continue; they are not, however, necessarily mutually exclusive. Numbers are useful as they are relatively easy to manipulate in a variety of ways. Numbers however, should be kept in context, and the approach taken by this researcher is that "Numbers are not the name of this game but rather representational structures that permit functional reasoning, however qualitative it may be." (Simon, 1981, p.169)

Having decided that any approach used would have to maintain meaning while permitting quantitative evaluation, the problem of instrument selection was faced. A search for previously developed instruments revealed that none would be sensitive to the complexities of microcomputers in education. Microcomputers are multi-purpose tools, and as such they may be applied in a variety of ways. It was important, therefore, to avoid falling into one of two traps: the first would be to focus on programming, overlooking the other uses of computers; the second would be not to be precise enough, and ask about "educational computing" in general, without allowing for the differences among the range of activities possible to be considered. When one adds to these problems the desire to be sensitive to any particular concerns that teachers in the province of Quebec might have, the lack of success in finding an off-the-shelf instrument is not surprising. It became obvious that a measurement instrument would have to be created before the question could be answered.

The creation of attitude questionnaires is an area that is particularly susceptible to personal bias. Researchers are subject to emotional and psychological limitations which constrain their role as neutral observers. Formal, objective guidelines, while part of any research process, seemed especially needed in this area. However, after consulting a variety of development guidelines, it seemed that none was able to satisfy the criteria imposed by the problem: how to maximize the sensitivity to an area such as educational computing (inherently prone to cultural idiosyncrasies) while minimizing the possibility of experimenter bias.

One area did promise both a theory and a technique which would aid in the realization of the goal--Personal Construct Theory with its accompanying Repertory Grid Technique. The operationalization of the promise became the focus of attention at this point. The emphasis of the research project shifted therefore from a simple analysis of programming influence to the larger methodological issue of how one effectively measures such attitude changes. However, adapting an existing technique to a new application is an activity best contemplated in hindsight--it's only perfectly clear, if ever, after the fact.

The methodological component of the study yielded some surprising technical problems--it is quite startling to realize how easy it is to generate complexity which large mainframe computers cannot handle. Conceptual problems were less surprising, although more difficult to solve. Problem solving has been defined as "representing [the problem] so as to make the solution transparent" (Simon, 1981, p.153). In this case, however, the goal was more ambitious, namely to offer a representation which was not only transparent, but generalizable. A major portion of this dissertation, therefore, documents the circumstances and procedures by which similar applications might be guided.

The question to be answered here was a real one, and as with any problem of the real world, unprotected by laboratory walls, the complexity of the "system" must be considered. That is why the discussion following also touches on political history as well as psychological theories, on considerations of computer science as well as pedagogy, and on processes of change as well as concept formation. The process described is one of shipbuilding while rowing, and therefore subject to some pragmatic responses where the theory might suggest other actions. The solutions offered are not presented as final products which require no further development; additional research is needed to refine the technique and smooth out the rough edges, as well as explore new avenues opened up by the work described. However, in the words of Warren McCulloch, "don't bite my finger--look where it's pointing" (cited in Beer, 1978, p. ii).

# CHAPTER 2

## RATIONALE AND LITERATURE REVIEW

The fact of computers in education is now commonplace, and one no longer needs to be a prophet to predict that computers in schools are here to stay. Computers has been a buzzword for well over a decade. Under the title "Will the computer kill education?", Hicks (1973) commented, "The computer has become, after sex, the most overworked symbol in North America." (p. 886) As long ago as 1975, in pre-micro days, the Director of the National Development Programme in Computer Assisted Learning confidently asserted that "Computers in education are here to stay." (Hooper, 1975, p.79) That computers will be an <u>important</u> newcomer is reflected in a 1983 talk by Herbert Simon, given at a conference entitled "Computers in Education: Realizing the Potential".

> Nobody really needs convincing these days that the computer is an innovation of more than ordinary magnitude, a one-in-several-centuries innovation and not a one-in-a-century innovation or a one-in-ten-years innovation or one of those instant revolutions that are announced every day in the papers or on television. It is an event of major magnitude. (Simon, 1983, p.37)

The specific changes that computers will effect within education, however, are not so clearcut. In education, among other sectors, we are still in the "horseless carriage" stage where computers are being used by and large to do things that we have always done, such as drill and practice, only better or faster or cheaper (Simon, 1983).

This "horseless carriage" has been embraced by many with the hope that it will help in some way to solve the various political, financial, and economic woes that have been plaguing society in general and schools in particular. In the United States, the 1983 report of the National Commission on Excellence in Education, A Nation at Risk, made headlines with its claim that the American educational system might have been viewed as an act of war if it had been imposed upon the United States by an unfriendly foreign power. One of the recommendations of this commission was that computer science should be added as a "fourth R" to reading, 'riting, and 'rithmetic.

The government of Quebec, faced with the challenge of the new technologies, has similarly declared that it was the role of the educational system to lead the way by incorporating microcomputers into the schools (Ministère de l'Education du Québec, 1983).

Editorials in popular magazines have heralded personal computing as causing changes "more profound than those brought about by spacecraft, airplanes, or automobiles. While the latter amplify the potential of the [human] body, personal computing amplifies the potential, and thus the power, of the mind" (Lyndon, 1982, p.5). Berg and Bramble (1983) claim that microcomputers will play a major role in the "transformation" of public education.

At the same time, however, others were admitting that "although in education we are beginning to appreciate the variety of uses for microcomputers,... we are a long way from discovering what they do best" (Phillips, 1982, p.45). In a paper presented at the British Computer Assisted Learning 83 conference, Alfred Bork, while acknowledging that computers would be widely used in education, openly questioned the assumption that this use would <u>necessarily</u> lead to a better educational system (Bork, 1984).

That computers will have an impact on education is certainly clear. However, it is also clear that neither the direction nor the intensity of the impact is known, and the formulation of precise responses is therefore difficult.

<u>Implementation Strategies</u>

Different governments around the world have responded to the fact of microcomputers in different ways, as could be expected. As Dubreuil (1982) points out, "chaque pays a ses traditions scolaires et sa culture propre. Il serait dangereux de transposer sans modification, les politiques adoptées par [France and the United Kingdom]." (p.4) Rushby, James and Anderson (1981) identify three kinds of pressure which influence the development of computer-based learning: political, technological, and educational. As they explain:

> The pressures vary from country to country. Different national educational systems present different educational needs, and different national perceptions of the roles and importance of education and computers have influenced the level, and the means, of funding computer-based learning. Perhaps the most internationally uniform pressures are the consequences of technological development, but even here historical differences in the evolution of computer science have left their mark. (p. 72).

According to their analysis of the development of computer-based learning in continental Europe, the educational issues involved in this process are those which to date have had the least impact on practice. Decisions tend to be taken for "hard political and financial reasons" (p.78).

What are the implications of this? Simply that we must expect government policies to have as priorities goals other than "merely" improving the quality of education. Strategies for at least coping, or at best satisficing (Simon, 1981), are being developed by many governments in response to local pressures. The fact that the pressures will vary from place to place does not mean that we may not learn from the mistakes and successes of others, but only that strategies must be developed "locally" (with the definition of local shrinking and expanding depending on power structures).

The United Kingdom. The example of the United Kingdom shows clearly the political nature of the "microcomputerizing" of education. The first major effort at "computerizing" education, the National Development Programme in Computer Assisted Learning, ran in the pre-micro era from 1973 to 1977 with the twin goal of promoting the institutionalization and transferability of Computer Assisted Learning and Computer Managed Learning in education in Britain (Hooper, 1977). The roots of the program can be traced to 1967, when the National Council for Educational Technology set up a Working Party whose mandate was as follows.

> 1) to investigate the potential role of the computer as a component of educational and training systems in the United Kingdom, taking into account as necessary experience and trends in other countries.
>
> 2) to outline a systematic programme of applied research and development which it would be desirable to encourage in this country, aimed at exploiting the computer to the best advantage in education and training. (NCET, 1969, p.2)

These aims sound relatively modest, simply concerned with seeing if computers could help somehow in improving education and training. Compare these with the Microelectronics Education Programme, which began in 1981 with a five-year mandate.

> The aim of the Programme is to help schools to prepare children for life in a society in which devices and systems based on microelectronics are commonplace and pervasive. These technologies are likely to alter the relationships between one individual and another and between individuals and their work; and people will need to be aware that the speed of change is accelerating and that their future careers may well include many retraining stages as they adjust to new technological development. (DES, 1981, p.1)

The quality of education <u>per se</u> had certainly taken a back seat to more far-reaching concerns. The roots of MEP, rather than stemming from the educational community, sprouted from the political brouhaha created by the March 1978 screening of a BBC documentary "Now the Chips are Down" (Goldwyn, 1981).

<u>Quebec</u>. The government of Quebec responded similarly to the new technology with its embracing of "le virage technologique", translated roughly as "the technology conversion" (Ministère de Communication du Québec, 1982). What was being converted under this vision was not the technology, but rather the whole of Quebec society.

> L'évolution de la technologie dans le domaine de

> l'informatique, particulièrement depuis l'essor de la micro-informatique, place notre société en situation de mutation profonde. Nous pressentons, avec bien d'autres, que ces nouvelles technolgies auront des répercussions culturelles, sociales et économiques très importantes....Ces transformations, dont les effets se font déjà sentir dans beaucoup de secteurs d'activité, forcent toute société à refaire ses choix et à réviser ses priorités. C'est pourquoi le gouvernement du Québec a décidé de prendre résolument le "virage technologique" et, à cette fin, a convenu de réorienter certaines de ses politiques et de mettre en oeuvre des actions appropriées. (Ministère de l'Education du Québec, 1983, p.1)

The Proposition de développement, released by the Ministry of Education in 1983, had a similar goal to that of the MEP in Britain, namely training and educating (the meaning of the French verb former encompasses the two English words) students to function in a computerized society. The initial plan was presented more as a working paper than a finished document, with feedback being actively solicited by the Ministry with a view to releasing a revised version in December 1984. This period of consultation did not mean that nothing was going to be happening in the meantime, however.

Time was seen to be of the essence, and immediate action was required if Quebec was not going to fall seriously behind.

> Même si ces contraintes ne nous rendent pas la tâche facile, il faut nous rendre à l'évidence: nous n'avons guère le choix. Nous devons agir, dans ce dossier, dès cette année, sous peine d'un retard sérieux. Certains, plus alarmistes, nous en font même déjà le reproche. (Ministère de l'Education du Québec, 1983, p.3)

It is not clear of whom we were in danger of falling behind, but the threat was enough to loosen pursestrings. With this proposal came money--three million dollars were allocated for the 1983-84 year and $22.2 million for 1984-85 (Ministère de l'Education du Québec, 1985). This money was intended for hardware purchases, software production, curriculum development, and teacher training.

The scenario of computers in education is being played out in many venues, with many variations on the scripts. It is clear that there are many players in this game, and that the game changes depending on the location. Despite the fact that there are certainly underlying commonalities between different implementation strategies and contexts, our specific concerns must be with one set of players and one specific game so that we may gain insights into a process of change, insights which will allow us to make useful and relevant recommendations for action.

The Process of Change

The object of study. With any process of change, it is important to identify the actors in the affected system (Havelock, 1973). In light of our discussion above, the affected system of specific interest is limited to the publicly-funded compulsory education system in Quebec, particularly the English sector. This is comprised of government ministries, funding agencies, school boards, parent groups, students, and teachers.

Any one of these groups could be the object of study, as each is an integral part of the "system". Why then choose teachers? Teachers are key components of any governmentally-initiated change process as they are in a position of being able to support or sabotage change. Teachers are the ones faced with the machines in their classes and schools, and they constitute the front-line in the integration of computers into the curriculum. Teachers represent a relatively homogeneous group in terms of education and social class, factors which may be expected to influence reactions to changes of the kind under study (Rogers,1983). Also, teachers may be influenced through both pre-service and in-service training programs. This means that there is a mechanism which may facilitate the incorporation of research results into the system. For these reasons, the focus of this research involved putting teachers under the spotlight.

Computers in education: innovation or change. Although the terms change and innovation are often used interchangeably, there is an important distinction to be made. Change is any alteration of the status quo whereas innovation is a planned alteration. Changes can be positive or negative, whereas innovations are assumed implicitly to be positive, at least to those who propose or implement them (Bennis, Benne, Chin & Corey, 1976; Havelock, 1973). It is important to realize that what is new is what is perceived to be new, rather than what is objectively new. In summary, "an innovation is an idea, object, or practice perceived as new by an individual or individuals, which is intended to bring about improvement in relation to desired objectives, which is fundamental in nature and which is planned and deliberate." (Rogers & Shoemaker, 1971, p.4)

The haphazard nature of the usually grass-roots introduction of computers into education precludes their classification as solely planned intervention. Although coordinated planning of the kind implied by the term innovation is now underway, in most cases, governments have come in somewhat after the fact, with Quebec being no exception.

> La proposition de développement de la micro-informatique n'est pas présentée aux réseaux d'enseignement du Québec au moment zéro de leur appropriation de l'ordinateur. Au contraire, de nombreuses actions entreprises dans les institu-

> tions depuis une dizaine d'années ont permis d'appuyer la proposition sur des résultats déjà acquis. (Dubuc, 1983, p.456)

Another difficulty in classifying computers in education as an innovation in the strict sense of the word is the definition of the educational system. Even though one commonly talks of the "educational system", the fuzziness of the boundaries and lack of system integrity belies any attempt to approach major changes throughout the "educational system" with the same ideas of control as are assumed by the innovation literature, which refers to innovations as being planned and controlled in relatively well-defined organizational systems.

As Emmanuel Mesthane summarizes in his introduction to Run, Computer, Run, an early attempt to analyze and predict the impact of computers in education:

> Cannot systems analysis contribute at least as much to educational policy as it has to our [U.S.] national security policy? Perhaps, but consider the staggeringly greater complexity of the educational "system." It comprehends the pupils, the teacher, the principal, the parents, the school board, city hall, the taxpayer, the foundations, and the federal government, all of whom have different ideas about the proper ends of education. This is not to mention the neighborhood bookie, television,

comic books, the local drug trafficker, Selective Service, the professions and disciplines, the hit parade, the nation's foreign policy, the Urban League, and the John Birch Society, which must also be taken into account at some point. It is an extraordinarily complex system, and the techniques have yet to be developed that can subject it to a genuinely exhaustive systems analysis. (Mesthane in Oettinger, 1969, pp. viii-ix)

Factors pro and con. Factors influencing the success or failure of computers in education are numerous. Except for modern-day Luddites, a place for computers in society has been accepted, although the extent and form of that role is still evolving. The concept of computer literacy is large, and has been linked to the problem of quantitative literacy (Simon, 1983). While computer literacy may be subsumed under quantitative literacy, computers may also provide part of the solution to a problem that they did not create, only exacerbated. "The computer may give us a means for opening the world of technology to large numbers of people who, for good reasons or bad, would not have it opened to them by the calculus or by other classical mathematics." (Simon, 1983, p.46.)

These factors and many more are operating in the complex process of integrating microcomputers in schools. This is not an example of a controllable innovation, but neither is it a runaway train. One fact which distinguishes the fact of computers in education from previous "innovations" is the societal nature of the driving force behind their introduction into the schools. One could even argue that most of the pressure for their introduction has come from outside education, namely from the computer manufacturers. This is clearly, therefore, not an innovation in the strict sense of the word, but rather a change. In this process of change, individual teachers, administrators, and government agents may perceive their actions as controlling the introduction of computers into education. Given the acknowledged importance of participants' perceptions in the process of change, the perceptions of different groups of actors is important to assess and evaluate. What and how teachers think about different ways of using computers will influence, to some extent, how computers are used. Therefore, even though at times the challenge of researching the introduction of computers in education seems overwhelming, we should not throw up our hands in dismay, but we must carefully identify one aspect of the problem and focus on that if useful insights are to result.

Why Choose Attitude?

The aspect chosen for the present research was teacher attitudes towards the use of computers in education. This encompasses more than programming *per se*; as will be discussed in the Method section, a total of 15 different important uses of computers in education were identified for study. Why attitude? The attitude of participants to an innovation is a critical component in the success or failure of the specific innovation (Havelock, 1973). As Shaw and Wright (1967) point out, attitudes "significantly influence man's responses to cultural products, to other persons, and to groups of persons" (p.1). And as Rogers and Shoemaker (1971) phrase it, "Like beauty, innovations [in the strict sense of the term as inherently positive] exist only in the eye of the beholder. And it is the beholder's perceptions which influence the beholder's behavior." (p.138) With education, the role of the teacher is central. As Entwistle and Nisbet (1972) state: "Only if the teachers believe in the change is it likely to have any real effect." (p.328) And Stevens (1980) concurs: "computers will not be used productively in education unless teachers have positive attitudes toward them and believe computers to be viable instructional tools" (p.230).

Attitude definition. The classic definition of attitude (Allport, 1935 as cited in McGuire, 1971) is that it is a mental and neural state of readiness to respond, organized through experience, exerting a directive and/or dynamic influence on behavior. Smith, Bruner, and White (1956) consider "an attitude to be a predisposition to experience, to be motivated with respect to and to respond to a class of objects in a certain way" (p.7). This supports the definition by Cardno (1955, cited in Shaw & Wright, 1967, p.2) that "attitude entails an existing predisposition to respond to social objects which, in interaction with situational and other dispositional variables, guides and directs the overt behavior of the individual". Osgood, Suci and Tannenbaum (1970) summarize the major properties of attitude on which there are general consensus. Firstly, attitudes are learned and implicit. Secondly, they are predispositions to evaluative responses. Thirdly, attitudes have both direction and intensity. Rogers (1983), among others, includes the concept of stability; i.e. "a relatively enduring organization of an individual's beliefs about an object that predisposes his or her actions" (p.169) The word predisposition is one that recurs in all discussions of attitudes; no-one claims that attitude <u>causes</u> action, but that the two tend to vary together.

As with any intangible intervening variable, an operational definition of attitude is a person's response on a given measurement instrument. This is why the nature of the development of the instrument is of such importance.

<u>The introduction of change</u>. Bennis, Benne and Chin (1969) offer three models for introducing change into organizations: 1) power-coercive; 2) empirical-rational; and 3) normative-re-educative. The first implies the application of some form of power, usually political or economic, by those with greater power on those with lesser. Those

with lesser power must then comply with the wishes of those exercising the power or face some form of sanction or penalty. The second, empirical-rational, has as its underlying assumption that humans are rational and moved by self-interest. Therefore, once the advantages of a given innovation are explained and/or demonstrated, change will automatically follow. The third model, normative-re-educative adds another assumption to that of the empirical-rational, namely that "patterns of actions and practice are supported by sociocultural norms and by commitments on the part of individuals to these norms. Sociocultural norms are supported by the attitude and value systems of individuals--normative outlooks which undergird their commitments." (Chin & Benne, 1976, p.23) The empirical-rational model is associated with the views of classical liberalism and the Enlightenment, and relies on the dissemination of knowledge as its main tool. Power-coercive models of change "seek to mass political and economic power behind the change goals which the strategists of change have decided are desirable" (Chin & Benne, 1976, p.40). Both of these approaches have been invoked in the introduction of microcomputers in Quebec schools with the government's <u>Proposition de dèveloppement</u> putting its weight behind the process with money for equipment, curriculum changes, and teacher training. However, in education, given the importance of individual teachers, coercion alone is not effective and the empirical-rational model works slowly

(Chin & Benne, 1976). What must be recognized is the importance of noncognitive determinants of behaviour. For the individual, these noncognitive components are important influences on behavioural changes, albeit not the sole determinants.

Rogers (1983) outlines a five-stage innovation-decision process: knowledge, persuasion, decision, implementation, and confirmation. The knowledge stage begins when the individual is exposed to an innovation and gains a limited understanding of it. The formation of a favourable or unfavourable attitude towards the innovation occurs in the persuasion stage. Whether to adopt or reject the innovation is decided at the decision stage, and at the point when the innovation is actually put to use, one is in the implementation stage. Contrary to what one might think, though, the implementation stage is not the endpoint in the process; the individual continues to seek knowledge to reconfirm her or his actions, and may, in some cases, reverse an earlier decision in the fifth stage, confirmation.

For both Bennis and Chin, and Rogers, then, attitudes are an important factor to be considered in the process of change. According to Rogers (1983), "Attitudes toward an innovation, therefore, frequently intervene between the knowledge and decision functions. In other words, the individual's attitudes or beliefs about the innovation have much to say about his passage through the innovation decision process." (p.169) Even after having passed through the decision phase, though, attitudes continue to play an important role. The confirmation stage is another key attitudinal juncture. In other words, even though people may have adopted an initial positive stance, subsequent experiences may affect their final decision.

Implications for educational technologists. What are the implications of these models for educational technologists? Given the complexity of the process, we cannot ignore the problem of teachers adapting to change. What we must do is identify where in this process we may have an impact, and focus our attention there. In that teachers are flocking to courses in educational computing, it behooves us as educational technologists to consider the appropriateness and effectiveness of the various teacher training curricula they are being offered.

The experience that teachers have in their early computer courses will be instrumental in shaping attitudes and aiding a successful integration of computers into education. As Shaw and Wright (1967) report, "attitudes are learned, rather than being innate or a result of constitutional development and maturation" (p.8). If attitudes are learned, the knowledge that an individual received could be expected to influence the attitude formed. Where an individual seeks information, what messages are received, and how those messages are interpreted will influence attitude

(Rogers, 1983). It seems, then, that we are in the unusual position of being able to do something practical and useful within the context of teacher education. There are real questions to be asked, and researched answers can provide concrete recommendations to those involved in designing programs for those requesting them. As Evans (1979) predicted, "the first manifestation of [the growing social awareness] will be a rush of interest in learning about computers. People will feel the need to be informed and they will go wherever they can to get this information." (p.104) Currently, all Quebec universities but one are offering courses and/or programs at both the undergraduate and graduate levels on various aspects of educational computing. But what are we teaching, and more importantly, why?

Teacher Training Curricula

Suggested curricula for teacher training in educational computing abound (e.g., Bitter & Wells, 1982; Brebner, 1983; Dennis, 1979; Poirot, Taylor & Powell, 1981; Rawitsch, 1981; and Rushby, 1981), but little empirical evidence exists as to the effects of various curriculum decisions. For example, most suggested curricula include a programming element, even though there is a range of expertise deemed necessary. Recommendations for the programming language either specify "a high-level language", or recommend BASIC solely on the grounds that that is what most educational software is written in, or Logo because it's the "obvious" language for education. However, there have been no researched assessments of the effects of different language choices on teacher attitudes. This gap would not be so important if there were general satisfaction with the level of teacher training. However, this is clearly not the case as many authors bemoan the paucity of good teacher education programs (CEQ, 1985; Dennis, 1978, 1979; Dickerson & Pritchard, 1981; IFIP, 1972; Milner, 1975, 1979; Molnar, 1980; and Poirot et al., 1981).

Clearly, it would be helpful to research various effects of different curriculum decisions. As Cohen and Manion (1980) point out, most educational research methods are descriptive; they do not manipulate events, rather they describe and interpret what is. Descriptive or developmental studies are necessary in that they are the only way to identify components of situations where "traditional" experimental requirements for control are inappropriate or impossible. For educational technology research, the problems of experimental research are compounded by the fact that the target population is usually in the real-world, unlike traditional educational, psychological, or educational psychology studies. Our laboratory is usually the natural environment, and manipulations which remove the possibility of assessing actual change and learning are undesirable. As such, we must try as often as possible to conduct our research in the natural environment. "Et si possible, il faut éviter les situations de laboratoire. Il faut leur préférer le cadre naturel." (Bordeleau, 1983, p.277)

Soft systems. As we are dealing with so-called "soft systems", research methods which recognize the important distinctions between natural, designed physical, and designed abstract systems on the one hand and human activity systems on the other must be used (Checkland, 1981). A human activity system is defined as "a notional purposive system which expresses some purposeful human activity, activity which could in principle be found in the real world" (Checkland, 1981, p.314). The concept of human activity system as defined by Checkland is useful, though complex.

> The concept human activity system is crucially different from the concepts of natural and designed systems. These latter, once they are manifest, 'could not be other than they are', but human activity systems can be manifest only as perceptions by human actors who are free to attribute meaning to what they perceive. There will thus never be a single (testable) account of a human activity system, only a set of possible accounts all valid according to particular Weltanschauungen. (Checkland, 1981, p.14)

Given this possibility to be other than what they are, we may "aspire to design, modify, affect or improve (i.e. 'engineer') what we perceive as human activity systems, i.e. sets of purposeful human activities" (Checkland, 1981, p.14). In order that any attempts to "engineer" the system under consideration be based on more than gut feeling, intuition, or the sales pitch of a local representative, it is crucial that we first know where we are. The first step in the area of teacher attitudes must be to describe the situation, and explore possible relationships between variables identified as of interest (for reasons both theoretical and pragmatic, we can change what programming language we teach teachers, while it's harder to change other variables such as years of teaching experience or subject specialty). If as a result of exploratory research, differences are identified, it may then prove useful to examine these further under the strictures of an experimental design. However, given the necessity of knowing what people are thinking and feeling before one can determine why, the present study is exploratory in nature. An accurate portrait of the situation and the identification of promising areas for further exploration are the goals of this research.

The Research Question

It is clear from the discussion above that teachers are principal players in the technological revolution taking place within the schools. Whether they will embrace the technology, sabotage it, or ignore it into dusty cupboards remains to be seen. Educational technology is being provided with a sterling opportunity to assist curriculum planners within teacher education in making a sound, research-based decision which will undoubtedly have significant long-term effects. As a first step in accomplishing this goal, this study will examine one aspect of teachers' attitude development--programming language studied. By far, the two most common languages within education are BASIC and Logo, and these will be the object of investigation. The question is one of relative development--do BASIC and Logo result in qualitatively different attitudes towards the different uses of computers in education? There is no objective criterion for these attitudes to be measured against. By determining whether there is a differential effect with respect to programming language studied on attitude toward the uses of computers in education, a recommendation regarding instruction for teacher education programs can be made.

<u>Computer languages</u>. With natural languages, it has been claimed that the language used influences the perception of the environment (Whorf, 1956). The classic example is that of the Inuit language which contains 17 different words for snow; in English we cannot easily see that many types because our language does not allow

us to. There is no reason to assume that computer languages do not operate in a similar way. For example, if there is no way of writing procedures which can then stand alone and be used independently as "black boxes", then it is unlikely that the concept of modularity would be developed. It would seem important, therefore, that the computer language used to introduce teachers to computers not be decided by default. The decision may well have effects on teachers' perceptions of and attitudes to computers and these should be explored.

Logo vs. BASIC. The two languages most commonly used in teacher training curricula are BASIC and Logo, BASIC largely because of environmental prevalence and Logo because of its unique philosophical approach as stated in Mindstorms by Seymour Papert (1980). Both of these languages were developed within educational settings: BASIC (Beginners All-purpose Symbolic Instruction Code) at Dartmouth College in the 1960's to provide undergraduate students with a simple, interactive programming language, and Logo by a team headed by Seymour Papert in the 1970's at the Massachusetts Institute of Technology to create a "computer world" for children (Papert, 1980).

Design comparison. Harvey (1982) analyzes the design advantages of Logo, in contrast specifically with BASIC. Logo, like many other high-level languages, is procedural as it requires the specification of a sequence of procedures. This means that problems are divided into small pieces, each of which is addressed by a separate and independent procedure. With Logo, procedures may have inputs, which eliminates the need for one part of the program to have to know about the inner workings of other parts. Secondly, Logo is interactive (i.e. interpreted), as is BASIC. Interactive languages generally permit faster program development, although completed programs will run faster in compiled languages. BASIC has the advantage of being available in both interpreted and compiled versions, although Harvey downplays the importance of this for education.

> For a student of programming, there often is no production phase--the program is of interest only as long as it doesn't work. When it does work, the student goes on to the next problem. In that sort of environment, the speed advantage of the compiler never materializes. (Harvey, 1982, p.166)

A third characteristic of programming languages is whether or not they are recursive. Briefly, "a language is recursive if a procedure can be a subprocedure of itself" (Harvey, 1982, p.166). The advantage of recursion lies in the fact that certain kinds of very large problems <u>may</u> be stated in a compact form. Logo is recursive; most BASICs are not. The advantages of recursion may be seen more on a conceptual level than on a practical one. The fact is that Logo not only allows recursion, it encourages it. This may promote a problem-solving strategy useful for solving other problems in which recursion is either highly desirable or necessary.

The list processing capabilities of Logo are another point which Harvey emphasizes. Although BASIC introduced string manipulation into micros, and most BASIC dialects allow for some string handling that could compare with list handling, the advantages of list processing over array processing are twofold. First, arrays have a fixed size, whereas lists can change in size as needed during the course of a run. Second, arrays must be of uniform type, either numeric or alphanumeric strings. This is linked with the next point of comparison, variable typing. This refers to whether one must declare, before the fact and permanently, whether a variable will be numeric or alphanumeric. Variable typing occurred originally because it is then easier to write compilers; it has later been justified as good discipline for the programmer. The Logo view is that variables should be local, in other words, attached to specific procedures rather than the entire program. Logo is also extensible, which means that user-created operations both "act like" and "look like" genuine primitive procedures. This allows the user to respond to particular demands once, and function afterwards as if these demands had always been satisfied by the language.

A cybernetic perspective. Logo and BASIC can also be distinguished from a cybernetic point of view in terms of Ashby's (1958) Law of Requisite Variety. BASIC has stricter limitations on what one can and cannot do, thus handling variety by denying it. Logo was designed to have a greater variety-handling capability, thereby increasing the variety matched between user and computer rather than denied. For example, in most versions of BASIC graphics can be directly created only by addressing the screen according to Cartesian coordinates; in Logo either absolute position (i.e. Cartesian coordinates) or relative position can be used.

The Logo philosophy. Papert's interest stemmed from his work in Piagetian developmental theory; he felt that the computer could "concretize the formal". Logo, however, is more than just a programming language. As the subtitle of Mindstorms, "Children, Computers, and Powerful Ideas", alerts one, there is an underlying philosophy which is presumed to be disseminated with the language. Papert is by no means alone in his belief in Logo. The following quotes merely scratch the surface of what has been written about Logo, but should serve to illustrate the flavour of those writings.

> Logo is a language for learning. That sentence, one of the slogans of the Logo movement, contains a

subtle pun. The obvious meaning is that Logo is a language for learning programming; it is designed to make computer programming as easy as possible to understand. But Logo is also a language for learning in general. To put it somewhat grandly, Logo is a language for learning how to think. (Harvey, 1982, p.163)

The excitement and accessibility of Logo virtually guarantee success with students and teachers alike. (Coburn, Kelman, Roberts, Snyder, Watt & Weiner, 1982, p.149).

<u>LOGO: The Friendly Language</u> LOGO is a friendly, simple language based on Piaget's research into how children learn to think. It allows for experimentation without the fear of being "wrong". Anything you do in LOGO is right, it may not suit your needs, but it is valid. (CECM, 1983, p.21)

A computer language can be both simple and powerful at the same time. In fact, these two aspects are complementary rather than conflicting because it is the very lack of expressive power in primitive languages such as BASIC that makes it difficult for beginners to write simple programs that do interesting things. More important, we've found that it is possible to give people control over powerful computational resources, which they can use as

> tools in learning, playing, and exploring. (Abelson, 1982, pp.88-89)

> It seems, then, that Logo is not just the best educational software on the market at the moment (not, in itself particularly high praise), but a new type of educational resource with enormous potential for developing the social, aesthetic, emotional, and intellectual abilities of learners. (Higginson, 1982, p.328)

The ideas behind the development of Logo have clearly struck a responsive chord among many in the educational community. However, there are some who have not responded with quite the same enthusiasm. Steffin (1982) casts Papert in the role of Pied Piper, "leading educators down a street of rosy dreams, promising to cure all the ills currently besetting the educational establishment" (p.34). Others have embraced Logo, but have taken very different positions on the appropriate use of Logo and the claims of Papert (cf. Howe, 1983 and Pea, 1983).)

<u>BASIC--pragmatism not philosophy</u>. There is no corresponding BASIC philosophy which includes such a broad vision of the total learner and learning environment. Although both BASIC and Logo are products of university environments, the problems addressed were fundamentally different. BASIC was created to meet a perceived need of undergraduate students; its designers were not looking

outside the realm of teaching programming per se. The main contribution of BASIC was its interactivity, a feature now commonplace with micros. BASIC created a place for itself in education by virtue of its widespread availability--it is available on virtually all micros (although often in very limited versions) and there are plenty of "teach yourself" books available for the enthusiast. Rockhart and Morton (1975) see the strength of BASIC in its ability to handle the manipulation of both textual material and numbers. In their words, "[BASIC] includes enough of the logical and conceptual aspects of all the major programming languages and yet requires a minimum amount of both attention to detail and effort to learn" (p.115).

Clearly, then, Logo and BASIC differ fundamentally from design, philosophical, psychological and cybernetic perspectives. However, as was discussed earlier, perceptions of an innovation or change are very important. This includes the concept of perceived relevance. Innovations are usually more successful when the perceived usefulness of the innovation is higher (Havelock, 1973). Perhaps the widespread use of BASIC in educational software is a sufficient motivator to overcome the perceived technical limitations mentioned above. BASIC is explicitly mentioned as being useful because it is common (e.g. Coburn et al., 1982) or chosen "just because" with no explanation (e.g. Brebner, 1983). What is important is that "gut feeling" or historical precedence are not adequate decision-makers. Given the differences between the languages discussed above, one cannot nor should not assume that studies within the cognitive domain, i.e. programming languages, will not influence the affective domain, i.e. attitudes. Research about what actually happens to teachers' attitudes when different programming languages are studied is needed.

Attitude Measurement

Unfortunately, exploratory research has a reputation for lacking even the rudiments necessary to identify quantifiable variables. Work by Guba and Lincoln (1981) and others attests to the falseness of this picture, but researchers must nevertheless take great care to ensure that exploratory studies are not random walks. The methodological liability this study carries goes even a step further. Attitude measurement has suffered from a history of carelessness, often assessed as an addendum to other data. Therefore, a principal component of this study was to create and utilize a new method of attitudinal inquiry within a largely unexplored area. To then do so in the "natural, uncontrolled" environment constituted the major challenge and originality of this research.

Existing scales. The possibility of using an existing measure was explored. However, as Sandeen (1983) points out "teacher attitudes toward computer-assisted instruction have not yet been studied very throughly or systematically" (p.45). This statement makes two points; one explicitly, that not a lot of thorough and systematic work has been done in the area. Implicit in this statement, however, is the recognition that the object of concern is generally computer-assisted instruction, a rather broad category to treat as one object to have an opinion about. As Boyd (1982), Coburn et al. (1982), and Rushby (1979) illustrate with their different typologies of educational computing, there are fundamental differences in the ways that computers are used in education; to group them all together may be akin to asking someone if she likes fruit and being told "It's OK" when the person loves apples but hates oranges. People can only answer the questions they are asked; the level of questionning must therefore be appropriate to the topic and concerns of the research. No "standardized" instrument existed which met the criteria; this meant that a custom-made one had to be developed.

<u>Methods of measurement</u>. Attitudes have been defined operationally in terms of observable and scorable responses. Kiesler, Collins and Miller (1971) defined five general categories of attitude measurement: 1) self-reports of beliefs, behaviors, etc.; 2) observation of ongoing behavior in a natural setting; 3) an individual's interpretation of or reaction to partially structured stimuli; 4) performance of "objective" tasks; and 5) physiological reactions to the object in question or a representation of it. A problem

common to all of these forms, however, concerns how one identifies which behaviors will be observed, and which ones are irrelevant. For example, self-reports typically use the standard methods of Likert (1932), scalogram analysis (Guttman, 1950a,b), unfolding technique (Coombs, 1964), and Semantic Differential (Osgood, Succi, & Tannenbaum, 1957), all having been accepted as valid assessments of attitude.

The self-report approach is considered to be the preferred method in attitude assessment whenever possible (Henerson, Morris & Fitz-Gibbon, 1978; Oppenheim, 1966; Triandis, 1971) and seemed especially relevant in this case for two reasons. Logistically, the behavior to be affected; i.e. a teacher's use of a microcomputer in teaching, is removed in time and place from her or his learning experiences. As observation of the behavior would first require the prediction of when the behavior is likely to occur, this would be very difficult. The second reason is more fundamental and related to the realities of the educational system and human psychology. There are many factors influencing teachers' behavior besides their attitudes--as with <u>any</u> individuals, teachers' attitudes are only predispositions to behave in a certain way, not guarantees that the behavior will occur. However, as discussed earlier, attitudes also predispose an individual to receive information in one way or another. Therefore, how people think they think about something will be important when they begin thinking about acting. Although slightly overstated, as an individual may act contrary to her or his feelings in response to other pressures, one may say that in most cases a positive attitude towards an action is a necessary but not sufficient condition to act in that way.

The semantic differential is the most popular of the self-report techniques, and has years of use behind it. However, no matter how widespread its use, the technique is based fundamentally on a person's interpretation and ranking of verbal labels provided by someone (i.e., the researcher), often outside the target population's conceptual framework. As Osgood et al. (1957) explicate: "The crux of the method, of course, lies in selecting the sample of descriptive polar terms. ...In other words, from the myriad of linguistic and non-linguistic behaviors mediated by symbolic processes, <u>we</u> select a small but carefully devised sample" (p.58, my emphasis). This reliance on the "good judgement" of the researcher seems somewhat optimistic in light of natural human subjectivity and bias.

Claims have been made that the scales developed for use in semantic differentials are applicable across ages and cultures (Snider & Osgood, 1969). However, when one examines the claims of universality of the semantic differential, one finds that the cross-cultural validation was done mainly on adolescent males (Heise, 1970).

Another fact which must be considered with semantic differentials is that of meaning, somewhat ironic since the classic book introducing this technique was called The Measurement of Meaning. However, to echo Brown (1958) with his question "Is a boulder sweet or sour?", how does one rate items on scales which seem patently not to apply? Obviously, this is dealt with in the selection process, the creation of the "carefully devised sample" mentioned above. For example, Lumb and Childs (1976) used the semantic differential technique to assess students' attitudes towards mathematics. They chose eleven scales, using research done by McCallon and Brown in 1971 as their decision guide. When looking for guidance as to how to pick scales, the "how to" books are not much help. For example, Henerson et al. (1978) say:

> Select appropriate adjective pairs (approximately 10). You may wish to select from the list provided at the end of this chapter or from DiVesta's list [for inner city children] if it suits your students. You may, on the other hand, wish to make up your own list. (p.90)

Triandis (1971) discusses the inherent tradeoff with a general-purpose attitude assessment instrument and a situation-specific one.

> The more specific the set of scales the more comfortable are the subjects when they make their judgments, and the more relevant is the

> information for the particular problem in hand....On the other hand, there is a great advantage in having a most general instrument applicable to any kind of concept. (p.49)

The Necessity for a New Technique

Two factors combined to require the development of a new technique for attitude measurement. The first was the inherently subjective nature of the development of traditional attitude assessment instruments. The second, which compounded the first, was the object of interest. Educational computing is relatively new, and equally important, constantly changing. This means that not only has little work been done in the area, but transferability of tools over time may be quite limited. This is in addition to the very different situations that different countries, states, and provinces find themselves in with respect to this area, making geographical transferability also questionable.

Personal Construct Theory. In order to overcome the reliance on the "good judgement" of the researcher, an alternative developmental tool for a measurement instrument was sought. Triandis (1971) suggests adapting Personal Construct Theory to attitude measurement; however, his two paragraphs do not provide the detail necessary to implement such a technique. As was discovered during the present study, his advice that the "researcher can look at similarities in response patterns both among the columns and among the rows" (p.31) is unrealistic. However, despite the lack of concrete guidelines, Personal Construct Theory (Kelly, 1955) was considered as it offered a framework for creating an individually and contextually relevant assessment instrument. In Personal Construct Theory individuals each develop their own conceptual system or schema which can be expressed as a unique system of bipolar dimensions known as personal constructs. According to PCT, "Man looks at his world through transparent patterns or templets which he creates and then attempts to fit over the realities of which the world is composed." (Kelly, 1955, pp.8-9)

What are the implications of this in cases of interacting with the relatively unknown, as in the case of computers in education? If individuals enter a new area, do they go as a truly blank slate, or are they bringing with them ways of looking at the world which have served them well in the past? These ways, or conceptual frameworks, are especially useful in dealing with novelty. "Constructs are used for predictions of things to come, and the world keeps rolling on and revealing these predictions to be either correct or misleading." (Kelly, 1955, p.14)

This concept of schema has been used widely from Kant to present-day (Shaw, 1980). However, there is an area of overlap which suggests that "an individual uses a system of organisation together with interrelationships between components in the system, which interacting with the structure produce interdepencies." (Shaw, 1980, p.7) Osgood et al. (1957) agree that each person has such a set of constructs, and that some of these are common to all people. The problem is, then, how to determine those common concepts.

Repertory Grid Technique. The main technique of Personal Construct Theory is the Repertory Grid. This is a conversational method which elicits a grid, or "a schema or two-dimensional array of events or observations and abstractions so interlaced as to enable each to have meaning in the context of the other." (Shaw, 1979, p.623) A grid consists of a number of elements (these can be people, things, roles, etc.) rated along a series of constructs. A construct is "a bipolar dimension which to some degree is an attribute or property of each element" (Shaw, 1980, p.9).

Grids may be elicited in different ways (Kelly, 1955; Fransella & Bannister, 1977). Those suggested by Kelly are all variations on triads of elements. In other words, the subject is presented with or selects three elements, and is asked to answer the question "in what way are two of these alike and one different?"

The conversational approach of the Repertory Grid is well-supported by the work of Gordon Pask. Pask (1975) developed a "theory of conversations and individuals" which offers a cybernetic approach to the problem of psychological model-building. Conversations are not limited to the common conception of exchange between two physiologically distinct entities representing two points of view. Rather, Pask distinguishes between an "M-individual" or "mechanically characterized individual", which is a distinction based on whether the system is biologically self-replicating, and a "P-individual", which is a "psychologically characterized individual" and relates to role rather than biology. It is, according to Pask, possible to determine one P-individual across many M-individuals. Pask regards conversations as the basic tool of model-building.

Grid analysis. Grids, representing an externalization of internal schema, can then be analyzed in a variety of ways (Fransella & Bannister, 1977; Shaw, 1980), but analysis techniques fall generally into two categories: detection of pattern and structure in responses within and across grids, and psychological scaling. In this study, we are interested in common structures across M-individuals in order to better monitor changes in the common P-individual or individuals. The repertory grid technique allows each individual to articulate her or his individual set of constructs without intimidation by the group. A set of shared constructs can then be identified without resorting to simple "lowest common denominator" techniques.

There are a number of analysis possibilities available within the PLANET (Shaw, 1982a) suite for use with either single grids, a pair of grids, or a group of grids. Most of these use as their analytical model the concept of distance.

In distance analysis, each point on a vector may be represented as a point in a multi-dimensional space. If constructs occupy the same space, they may be said to be equivalent, if not then principal components analysis may be performed on the construct space to identify those constructs which account for most of the area covered. Constructs may also be grouped by their proximity in space, the approach which characterizes cluster analysis.

Once this set of shared constructs has been determined, it can be presented to others within the target population as rating scales for the selected elements. At first blush, this may seem to be a semantic differential scale in sheep's clothing. However, it is important to recognize the distinction between the "arbitrary" series of bipolar adjectives used in a semantic differential scale and the contextually-relevant, individually-meaningful constructs used in a repertory grid. As Fransella and Bannister (1977) point out, analysis of grids results in "a sort of idiographic cartography as contrasted with, say, the nomothetic cartography of the semantic differential" (p.3).

Kemmis, Atkin, and Wright (1977) discuss this concept of nomothetic vs. idiographic. "Nomothetic approaches are those concerned with establishing laws...and idiographic approaches are those concerned with the intensive study of individuals." (p.5) The idiographic grid puts the individual first; the nomothetic semantic differential charts the individual against some predetermined standard. As was discussed above, in processes of change such as the one under study, individual's perceptions are very important. When one adds to this the fact that there is no "standard" attitude towards computers in education that we may measure teachers against, the importance of using a technique that places the individual first becomes pressing.

Another advantage of the proposed technique is that, because of the way in which constructs are elicited, their focus is to discriminate between and rate elements rather than just being concerned with evaluating a series of elements. This difference in emphasis can be seen by the format of presentation: the semantic differential has subjects rate one item on all of the scales, then the next item on all of the scales, etc. or even more frequently, many single item/scale pairs; the proposed technique involves having the group of items rated on one scale, then the group rated on the next scale, etc.

Elicited vs. provided constructs. Given that a better technique can be utilized for the generation of a response scale, one must still confront the question of whether elicited versus supplied constructs are valid when applied to quasi-experimental sampling procedures. Does one negate the value of the technique if each individual does not provide his or her own constructs?

If you are in doubt about what kind of constructs

> are applicable to a certain group of people, it is common practice to collect a sample of constructs from a comparable group or the group itself. You are then fairly safe in assuming that the most commonly used constructs for that group will be meaningful to the individual. But as they have been selected from a common elicited pool they are not, in any simple sense, either "provided" or "elicited". (Fransella & Bannister, 1977, p.19)

It would seem, then, that valid grids could be completed from constructs elicited from other members of the target population.

Problems with a new technique. Obviously, when one embarks on a research study with untried equipment, success is not guaranteed. However, given the inadequacy of the known alternatives, the risk must be taken. The fact that this study is at the same time developing a technique and using it to assess a situation will inevitably lead to difficulties, and unrealized goals. However, with no intent to apologize for the work presented, the following quote from Kemmis et al. seems relevant. They were faced with the challenge of evaluating the National Development Programme in Computer Assisted Learning in Great Britain, a task which lead them to explore new ways of evaluating new areas.

> The methods of idiographic evaluation are relatively unexplored outside Piagetian and neo-

> Piagetian research, and there is consequently a need for a considerable amount of 'playfulness' on the part of evaluators who would like to try its possibilities. This 'playfulness' involves the temporary suspension of conventional methodological prescriptions, though that does not imply that the methods should lack rigour; rather it is a plea for imaginative work, deliberate trial of non-standard techniques and critical independent analysis. It is thus likely to demand a considerable amount of tolerance from evaluation sponsors who will be put at a rhetorical disadvantage without the support of conventionally-accepted instruments and methods. (p.12)

The technique developed for this study and described in the following pages attempts to have the "best of both worlds". The fact of having "personally" defined constructs, related to the time, place, and subject of assessment, adds a dimension of meaning and relevance missing from standardized, pre-packaged instruments. It provides a way to add this dimension while minimizing the potential for introducing bias from the researcher. However, the technique still matches more conventional instruments in that it is quantifiable and comprehensive.

# CHAPTER 3

# METHOD

Two processes were involved in this research: the first involved the formulation of a unique method for questionnaire development, and the second a field test and quasi-experiment implemention of the newly developed technique. Both will be discussed in this section.

## Subjects and Design

Subjects for the pilot and field test components of the study were students enrolled in BASIC or Logo programming courses in the Educational Media Program at McGill University in the Winter term of 1984. There were ten sections of each with enrolments of 185 in the BASIC courses and 149 in the Logo courses. The students were teachers in the province of Quebec from a variety of subject backgrounds. The quasi-experimental design was a two-level <u>ex</u> <u>post</u> <u>facto</u> design (Cohen & Manion, 1980) with the independent variable being course of study (Logo vs. BASIC). Data were collected during the second week of term to allow for investigation of group equivalence. Demographic data were also collected to determine the equal distribution of characteristics which may have influenced attitude. Eight weeks later, near the end of the courses, data were collected again to assess attitude, specifically differential effects of the courses.

## Questionnaire Development

As was discussed in the rationale, the development of attitude questionnaires has been subjective, and thus potentially susceptible to experimenter bias. The methodology developed by the researcher used Personal Construct Theory as the theoretical base to overcome this problem. The PLANET (Personal Learning, Analysis, Negotiation, and Elicitation Techniques) suite of programs developed by Shaw (1980) formed the basis for initiating the procedure. The version used was release 1.4 for the Apple II Plus with 48k of memory and two disk drives (Shaw, 1982a). As prescribed by PCT, the constructs utilized for attitude assessment were elicited directly from the a sample of the target population. Ten student volunteers, three from the BASIC stream, three from the Logo stream, and four from the Introduction to Educational Media courses in the Fall 1983 term participated in this phase. This group reflected the broad range in age, teaching experience, computer experience, subject specialty, and grade levels anticipated of the target population.

### Element Selection

Ten elements were initially selected by the researcher by survey of literature in educational computing (Bitter & Camuse, 1984; Chandor, Graham & Williamson, 1977; Coburn et al., 1982; Heinich, Molenda & Russell, 1982; Rushby, 1979; Shepherd, Cooper & Walker, 1980) and consultation with subject matter experts. These were Drill and Practice, Graphics, Tutorial, Games, Simulations, Computer Managed Instruction, Programming, Computer Literacy, Problem Solving, and Computer Based Testing. Definitions were developed for each of these uses, drawing from the same sources cited above. (See Table 1.) These ten elements provided the basis for the implementation of PLANET, and served as examples from which the target population was invited to expand (as described below).

Construct Elicitation

The PLANET suite is a menu-driven program which allows for the elicitation and analysis of repertory grids, either from individuals or groups. It uses the triadic approach to construct elicitation, and in the elicitation option used in this research, titled NO MATCHES, no feedback is given to the user regarding how well the constructs or elements are discriminated from each other. This version was used because of Shaw's (1980) recommendation that when comparisons between members of a group are to be done, it is important to use a reflection of their unforced construct pattern.

Each of the volunteers worked through the software individually. As a trial run to become familiar with the procedure, a topic such as books, music, or television programs, suggested by the researcher, was selected by the subject. The user-computer interaction then proceeds as follows. The user is asked to input a set of six elements

Table 1--Definitions for Initial Ten Elements

Drill and Practice: A learning technique in which the student is presented with a structured succession of exercise questions designed to give him or her practice in a particular subject area.

Graphics: The process of developing arrangements of characters or other symbols on an output device to represent a visual pattern such as a map, diagram, or picture.

Tutorial: A use of the computer in which the student is led through the learning material via a structured question and answer dialogue, with remediation provided when necessary.

Games: The use of the computer for an activity in which one or more players strive toward the attainment of a goal within prescribed rules.

Simulation: The use of the computer to allow students to manipulate certain aspects of a model of a real or imaginary system.

Computer Managed Instruction: The use of the computer to manage the process of learning by routing students through non-computerized learning material, testing their progress, keeping records of their performance, etc.

Programming: The process by which a set of instructions is produced for a computer to make it perform specified activities; carried out in languages such as BASIC or Logo.

Computer Literacy: The general range of skills and understanding needed to function effectively in a society increasingly dependent on computer and information technology.

Problem Solving: The analysis of a situation and the application of appropriate skills and knowledge for the realization of a specified goal.

Computer Based Testing: Using the computer to store test questions, generate tests, administer tests, and/or analyze and store results.

from the topic area. Constructs are then elicited by presenting the user with different combinations of three elements. For each triad, the user is asked to think of a construct which distinguishes between any two of the elements and the other one. The construct pole names are requested and then each element is rated on the 1-5 scale.

For example, if books were the topic selected, the user might input Moby Dick, 2001: A Space Odyssey, Dune, The Color Purple, The Apprenticeship of Duddy Kravitz, and Macbeth. The first triad presented would be Moby Dick, 2001, and Dune, and the user could say that Moby Dick was different. The next question would take the form of "How can you describe the two ends or poles of the scale which discriminate 2001 and Dune on the left pole from Moby Dick on the right pole? Just type one or two words for each pole to remind you what you are thinking or feeling when you use this construct." The user could then identify the left pole as "futuristic" and the right pole as "historical". The user is then asked to assume that 2001 and Dune are assigned a provisional value of 1 and Moby Dick a provisional value of 5 and assign a provisional value from 1 to 5 to each of the other elements in turn; i.e. The Color Purple, The Apprenticeship of Duddy Kravitz, and Macbeth. The elements are then presented on the screen, grouped by rankings, with those ranked 1 at the top of the screen, those ranked 5 at the bottom, and the others grouped in between.

The user is given the opportunity to revise the ratings for any of the elements until she or he is completely satisfied. The user is also allowed to change the pole names to reflect more accurately the construct invoked. After four constructs are elicited from different triads, the user is given the option of selecting the triad to be used. After six constructs, the user may choose to add another element, add another construct, or finish. The timing of the options of triad selection after four constructs and finishing after six are arbitrary and built into the software.

When the subject expressed confidence in interacting with the software with the trial topic, the procedure was repeated with the ten common elements on computer use in education described above. Each subject had the option of adding up to five elements (a software limit); alternatives with definitions were available (Artificial Intelligence, Demonstration, Informatics, Information Retrieval, Numerical Analysis, and Word Processing) or they could supply their own.

Each person's interaction resulted in an m-element (a minimum of the 10 provided) by n-construct (a minimum of the six elicited before the user is given the option of finishing) grid, which can then be analyzed. A total of 83 constructs was elicited from the ten people. Aside from the ten core elements, 16 others were added, all but two from the list provided. Each session lasted approximately 45 minutes. It should be noted that the hard limits of the software were never the reason for stopping; rather fatigue on the part of the user was.

## Construct Analysis

The goal here was to analyze the grids so as to extract common constructs as well as identify constructs which were particularly important for any given individual. A reduction procedure of this sort was necessary to allow the creation of a questionnaire of manageable size, while maintaining the most sensitive and discriminating scales possible.

The ten elicited grids were analyzed using the SOCIOGRIDS analysis procedure of the PLANET software. Based on cluster analysis techniques, this analyzes a set of repertory grids elicited from a group who share the same core of elements. Constructs with similar patterns of ratings across grids are listed and elements which appear to be construed in the same way are identified (Shaw, 1982b).

However, because this procedure is based only on the common elements, it was felt that further analysis would be useful. As an additional decision guide for the extraction and identification process, cluster analysis using the single-linkage criterion recommended by Anderberg (1973) was performed using BMDP2M (Dixon, 1981) on all constructs, in order to identify the clusters of which the common constructs were a part.

Cluster analysis approaches the problem of reducing a matrix from a classificatory perspective. To illustrate:

An Ancient Chinese Classification of Animals

> Animals are divided into (a) those that belong to the Emperor, (b) embalmed ones, (c) those that are trained, (d) suckling pigs, (e) mermaids, (f) fabulous ones, (g) stray dogs, (h) those that are included in this classification, (i) those that tremble as if they were mad, (j) innumerable ones, (k) those drawn with a very fine camel's hair brush, (l) others, (m) those that have just broken a flower vase, and (n) those that resemble flies from a distance. (Jorge Luis Borges cited in Aldenderfer & Blashfield, 1984, p.7)

One can see from this illustration that the goal is to group "like" objects together, however one defines "like". The common element of cluster definition is that according to some criterion, elements within a cluster are more alike than elements from different clusters (Everitt, 1974). The definition of what are "like" objects is obviously of prime importance. If one considers objects (in this case ratings of elements on different constructs) to be physically located in space, one can then define "like" as physical proximity in that space. The "distance" between different objects can be measured, and the relationships between objects may be represented in a tree-type structure.

Although the development of classifications or typologies is certainly not new, numerical methods of clustering are relatively recent, dating really only to the sixties. This is due in large part to the computational demands of the technique, which needed the power of computers to make it practicable (Aldenderfer & Blashfield, 1984; Everitt, 1974; Green, 1978).

Cluster analysis, then, is an approach to the categorization of objects or experimental units that establishes the number and composition of the groups from the data themselves. Although mathematically similar to factor analysis, it opposes the tendency to reification of groupings common to that technique. Cluster analysis is based on the premise that "one can discover the general properties of objects by an objective clustering procedure of grouping variables without imputing causative underlying dynamics to the properties" (Tryon & Bailey, 1970, p.2).

Methods for cluster derivation are either hierarchical or nonhierarchical. In both cases, the extreme conditions are the same; either each cluster is composed of only one unit (weak clustering) or all units are in one cluster (strong clustering). The difference between the hierarchical and non-hierarchical methods is that the intermediary stages in the latter do not have a monotone character of strength of clustering, whereas at any step i, the strength of clustering obtained with a hierarchical weak (strong) method will consistently be less (greater) than that at step i-1. This property of the hierarchical method permits one to stop the procedure at any point i, with the certainty that no stronger (weaker) linkage is being ignored.

For the purposes of this analysis, hierarchial weak clustering was chosen because of the desire to respect the integrity of individual data units, as each represents one person's construct rating for a particular use of computers.

The cluster analysis was performed on all 83 constructs, in both the elicited and reversed form (i.e. with the values for the poles reversed so that differences would not be due merely to mismatched pole ends; e.g. good--bad vs don't like--like might appear as far apart in space because they were inversely correlated). A cut-off point of half-way between 166 clusters of one construct each and one cluster of 166 constructs was chosen. At least one construct was chosen from each of the eight clearly identifiable clusters, with the construct ranking from SOCIOGRIDS serving as one selection criterion; clarity of language served as the second. Seven constructs were chosen which spanned the distance not included in any cluster at the cutoff point, and five additional constructs were selected from within the groups identified; again, the criteria used were the ranking from SOCIOGRIDS and simplicity of language. A total of 20 identifiable constructs were produced as a result of this reduction procedure. (See Table 2.)

Pilot Test

A paper-and-pencil version of the questionnaire was

Table 2--Constructs Used for Pilot Questionnaire

Not Essential--Essential

Desirable--Not Desirable

Involvement--No Involvement

Creative Learning--Not Creative Learning

Active--Passive

Guided Instruction--Free Exploration

Colourful--Not Colourful

Fun--Boring

Pictorial--Non-Pictorial

Product Oriented--Process Oriented

Would Use With Young Children--Would Use With High School Students

Child Oriented--Adult Oriented

Complicated--Simple

Does Not Need Commitment--Needs Commitment

Impersonal--Personalized

Satisfying--Frustrating

Used for Teaching--Used for Administration

School Use--Home Use

Useless--Very Useful

At Ease With--Not At Ease With

created to be pilot tested. All twenty constructs selected in the procedure above were used. In addition to the ten original elements, five more were included. Of the original six options, four were selected often by the subjects or elicited strong opinions (Artificial Intelligence, Demonstration, Information Retrieval, and Word Processing). The fifth, Creative Writing, was the only use which was added by an individual from the target population. (See Table 3 for a list of the definitions provided for these elements.)

The design of the questionnaire called for a row of fifteen boxes across an 8 1/2 by 5 1/2 inch sheet of paper, each box labelled with an element. The order of presentation of the elements was decided by using a random number table. Each new construct appeared on a separate page below the row of element boxes, thus allowing the assembly of each questionnaire's constructs in a random order to guard against an order effect. Responses on a 1-5 scale could then be made in each box for each element for each of the 20 constructs.

An information sheet asking for data on age, sex, teaching experience, subject, and grade level, experience with computers, and knowledge of different programming languages was included as the first page of the questionnaire. Comments on the questionnaire, specifically about problems with understanding any of the uses or rating scales, as well

Table 3--Definitions for Additional Elements

Artificial Intelligence: Using a computer to carry out functions normally associated with human intelligence such as learning, reasoning, self-correction, and adaptation.

Creative Writing: The use of the computer to allow students to create and revise compositions, either individually or in groups.

Demonstration: Using the computer to illustrate principles or processes, either as proof or supporting evidence.

Information Retrieval: The searching of a data base (an organized and structured collection of data) to elicit useful information.

Word Processing: The use of a computer to facilitate the production, design, revision, reformatting, and storage of textual material.

as general comments were solicited. Respondents were also asked to identify what they felt were the most significant contributors to their attitude, both within the course and externally. (See Appendix A for a complete copy.)

The pilot version was produced in the following order: cover sheet, information sheet, the 20 rating scales (i.e. constructs) for each of the 15 different uses of computers in education (i.e. elements), and the comments section. These were sent to the 10 people who had participated in the construct elicitation phase and four from the same target population who had not. Copies were also circulated for review to various Subject Matter Experts in questionnaire development. This process served both to check for the reliability of the paper-and-pencil questionnaire as compared to the computer-based interaction as well as checking for the validity of this format with naive users.

Pilot Version Evaluation

Taking the data from each of the seven individuals who completed both the computer-elicited grid and the paper-and-pencil questionnaire version, comparisons were made between the element clusters in the original elicited grids and those obtained from the pilot version. Appendix B presents the clusters obtained from analysis of the data using the Focus option of the PLANET suite of programmes. There does not appear to be any statistical test available which would establish empirically the equivalence of the clusters; however, visual examination of both the placement and order of inclusion of elements suggest that the results are similar.

Minor modifications were made to the instructions and definitions based on written comments. It also became clear that the number of rating scales would have to be reduced due to the amount of time required to complete the questionnaires (an average of 1.2 hours).

Construct elimination. A decision guide for construct elimination was sought at this point. Since the aim at this stage of analysis was to reduce the number of constructs while sacrificing the minimum amount of information, a logical step was to identify those constructs which accounted for the least variance. Principal components analysis extracts factors consisting of linear combinations of variables so as to account for the most possible variance in the data, without making any seriously restrictive assumptions about the underlying structure of the data. In the present context, the results of the analyses were to be used as exploratory rather than confirmatory; in other words, the problem was not to eliminate all non-significant constructs, but rather to avoid eliminating any which would contribute significantly. Extreme caution was therefore exercised in eliminating any construct. Because each construct could be expected to contribute to each element differentially, 15 separate principal components analyses were performed, using the 20 constructs to create the factors.

The decision was made to examine the first five factors for each element, which combined, accounted for at least 90% of the variance. The principal components analyses were followed by oblique rotation on the five factors for each of the 15 elements. The initial analysis serves to determine the number of factors required to account for the variance; some form of rotation, either orthogonal or oblique, is then performed to improve the interpretability or the scientific utility of the factors (Kim & Mueller, 1978; Tabachnick & Fidell, 1983). Oblique rotation was selected because of the relaxation of the requirement of orthogonality, an unrealistic constraint because of the probable correlated nature of the data. After rotation, the number of factors considered was reduced from five to the minimum number required to account for at least 50% of the variance (two factors for all elements except Computer Literacy which only required one). The results are summarized in Appendix C. Six constructs were eliminated which both did not load significantly on a large number of elements and were not the most significant constructs for any one element. The constructs eliminated were: Not Essential--Essential, Guided Instruction--Free Exploration, Colourful--Not Colourful, Pictorial--Non-pictorial, Would Use with Young Children--Would Use With High School Students, and Used for Teaching--Used for Administration.

Revised Version

The final version of the questionnaire, used for both administrations, consisted of the modified instructions and definitions, demographic information and comment report sheets, 15 uses (elements), and 14 rating scales (constructs). The questionnaire pages were each on 8 1/2 by 5 1/2 sheets of paper. The cover page had the name of the director of the Educational Media Program as the originator of the questionnaire. The information sheet and instructions were next, including a sample page with an extra construct with the ratings filled in. Two pages of definitions were next, printed on blue paper to facilitate reference during the filling in of the questionnaire. Each construct was printed on a separate sheet of paper to allow for their presentation in a random order for each individual. After the first two construct sheets, a "reminder" sheet on yellow paper was included which encouraged people to refer to the sample page if they were not "absolutely certain" that they were filling out the pages correctly. (See Appendix D for a sample copy.)

## Procedure

In the first week of winter term, questionnaires were distributed to all instructors of on- and off-campus BASIC and Logo courses at McGill. Each instructor received sufficient questionnaires for her or his section(s), a return envelope, and a covering letter from the director of the

Educational Media Program outlining the purpose of the study and requesting cooperation (see Appendix E). The instructors were asked to distribute the questionnaires in class, ask students to complete them at home during the following week, collect them in the next class, and return them to the director of the program at McGill. Each instructor was also asked to complete a questionnaire, label it, and return it with the students' questionnaires.

One hundred and thirty-seven questionnaires were returned from the first administration. This represents a response rate of approximately 41%, comparable to what may be expected from similar surveys (Tuckman, 1978). Nevertheless, an effort was made to increase the return rate for the second administration. Each instructor was contacted by the researcher by phone prior to the second distribution and asked if the questionnaires could be completed in class. All agreed, and packages containing questionnaires, return envelopes, and a new covering letter (signed by the researcher) were sent to all instructors. However, a similar return rate (one hundred and nineteen or 36%) was recorded for the second administration. In most cases the questionnaires were given to the students before the break between lab and class, rather than actually being a part of the class period.

Even though this response rate was on line with results reported in the literature (Rossi, Wright & Anderson, 1983), this may not necessarily be the best perspective from which to evaluate the adequacy of the number of questionnaires received. Response rate data come typically from sociology or marketing, and the rates are calculated on the percentage of interviews or questionnaires completed within the sample preselected, either randomly or variations thereof.

In this case, the population was defined generally as anglophone teachers in Quebec seeking in-service training in educational computing through courses in programming. This population is to be found almost exclusively at McGill, as Concordia University does not offer programming courses within the education curriculum, and Bishop's runs only pre-service teacher training. Therefore, virtually the entire population was sampled. The other concern is that the respondents are best considered as volunteers. The primary danger when working with volunteers is comparing them to non-volunteers (Tuckman, 1978). It is impossible to know what the people who did not answer thought, but as the main question concerned differential effects, the comparison is being made of volunteers against volunteers. The characteristics of volunteers have been studied, and Borg and Gall (1983) summarize the findings. The single characteristic which has received the most support from research is that volunteers tend to be better educated than nonvolunteers; in this case, the education level of all teachers can be considered as more homogeneous than that of the population at large. The second most significant characteristic concerns social class (volunteers tend to have higher status); again, teachers may be considered as a relatively homogenous group. It would seem then that the characteristics of volunteers vs. nonvolunteers which contribute most significantly to spurious results in some kinds of research studies would be of minimal impact in this case.

The only remaining concern regarding response rate would be that the sample characteristics meet the normal assumptions for the different analyses, a matter which is dealt with in the Results chapter.

# CHAPTER 4

## RESULTS AND DISCUSSION

The results will be reported in two sections: the first will deal with the results of the questionnaire ratings, and the second with the methodological results. As the primary thrust of this dissertation was on a method of questionnaire development based on Personal Construct Theory, the emphasis will be on the latter, although, of course, the results of the teacher attitude study are of significant interest. Obviously, the two threads cannot be completely separated; however, as much as possible, concerns specific to the field test of the questionnaire will be discussed in the first part, while those of general relevance to the methodology will be discussed in the second.

### I: Field Test of Teacher Attitudes

#### Data Processing

Upon receipt of the completed questionnaires, the first step was to eliminate all of those which were, for various reasons, unusable. Fifteen questionnaires were eliminated from the first administration and three from the second administration because of incomplete data (defined as less than seven of the fourteen rating scales completed for at least half of the computer uses) and/or comments which made it clear that the individual had not answered in good faith (e.g. "I learned in a time-management seminar not to waste my time doing things like this!", stated on both administrations.) None of the instructor data was included as only three instructors had returned completed questionnaires. This left a total of 122 from the first administration and 116 from the second. All data were coded and entered into SPSS files, including all responses to elements on constructs, demographics and other gathered information. Missing data were appropriately coded.

Repeaters vs. Non-repeaters

The experimental variable, BASIC vs. Logo, was easily determined, with 58 BASIC and 64 Logo respondents on the first administration, and 63 BASIC and 53 Logo on the second. However, a potentially confounding factor emerged following the second administration. Of the 122 who responded to the first administration of the questionnaire, only 49 responded to the second. An additional 67 returned completed questionnaires at the second administration. To analyze only those who responded both times would have meant a tremendous loss of information. It was therefore decided to examine if those responding twice, dubbed "repeaters", were different from the one-time respondents. If the groups were found to be equivalent, then the data could be pooled for all subsequent comparisons.

Logically, the first comparison required was whether repeaters and non-repeaters were equally distributed between the BASIC and Logo groups. The chi-square analysis yielded a non-significant index of 5.54 (3 d.f.), thus verifying no differences on this critical variable.

Several other demographic and descriptive factors were also examined to insure group equivalence. The following comparisons all proved non-significant: male/female; use of computer on a regular basis; the subject and level of teaching (arts and sciences vs. computer related, and primary vs. secondary); level of non-teaching vs. teaching activities; age; teaching experience; and time taken to complete the questionnaire.

Missing data. As Tabachnik and Fidell (1983) point out, patterns within missing data may themselves be important clues to a group's attitudes or behaviours. It is tempting to simply assume that data were randomly missing; however, if certain constructs and/or elements were systematically omitted more often by one group than by another, this would signal possible differences. It was therefore important to establish if there was a differential pattern of missing data with respect to either the elements or the constructs between repeaters and non-repeaters.

The first comparison examined the way the four different groups (BASIC and Logo repeaters and non-repeaters) responded to the questionnaire, in terms of how often the ratings were completed rather than how elements were rated.

Table 4 summarizes the percentage of times each construct was used for at least one element by individuals in

Table 4--Percentage of Times Constructs Used

| | LOGO | | BASIC | | |
|---|---|---|---|---|---|
| con | nr (n=40) | rep. (n=24) | nr (n=33) | rep (n=25) | av. (n=122) |
| 1 | 97.5 | 100 | 93.9 | 96.0 | 96.85 |
| 2 | 100 | 95.8 | 90.9 | 92.0 | 94.92 |
| 3 | 100 | 100 | 93.9 | 100 | 98.47 |
| 4 | 95.0 | 91.7 | 90.9 | 96.0 | 93.40 |
| 5 | 100 | 100 | 97.0 | 96.0 | 98.25 |
| 6 | 90.0 | 79.2 | 78.8 | 84.0 | 83.00 |
| 7 | 90.0 | 100 | 78.8 | 100 | 92.20 |
| 8 | 95.0 | 91.7 | 97.0 | 96.0 | 94.92 |
| 9 | 92.5 | 100 | 87.9 | 92.0 | 93.10 |
| 10 | 95.0 | 95.8 | 90.9 | 96.0 | 94.42 |
| 11 | 100 | 100 | 90.9 | 96.0 | 96.50 |
| 12 | 90.0 | 100 | 87.9 | 96.0 | 93.47 |
| 13 | 97.5 | 95.8 | 90.9 | 100 | 96.05 |
| 14 | 92.5 | 100 | 84.8 | 100 | 94.32 |

con: Construct

nr: Non-repeaters

rep: Repeaters

av: Average for group as a whole

the four groups. The result of chi squared analysis on construct 6, which had the lowest rate of usage (83% of the questionnaires), was not significant (.99, 3 d.f.) A similar analysis on construct 7, which had the largest range across the four groups (21.2%), also resulted in a non-significant (chi square 3.03, 3 d.f.). Chi square analyses were, in fact, conducted on all of the constructs; none was significant.

Table 5 summarizes the percentage of times each element was rated on each construct by individuals in the four groups. Each element had the opportunity to be rated 14 times; one can see from these data that although there is only one case in which an element is rated on all 14 constructs by an entire group (element 1 for BASIC repeaters), there is no case in which an element was not rated at least 90% of the time. Even though there was an apparently even distribution (the largest range is 5.8% on element 12), chi square analyses were performed for each of the fifteen elements; none was significant.

BASIC vs. Logo

As a result of the above comparisons, it was determined that the repeaters and non-repeaters were sufficiently homogeneous that their data could be pooled. Note however, that no repeated measures analyses which might assume group dependence were conducted. It was also important to ascertain group characteristics of the BASIC and Logo groups. It

Table 5--Percentage of Elements Rated

| | LOGO | | BASIC | | |
|---|---|---|---|---|---|
| ele. | nr (n=40) | rep. (n=24) | nr (n=33) | rep. (n=25) | av. (n=122) |
| 1 | 96.8 | 98.8 | 97.8 | 100 | 98.35 |
| 2 | 94.8 | 94.6 | 96.5 | 98.6 | 96.12 |
| 3 | 90.5 | 94.0 | 95.9 | 90.6 | 92.75 |
| 4 | 94.5 | 98.8 | 96.5 | 98.6 | 97.10 |
| 5 | 96.4 | 97.9 | 96.8 | 98.6 | 97.42 |
| 6 | 97.3 | 99.7 | 97.8 | 99.7 | 98.62 |
| 7 | 96.3 | 99.1 | 96.8 | 99.1 | 97.82 |
| 8 | 98.8 | 99.7 | 96.5 | 98.3 | 98.32 |
| 9 | 97.1 | 98.8 | 96.5 | 98.3 | 97.67 |
| 10 | 94.8 | 92.6 | 95.7 | 92.9 | 94.00 |
| 11 | 95.7 | 93.5 | 96.3 | 91.9 | 94.35 |
| 12 | 93.6 | 96.4 | 93.5 | 99.4 | 95.72 |
| 13 | 96.3 | 98.2 | 98.3 | 98.9 | 97.92 |
| 14 | 95.4 | 96.7 | 95.9 | 99.1 | 96.77 |
| 15 | 97.9 | 95.5 | 95.9 | 98.9 | 97.05 |

ele: Element

nr: Non-repeaters

rep: Repeaters

av: Average for group as a whole

had been hoped that students following different courses would be relatively "uncontaminated" by knowledge of programming languages other than that being studied. However, this was clearly not the case. From the first administration, which was during the second week of term, the following information emerged. In the Logo group, 65.6% (42) claimed to know Logo with 43.8% (23) stating that this was the language that they felt most comfortable with. However, 50% (32) of this same group also claimed to know BASIC, and 31.3% (20) stated that BASIC was the language they felt most at ease with. For the BASIC group, 60.3% (35) claimed knowledge of BASIC, and 31% (18) stated that BASIC was the language they felt most comfortable with. At the same time, 36.2% (21) of this group said that they knew Logo, and 22.4% (13) felt most at ease with Logo. By the second administration, the language groups had clearly polarized, with 84.9% (45) of the Logo group feeling most comfortable with Logo and 74.6% (47) of the BASIC group feeling most comfortable with BASIC. At that point, twelve weeks into the term, 100% of the Logo group claimed knowledge of Logo and 93.7% (59) of the BASIC group claimed knowledge of BASIC. The heterogeneous nature of the groups at the beginning of their courses in terms of language knowledge suggests that they may be more reasonably considered as one group which then is non-randomly assigned (actually self-selected) to one of two treatments--BASIC or Logo--than as two distinct groups.

Description of the Sample

Finally, it was decided that the four groups (Logo non-repeaters, Logo repeaters, BASIC non-repeaters, and BASIC repeaters) could logically and usefully be described as one, if for none other than descriptive purposes. The general information data from the first administration follows. One hundred and twenty-two (122) students returned completed questionnaires. Sixty-seven (67) were female and fifty-three (53) male. (Note: whenever the total, e.g. 67 + 53 = 120, is less than 122, the difference, e.g. 2, are cases for which data are missing.) The age range of the group was from 21 to 64 years, with a mean age of 37.4 (s.d. 7.9). The number of years of teaching experience ranged from 0 to 33, with the mean being 13 (s.d. 6.9). One hundred and ten (110) were involved in primary and/or secondary level teaching, with six teaching Special Education classes, and one teaching only adults. The subjects taught were classified as Arts only (27), Science only (20), Arts and Science (51), Computer-Related (8), and Vocational (1). Of the sample, 102 reported being currently active as teachers, 11 were involved in non-teaching activities, and one was in a computer-related non-teaching job.

Respondents were asked if they used computers on a regular basis; 40 replied "Never", 43 "Sometimes", and 34 "Frequently". Of those who did use computers, 40 cited teaching as a primary function, 22 personal learning activities, and the remaining 13 mentioned word processing, computer-managed instruction, administration, games, and programming.

The mean time taken to complete the questionnaire was 34 minutes (s.d. 15.5), with a range from 10 to 70 minutes.

The Question of Differential Effects

The major experimental question posed in this study was whether there was a differential effect on attitudes towards computer uses in education due to different programming language courses followed, specifically Logo and BASIC. In order to assess this, a 2 x 2 (language by administration) MANOVA using SPSS version 9.0 (Hull & Nie, 1981) was performed on each of the fifteen elements.

One point concerning the analysis which will be discussed in detail in the second section is how to treat missing data. Briefly, those respondents who left out more than half of the responses to any given item were eliminated; for those remaining, missing values were substituted by the mean. The number of subjects eliminated for each analysis is indicated; this also explains the differing numbers of degrees of freedom for the different analyses.

Another problem was associated with the high number of univariates involved and their likelihood of significance due to chance (Type I error). This issue is dicussed in more detail in Section II. However, for the purposes of this section suffice it to say that beyond interpreting only those effects couched within significant overall (MANOVA) Fs, a conservative stance was maintained by establishing the alpha level at .01 to reduce the possibility of committing a familywise Type I error.

The overall 2 x 2 MANOVA checks for an interaction between the results for the two language groups with the two administrations. In other words, drawing an analogy with univariate analyses, if the lines for the groups deviate "significantly" from parallel paths, an interaction has occurred. However, if the lines remain parallel, then no interaction has occurred. What then, do the main effects mean? If there is only an effect for administration, it means that the two language groups are not different from each other, at either administration 1 or 2. A significant multivariate effect for administration only, then, means that the language groups can be pooled together, because although different over time, they are not different from each other. If, on the other hand, there is a significant effect for language only, this means that there is no difference over time (i.e. the two administrations can be pooled together), but that there is a significant multivariate effect between the two language groups. Because no significant change occurred over time, the same differences were present at both the first administration and at the second, or there would have been an interaction. If there are significant main effects for both administration and language, this means that there were differences both over time and between the language groups; however, the differences between the language groups did not change over time. In other words, no interaction occurred. If there is no significant main effect for either administration or language, then there is no difference between any of the four groups defined; results then may be pooled across both language and administration.

Of the fifteen analyses, it is important to note that none had a significant interaction. Two elements in particular might have been expected to produce an interaction: Graphics because of the fundamentally different approach to graphics inherent in Turtle geometry, and Programming because this was an aspect of educational computing which subjects had just had personal experience with. There were, however, some significant main effects which may offer interesting insights into the broader area of teacher attitudes and possible influences. Some changes did occur over time, but in no case was the study of a particular programming language sufficient to alter the framework which apparently contributed to the selection of the language of study. If the fundamental differences between languages claimed by proponents of the various languages are both real and important, this result argues strongly for students self-selecting into languages which they feel will confirm their attitudes. Where that framework comes from initially was not addressed by this study, and so no discussion of that will be entertained; however, the single most striking result of the field test part of this research must be the overwhelmingly minor nature of the few changes which did occur. Perhaps either programming languages per se are irrelevant to teachers' attitudes, or, alternatively, by the time teachers take the step of enrolling in a course, their minds are already made up about how they feel computers should be used in education. Therefore, differences between BASIC and Logo (i.e. language as a main effect) may be seen as the conceptual framework that students have when they decide to enroll in a course, which framework is then confirmed or altered.

## Language as a Significant Main Effect

There were five uses of the computer for which significant multivariate F's were obtained when comparing the element by language groups. These were: Computer Literacy, Computer Managed Instruction, Graphics, Programming, and Word Processing. See Table 6 for the ratings for all constructs on these five elements. The statistical indices of each are presented first. Then, they are interpreted, both individually and together.

Computer literacy. An overall multivariate F of 1.88 (14,204), $p<.03$ (17 cases missing) was obtained for this element. Only one univariate was significant, that for construct 7 (Child Oriented--Adult Oriented), F=7.22 (1,217),

Table 6--Ratings for Language as Main Effect

Elements

| construct (Pole 1) | Comp.Lit. L | Comp.Lit. B | Word Proc. L | Word Proc. B | Prog. L | Prog. B | Graphics L | Graphics B | C.M.I. L | C.M.I. B |
|---|---|---|---|---|---|---|---|---|---|---|
| | M | M | M | M | M | M | M | M | M | M |
| | SD | SD | SD | SD | SD | SD | SD | SD | SD | SD |
| 1-Desira- | 1.6 | 1.5 | 1.6 | 1.6 | 1.6 | 1.7 | 1.8 | 1.9 | 2.6 | 2.3 |
| ble | .89 | .87 | .86 | .98 | .92 | .98 | .98 | .93 | 1.45 | 1.05 |
| 2-Involve- | 1.8 | 1.6 | 1.9 | 2.0 | 1.5 | 1.5 | 1.8 | 2.1 | 2.7 | 2.2* |
| ment | 1.19 | 1.02 | 1.04 | 1.12 | .96 | 1.10 | .89 | 1.17 | 1.27 | 1.17 |
| 3-Creat. | 2.6 | 2.4 | 2.4 | 2.5 | 1.9 | 1.8 | 1.7 | 2.0 | 3.3 | 2.8* |
| Lrng. | 1.37 | 1.21 | 1.19 | 1.24 | 1.18 | 1.00 | .95 | 1.00 | 1.23 | 1.05 |
| 4-Active | 2.4 | 2.0 | 1.9 | 2.2 | 1.5 | 1.5 | 1.8 | 2.3* | 3.0 | 2.6* |
| | 1.32 | 1.13 | .98 | 1.18 | .76 | .78 | 1.02 | 1.14 | 1.13 | 1.05 |
| 5-Fun | 2.2 | 2.3 | 2.0 | 2.4* | 2.0 | 2.2 | 1.6 | 1.8 | 2.9 | 2.6 |
| | 1.14 | 1.04 | .95 | 1.13 | 1.14 | 1.07 | .84 | .89 | 1.10 | 1.05 |
| 6-Product | 3.3 | 3.2 | 2.8 | 3.2 | 3.4 | 3.2 | 2.9 | 3.0 | 2.8 | 3.0 |
| | 1.43 | 1.26 | 1.51 | 1.35 | 1.34 | 1.38 | 1.45 | 1.17 | 1.30 | 1.22 |
| 7-Child | 3.2 | 3.6* | 3.7 | 3.7 | 3.6 | 3.7 | 2.7 | 2.7 | 3.4 | 3.0* |
| | 1.13 | .96 | .95 | .92 | 1.04 | .92 | .95 | 1.00 | 1.11 | 1.01 |
| 8-Compli- | 2.7 | 2.6 | 3.1 | 3.0 | 2.2 | 2.3 | 2.8 | 2.7 | 3.0 | 3.1 |
| cated | 1.15 | 1.19 | 1.09 | 1.18 | 1.07 | 1.08 | 1.05 | 1.09 | .96 | .99 |
| 9-No Com- | 4.1 | 4.0 | 3.6 | 3.6 | 4.4 | 4.2 | 3.8 | 3.6 | 3.4 | 3.3 |
| mitment | 1.21 | 1.34 | 1.11 | 1.23 | .95 | 1.26 | 1.06 | 1.25 | 1.19 | 1.22 |

| | Comp.Lit. | | Word. Proc. | | Prog. | | Graphics | | C.M.I. | |
|---|---|---|---|---|---|---|---|---|---|---|
| (Pole 1) | L | B | L | B | L | B | L | B | L | B |
| | M | M | M | M | M | M | M | M | M | M |
| | SD | SD | SD | SD | SD | SD | SD | SD | SD | SD |
| 10-Imper- | 2.6 | 2.4 | 2.9 | 3.0 | 3.1 | 3.2 | 3.3 | 3.1 | 2.4 | 2.9* |
| sonal | 1.21 | 1.22 | 1.24 | 1.23 | 1.19 | 1.39 | 1.26 | 1.24 | 1.17 | 1.12 |
| 11-Satis- | 2.2 | 2.1 | 1.9 | 2.1 | 2.2 | 2.5 | 1.8 | 2.3* | 2.9 | 2.5* |
| fying | 1.24 | 1.19 | 1.03 | 1.11 | 1.35 | 1.43 | 1.02 | 1.07 | 1.01 | 1.15 |
| 12-School | 2.3 | 2.3 | 2.4 | 2.4 | 2.4 | 2.3 | 2.2 | 2.3 | 2.4 | 2.0* |
| Use | 1.03 | 1.09 | 1.11 | 1.15 | 1.13 | .98 | 1.03 | .98 | 1.08 | 1.01 |
| 13-Useless | 4.3 | 4.2 | 4.4 | 4.2 | 4.2 | 4.1 | 3.9 | 3.8 | 3.3 | 3.5 |
| | 1.03 | 1.16 | 1.01 | 1.14 | 1.04 | 1.20 | 1.09 | 1.08 | 1.09 | 1.16 |
| 14-At Ease | 2.2 | 2.4 | 2.3 | 2.8* | 2.4 | 2.9* | 2.1 | 3.1* | 2.9 | 2.8 |
| | 1.19 | 1.18 | 1.18 | 1.22 | 1.24 | 1.28 | 1.07 | 1.28 | 1.19 | 1.23 |

L: Logo B: BASIC Pole 1: The label for the pole ranked 1; the complete labels may be found in Table 2.

M: Mean

SD: Standard deviation

Logo: n=117, BASIC: n=121

*Significant univariate results.

p<.01. On the significant univariate, the BASIC group rated Computer Literacy as more adult-oriented than did the Logo group.

Word processing. The result for Word Processing was an F of 1.95 (14,205), p<.02 (16 cases missing). Two univariates were signficant: construct 5 (Fun--Boring), F=6.57 (1,218), p<.01; and construct 14 (I Feel At Ease With--I Do Not Feel At Ease With), F=10.38 (1,218), p<.01. The Logo group felt more at ease with Word Processing and found it more fun than did the BASIC group, although both were positive about this use of computers in education.

Programming. The result for Programming was also significant (F=1.9 (14,204), p<.03, 17 cases missing). One univariate was signficant: construct 14 (I Feel At Ease With--I Do Not Feel At Ease With), F=12.80 (1,217), p<.01. The Logo group again is more to the "Ease" side of the scale, with the BASIC group hovering at the midpoint.

Graphics. A significant result was obtained for Graphics (F=3.92 (14,206), p<.01, 15 cases missing). Three univariates were significant: construct 4 (Active--Passive), F=8.82 (1,219), p<.01; construct 11 (Satisfying--Frustrating), F=12.48 (1,219), p<.01; and construct 14 (I Feel At Ease With--I Do Not Feel At Ease With) with an F of 40.87 (1,219), p<.01. The Logo group is more to the "Active", "Satisfying", and "Ease" sides of the midpoint whereas the BASIC group is closer to the middle (with "Ease" on the midpoint) for these constructs.

Computer managed instruction. An F of 2.78 (14,197), $p<.02$ (24 cases missing) was obtained for this element. In this case however there were seven significant univariates: construct 2 (Needs Involvement--Does Not Need Involvement), F=10.47 (1,210), $p<.01$; construct 3 (Creative Learning--Not Creative Learning), F=9.30 (1,210), $p<.01$; construct 4 (Active--Passive), F=8.21 (1,210), $p<.01$; construct 7 (Child Oriented--Adult Oriented), F=7.51 (1,210), $p<.01$; construct 10 (Impersonal--Personalized); F=11.64 (1,210), $p<.01$; construct 11 (Satisfying--Frustrating), F=7.23 (1,210), $p<.01$; and construct 12 (Appropriate for School Use--Appropriate for Home Use), F=9.44 (1,210), $p<.01$). As a summary, one can say that as the BASIC group rated Computer Managed Instruction as requiring more involvement and being more active, being more child and school-oriented, involving more creative learning, and as being more personalized and satisfying than did the Logo group. This element reversed the trend of the other four uses which had significant main effects, that being a generally more positive view by the Logo group. For computer managed instruction, the BASIC group had an overall attitude that was more positive.

What these results indicate is open to discussion. Could the fact that there are differences on these uses of the computer be due to some kind of self-selection process--for example, people who feel more comfortable with graphics are interested by Logo, whereas those who are less comfortable are attracted by BASIC? The same "chicken and egg" question may be asked about computer literacy--does the initial accessibility of Logo lead people to believe computers in general are equally applicable to children and adults, or do those who are more interested in children and computers go to Logo courses, while those interested in adults go to BASIC courses? Do those people who generally feel more comfortable with computers go into Logo courses, and Word Processing and Programming benefit by association? And do the opinions towards more "individual" uses of computers, such as word processing, programming, computer literacy, and graphics, in turn influence the opinions of people towards more "institutionalized" applications such as computer managed instruction?

Each of the above questions assumes that the individual statistically significant results are in and of themselves meaningful, or that together they form an interpretable pattern. However, what is perhaps the most outstanding result was that no differential effects occured, and that the vast majority of attitudes remained similar between groups. Indeed, few attitudes changed at all. The question remains as to whether the remaining differences provide a potentially more important kind of information. If it is self-selection that accounts for individual teachers choosing to study different programming languages, and if following a course serves only to confirm pre-existing attitudes rather than change them, it would appear that one cannot influence teachers' attitudes solely by programming courses (or at least that the present courses did not). Teacher training courses would have to have explicit components discussing the different possible applications of computers. It is unreasonable to expect teachers to be able to extrapolate from the experience of learning to program themselves to the wide variety of educational applications of computers possible.

It was reported above that at the beginning of the courses, 50% of the Logo group claimed to know BASIC, and 31% stated that this was the language they felt most at ease with, and for the BASIC group, 36% said they already knew Logo and 22% felt more comfortable with that language. This would certainly lead one to believe that a significant number o+f people in the study had already followed courses in the other language, and yet there was no interaction even though there were significant differences between the groups. It should be remembered that the concept of "feel most comfortable with" is a relative one; in other words, "Of these n items, which do you prefer?" This is not the same as asking on a more absolute scale how someone feels about the items in question--the answer to that may be, "I really don't like any, but I don't like this one less than I don't like the others."

The lack of differences is explainable if one assumes that students go into courses with well-defined attitudes that serve as a framework for their reception of new information. And it would appear that these attitudes, which are relatively stable over time, were relatively uninfluenced even by previous courses. This would indicate that perhaps courses are not the significant determinants of attitudes that could be expected.

For example, if one looks specifically at Word Processing, this result could perhaps be explained by one of the assignments in the Logo course which was not present in the BASIC one, namely using the Bank Street Writer program to produce a paper. Bank Street Writer is a word processing package specifically intended for children, and as such would contribute to the perception that computers can be suitable for young children. It would also, presumably, be relatively easy to learn and would therefore contribute to the overall ease of interaction that people in the Logo group felt. However, when one realizes that the Logo group did not develop this more positive attitude after their experiences but came into the course this way, the explanation of effect weakens, and the argument for self-selection strengthens.

<u>Administration as a Significant Main Effect</u>

Three elements had significant changes between the first and second administrations: Artificial Intelligence, Programming, and Computer Managed Instruction. Table 7 presents the results for all constructs for these three elements.

Artificial intelligence. An F of 2.42 (14,191), $p<.01$, 30 cases missing, was obtained for this element. One univariate was signficant: construct 4 (Active--Passive), F=8.80 (1,204), $p<.01$. AI was perceived as more active at the second administration than at the first.

Computer managed instruction. Computer Managed Instruction had a significant effect for Administration (F=2.02 (14,197), $p<.02$, 24 cases missing) as well as for Language, although there was no interaction. The only significant univariate was for construct 12 (Appropriate for School Use --Appropriate for Home Use), F=9.93 (1,210), $p<.01$. At the second administration, the group as a whole was more to the School Side of the scale than it had been at the first administration, although not surprisingly, both were to the School Side of the midpoint.

Programming. Programming also had a significant effect for Language and Administration. The result for Administration was an F of 2.1 (14,204), $p<.01$, 17 cases missing. In this case, however, there was no univariate significant at the .01 level. (As a point of information, only construct 4 (Active--Passive) was significant even at .05, with an F of 4.3 (1,217), $p<.04$.)

Table 7--Ratings for Administration as Main Effect

| construct | A.I. | | Prog. | | C.M.I. | |
|---|---|---|---|---|---|---|
| (Pole 1) | 1 | 2 | 1 | 2 | 1 | 2 |
| | M | M | M | M | M | M |
| | SD | SD | SD | SD | SD | SD |
| 1-Desirable | 2.5 | 2.7 | 1.6 | 1.7 | 2.4 | 2.6 |
| | 1.2 | 1.31 | 1.02 | .98 | 1.0 | 1.11 |
| 2-Involve- | 2.5 | 2.5 | 2.4 | 2.5 | 2.3 | 2.6 |
| ment | 1.25 | 1.33 | .99 | 1.07 | 1.16 | 1.31 |
| 3-Creative | 3.0 | 2.8 | 1.8 | 1.9 | 3.1 | 3.0 |
| Learning | 1.22 | 1.15 | 1.17 | .98 | 1.22 | 1.08 |
| 4-Active | 3.1 | 2.7* | 1.4 | 1.6 | 2.7 | 2.9 |
| | 1.30 | 1.21 | .75 | .79 | 1.07 | 1.15 |
| 5-Fun | 2.6 | 2.8 | 2.0 | 2.3 | 2.7 | 2.8 |
| | 1.19 | 1.25 | 1.11 | 1.11 | 1.08 | 1.08 |
| 6-Product | 3.3 | 3.3 | 3.5 | 3.1 | 3.0 | 2.8 |
| | 1.38 | 1.25 | 1.36 | 1.35 | 1.30 | 1.20 |
| 7-Child | 3.7 | 3.6 | 3.6 | 3.7 | 3.4 | 3.0 |
| | 1.11 | .91 | .95 | 1.01 | 1.10 | 1.03 |
| 8-Compli- | 2.5 | 2.2 | 2.3 | 2.2 | 3.0 | 3.1 |
| cated | 1.23 | 1.22 | 1.03 | 1.13 | 1.04 | .89 |
| 9-No Commit- | 3.4 | 3.3 | 4.4 | 4.2 | 3.5 | 3.2 |
| ment | 1.31 | 1.28 | 1.07 | 1.16 | 1.18 | 1.23 |
| 10-Imper- | 2.0 | 2.2 | 3.2 | 3.2 | 2.7 | 2.6 |
| sonal | 1.07 | 1.07 | 1.28 | 1.32 | 1.24 | 1.08 |

| | A.I. | | Prog. | | C.M.I. | |
|---|---|---|---|---|---|---|
| (Pole 1) | 1 | 2 | 1 | 2 | 1 | 2 |
| | M | M | M | M | M | M |
| | SD | SD | SD | SD | SD | SD |
| 11-Satisfying | 2.7 | 2.9 | 2.3 | 2.5 | 2.7 | 2.7 |
| | 1.12 | 1.15 | 1.39 | 1.39 | 1.07 | .93 |
| 12-School | 2.5 | 2.6 | 2.4 | 2.2 | 2.0 | 2.4* |
| Use | 1.04 | 1.07 | 1.10 | .99 | 1.01 | 1.09 |
| 13-Useless | 3.4 | 3.35 | 4.1 | 4.2 | 3.4 | 3.5 |
| | 1.18 | 1.25 | 1.18 | 1.08 | 1.13 | 1.13 |
| 14-At Ease | 3.3 | 3.4 | 2.8 | 2.5 | 3.0 | 2.7 |
| | 1.31 | 1.26 | 1.35 | 1.19 | 1.27 | 1.13 |

Pole 1: The label for the pole ranked 1; the complete labels may be found in Table 2.

M: Mean

SD: Standard Deviation

Admininstration 1: n=122, Administration 2: n=116

*Significant univariate results.

This case highlights the intrinsic multivariate nature of attitudes, and provides a caution against placing too much emphasis on individual univariates; what is important to note is when there are significant multivariate differences. All constructs, even those which do not result in significant univariate differences, must be considered to be contributing to these differences.

The specific effects of history, especially in an area as high-profile and rapidly-changing as computers, are difficult to assess. However, it is self-evident that teachers following courses in computer programming from January to April 1984 were subject to a barrage of information from the media (e.g. Feigenbaum & McCorduck's 1983 best-seller on artificial intelligence), the government (the Ministry of Education of Quebec had released its Proposition de développement in 1983 and the impact in the schools was beginning to be felt), not to mention whatever effects merely following a course, using computers, and talking with colleagues might have.

That there is a difference in people's attitudes towards programming *per se* after ten weeks of concentrated effort is certainly not surprising. As mentioned above, there were no significant univariate effects, and therefore it impossible to point to specific differences. Having said that, it is nonetheless interesting to "eyeball" the data. One possible explanation for the change could be that of fatigue--after ten weeks of classes, the students seem to be slightly more at ease (2.8 to 2.5), although they find the whole activity of programming less fun (2.3 to 2.0), less satisfying (2.5 to 2.3), less active (1.4 to 1.6), and less process oriented (3.5 to 3.1).

For Artificial Intelligence and Computer Managed Instruction, there is no reason to assume that programming courses would have had a significant impact on these two particular applications; however, taking a course in the area may have sensitized them to events outside of the courses which influenced the group as a whole.

Elements with No Significant Main Effects

Nine applications--Demonstration, Computer Based Training, Drill and Practice, Problem Solving, Simulation, Creative Writing, Games, Tutorial, and Information Retrieval showed no differences between language groups or over time. The results presented in Table 8 come from the 116 respondants to the second administration. The vast majority of the ratings (91%) fall in the middle range between 2 and 4. For eleven specific ratings, however, the mean for the group as a whole is between either 1 and 2 or 4 and 5. These will be discussed briefly below because they represent extremes which should be noted for the group as a whole. Also, from a methodological standpoint, one would have expected certain items to have fallen at the extremes; were this not to have occurred, the validity of the measuring instrument would

Table 8--Ratings for Elements with no Significant Effects

| construct | | | | Prob | | Creat | | | Info. |
|---|---|---|---|---|---|---|---|---|---|
| Pole 1 | Demo | CBT | D&P | Solv | Sim. | Writ. | Games | Tut. | Ret. |
| | M | M | M | M | M | M | M | M | M |
| | SD | SD | SD | SD | SD | SD | SD | SD | SD |
| 1-Desira- | 2.0 | 2.4 | 2.2 | 1.8* | 2.0 | 2.1 | 2.6 | 2.2 | 1.9* |
| ble | .95 | 1.06 | 1.13 | .89 | 1.04 | 1.22 | 1.22 | .98 | 1.0 |
| 2-Involve- | 2.6 | 2.6 | 2.6 | 1.9* | 2.1 | 1.9* | 2.6 | 2.3 | 2.8 |
| ment | 1.28 | 1.21 | 1.38 | 1.08 | 1.16 | 1.15 | 1.42 | 1.2 | 1.33 |
| 3-Creat. | 2.8 | 3.5 | 3.5 | 2.0 | 2.3 | 1.8* | 2.9 | 2.9 | 3.3 |
| Lrng. | 1.11 | 1.12 | 1.18 | .99 | .97 | .93 | 1.23 | 1.0 | 1.29 |
| 4-Active | 2.8 | 2.8 | 2.5 | 1.8* | 2.1 | 1.9* | 2.1 | 2.3 | 2.9 |
| | 1.29 | 1.21 | 1.20 | .90 | 1.01 | 1.07 | 1.20 | 1.0 | 1.33 |
| 5-Fun | 2.5 | 2.9 | 3.2 | 2.1 | 2.01 | 2.2 | 1.9* | 2.6 | 2.7 |
| | 1.02 | 1.08 | 1.21 | .99 | 1.01 | 1.07 | 1.20 | .99 | 1.00 |
| 6-Product | 2.7 | 2.6 | 2.4 | 3.3 | 3.2 | 3.2 | 2.5 | 2.9 | 2.5 |
| | 1.14 | 1.27 | 1.25 | 1.25 | 1.24 | 1.26 | 1.34 | 1.12 | 1.18 |
| 7-Child | 3.1 | 3.3 | 2.5 | 3.0 | 2.9 | 2.9 | 2.0 | 2.8 | 3.8 |
| | 1.02 | 1.03 | 1.06 | .96 | .91 | 1.00 | .96 | .92 | .93 |
| 8-Compli- | 3.0 | 3.1 | 3.8 | 2.8 | 2.7 | 2.8 | 3.5 | 3.2 | 3.4 |
| cated | 1.06 | 1.06 | 1.06 | 1.06 | .94 | 1.02 | 1.15 | 1.03 | 1.04 |
| 9-No Com- | 3.2 | 3.1 | 2.9 | 3.8 | 3.3 | 3.7 | 2.5 | 3.2 | 2.7 |
| mitment | 1.20 | 1.36 | 1.44 | 1.24 | 1.24 | 1.29 | 1.36 | 1.27 | 1.33 |
| 10-Imper- | 2.5 | 2.3 | 2.2 | 3.0 | 2.7 | 3.7 | 2.6 | 2.9 | 2.2 |
| sonal | 1.05 | 1.11 | 1.06 | 1.25 | 1.14 | 1.37 | 1.25 | 1.31 | 1.20 |

| Pole 1 | Demo | CBT | D&P | Prob Solv | Sim. | Creat Writ. | Games | Tut. | Info. Ret. |
|---|---|---|---|---|---|---|---|---|---|
| | M | M | M | M | M | M | M | M | M |
| | SD | SD | SD | SD | SD | SD | SD | SD | SD |
| 11-Satis- | 2.4 | 2.7 | 2.7 | 2.1 | 2.2 | 2.2 | 2.4 | 2.5 | 2.3 |
| fying | .96 | 1.03 | 1.17 | .96 | .96 | 1.10 | 1.11 | .95 | 1.01 |
| 12-School | 2.1 | 1.9* | 2.0 | 2.2 | 2.3 | 2.4 | 3.3 | 2.1 | 2.6 |
| Use | .92 | .95 | .98 | .91 | .99 | 1.18 | 1.27 | .89 | 1.03 |
| 13-Useless | 3.7 | 3.4 | 3.6 | 4.1* | 3.8 | 3.7 | 3.1 | 3.7 | 4.1* |
| | 1.01 | 1.07 | 1.17 | 1.05 | 1.09 | 1.27 | 1.16 | 1.04 | 1.05 |
| 14-At Ease | 2.5 | 2.7 | 2.1 | 2.3 | 2.6 | 2.6 | 2.5 | 2.3 | 2.3 |
| | 1.04 | 1.14 | 1.06 | 1.05 | 1.15 | 1.04 | 1.27 | .96 | 1.05 |

L: Logo B: BASIC Pole 1: The label for the pole ranked 1; the complete labels may be found in Table 2.

*Value between 1 and 2 or 4 and 5.

M: Mean

SD: Standard deviation

n=116

have been in question.

Demonstration, Drill and Practice, Simulation, and Tutorial had no ratings in the extreme ends of the poles. People seemed to have moderate ideas about these applications coming into the course, and the same moderate ideas at the end in terms of desirability.

None of the more extreme ratings could be characterized as surprising. Computer Based Testing was rated definitely as more appropriate for school use than home. Problem Solving was very desirable, and was perceived as needing a lot of involvement, being very active, and very useful. Creative Writing was seen as being creative learning, needing involvement, and very active. Games were definitely rated as fun, and finally, Information Retrieval was seen as very desirable and very useful.

The general tone of responses implies at least an initial receptiveness to a broad range of uses of computers. Of course, the group of teachers in this sample may be seen as biased, as they are interested enough to enroll in computer courses. But perhaps this willingness to learn is not as unusual as some reports would have us believe (Samson, 1985; Vincent, 1985). A recent study by the CEQ, the union of more than 90% of the primary and secondary school teachers in Quebec, showed clearly that teachers want training, want to be informed, and are not afraid to welcome the new technology as it is being thrust upon them

(Centrale de l'enseignement du Quebec, 1985).

Attitude Stability

The implications of this overall receptiveness are heartening for those who believe in the potential for diverse applications--beyond programming--and must give the skeptics pause. Teachers are not reacting in a "knee-jerk" way, but are actively seeking information. However, as we have seen, this information may not have the kind of impact on attitudes that one might hope for. Attitudes are, by definition, "consistent over time" (Summers, 1970, p.2) and "relatively enduring" (Rogers, 1983, p.169; Shaw & Wright, 1967, p.3) and represent "consistencies in the responses of individuals" (Triandis, 1971, p.7). As Summers (1970) is quick to point out, though, this does not mean that attitudes are immutable. If they were, much of the advertising industry would not exist!

How does this attribute of attitudes fit with the results of the research reported here? As was stated above, the most striking result of the study was the relatively minor nature of changes in attitude which occured, considering both programming languages and time as independent variables. This supports the consensus within the literature that while changeable, attitudes are certainly distinct from whims, in that explicit effort is usually required from someone (either the person involved or an external agent) to realize significant changes in attitude.

## II: A Method for Questionnaire Development

### Development Phase

The process of and rationale for the development of an attitude questionnaire using Personal Construct Theory as a base have been described in some detail in earlier sections of this document. The goal was to produce, as objectively as possible, an instrument which would serve to both seek out a consensus among a group of people towards a group of items at the same time as allowing one to perceive the discriminations that a group of people makes among items. In order to clarify the generalizability of this procedure, this section will restate the steps followed in more generic terms than ones specifically related to computers in education.

### Technique Selection

As McGrath, Martin and Kulka (1982) point out, much of the research process is marked by "judgment calls"; decisions which must be made without the benefit of objective rules or algorithms which if followed will necessarily lead to the "correct" answer. This may initially appear to be just another appeal to the "good judgment" of the researcher that Osgood et al., (1957) defer to. However, judgement calls can be based on general <u>public</u> guidelines, if not about what to do, at least about what not to do. In that spirit, and with no intention of speaking as a "methodological evangelist" (McGrath et al., 1982), the following guidelines are offered for choosing a Personal Construct Theory-based Questionnaire. (In the interests of brevity, this will be referred to from now on as a PCT Questionnaire.) Although one of the primary motivations behind the development of the methodology detailed above was to diminish the reliance on "good judgement", we are still a long way from algorithmizing the research process.

Appropriateness of the self-report approach. Although self-report techniques are recommended whenever possible for attitude assessment (Henerson et al., 1978; Oppenheim, 1966; Triandis, 1971), there are times when a self-report approach will not be the most appropriate. There are three basic questions which must be answered before one can choose this approach: 1) Are the people whose attitudes you are investigating able to understand the questions? 2) Do they have sufficient self-awareness to answer? 3) Do they have any reason to lie (or not be completely honest)? (Henerson, et al., 1978) If the answers to these questions are 1--yes, 2--yes, and 3--no, then it is reasonable to proceed with this approach; if not, one must examine alternatives such as reports of others, sociometric procedures, projective techniques, records, or physiological responses.

Self-report criteria. As mentioned above, the method developed by this researcher relies on the triadic approach to construct elicitation, one of the six originally descibed by Kelly (1955). Given the complexity of this method, it is not recommended for children under the 10 to 12 years-of-age range, the mentally handicapped, the deaf, or those who have not mastered the language used in the dialogue (Fransella & Bannister, 1977). Self-report techniques are not necessarily inappropriate with children; however, the PCT method should not be used with the groups mentioned above.

Criteria for choosing PCT questionnaire. Once one has established that a self-report approach may be used, the next task involves choosing among the many tools and techniques which exist for measuring, or developing measurement instruments for, attitudes. There are certain requirements which must be met in addition to those common to all self-report techniques; there are also indicators which can help one to determine if the PCT approach will be the most appropriate for the specific case at hand.

Appropriateness of topic. Not all topics are best dealt with by a PCT Questionnaire. If one is interested in exploring norm-referenced attitudes, such as attitudes toward self or others, or attitudes toward school, school-related concerns, work, or general interest, many standardized instruments exist which may well be easier and more useful (e.g. for comparison purposes) (Henerson et al., 1978). However, the topic of interest may be one for which no standardized instrument exists, or the group being assessed may be sufficiently "different" that standardized tests with standardized norms do not apply. The key here is standardized for whom: for example, a test normed to American male teenagers may not provide a useful point of comparison for an older mixed group of Canadians.

The topic must also be sufficiently complex to allow for the construct elicitation process. If the question is only how a group felt about _a_ book or _a_ film then a PCT Questionnaire is not appropriate; if rather, one is interested in reactions to a number of books or films, then one is in the range covered by this technique. For example, with the PLANET software a minimum of six elements is needed--these can be six courses or six elements of a course; the level of each element is not important, only that all elements are on the same level. One should not, for example, compare _Time_, _Newsweek_, _Maclean's_, _Business Week_, _People_, and books.

_Appropriateness to question._ As with any research problem, the question being asked will influence the method chosen. A PCT Questionnaire will not provide one with an approval rating _per se_, but rather give an indication of _how_ and _what_ a specific group thinks about a group of elements. There are also no guarantees that the elicited constructs will parallel the researcher's if the researcher has specific questions to be answered (i.e. constructs to be rated).

One point about this technique is either a plus or a minus, depending on the context. Because each questionnaire must be generated for a specific group and a specific topic, the comparability to other populations or topics is inherently limited, as questionnaires arising from those investigations would be different. However, because each PCT Questionnaire is context and population specific, it will have a local relevance that a standardized test cannot have. The trade-off between generalizability and specificity is one that must be evaluated on a case-by-case basis.

Who is the researcher. If the researcher generates a questionnaire for a group of which she or he is a member, then there is at least a sample of one from the target population. On the other hand, the values of an insider are likely to be biased, resulting in a biased questionnaire. When the researcher is from outside the target population, the generation of a questionnaire with no input from that population is more likely to reflect the researcher's constructs than the target population's, resulting in asking the wrong questions or asking questions which the population is incapable of answering at an acceptable level of validity. The PCT Questionnaire approach overcomes aspects of both these problems. Refering to the literature for the generation of constructs does not really address the problem; literature is a medium which transmits values from authors to readers. Therefore, when a review of the literature is used to identify constructs, these constructs will again be coming from outside the target population. One has merely substituted the good judgement of the researcher with the good judgement of previous researchers.

Logistical considerations. There is no denying that this procedure is the antithesis of a "quick-and-dirty" technique of developing a measurement instrument. There are significant requirements in terms of time, on the part of both the researcher and the members of the target population, and resources, in terms of access to computer support and volunteers for the development phase. The time required is not only hours of work, but also a sufficient time-span to allow for instrument development, pilot testing, revision, group administration, and analysis. Each circumstance will define the viability of such an investment of time and effort. However, it is argued that educational curriculum questions which cost such vast sums of time and money deserve a level of advisement seldom allotted.

Some requirements are imposed by the statistical analyses. MANOVA, for example, requires a sample size that would produce 20 degrees of freedom for error in the univariate case (Tabachnick & Fidell, 1983); in other words, a minimum of 20 cases in the smallest group that will be compared. Conversely, large samples may present limitations with respect to data processing; for example, this design could not be analyzed as a single matrix (e.g. 14 constructs x 15 elements) due to hardware limitations.

Questionnaire Development

Assuming that one does indeed have a problem for which this technique is the most appropriate, there are then five steps to be followed in the development of a PCT Questionnaire. These are element selection, construct elicitation, construct analysis, pilot test, and pilot evaluation and revision (Winer & Schmid, 1985).

1) Element selection. In research applications which have as a goal the assessment of attitudes towards a given topic, or extraction of knowledge in a specific domain, the researcher is starting with an area of focus. This translates into a set of elements which she or he has a rationale for selecting *a priori*. In this particular example, the area of focus was computers in education; Shaw (1980) and Shaw and McKnight (1981) offer many examples of other possible target areas.

The process followed to identify the specific elements will vary depending on the nature of the target area: if it is public and established, a literature review will serve to highlight elements of public interest; if the target area is particular to a situation or a time, consultation with local "experts" will serve to highlight elements of group interest. No matter which route is followed, and some combination of both may prove to be the most useful (as was the case in this study), what is crucial is that clear, unambiguous definitions of these elements are available for consultation by the raters. Review of these definitions by experts and intelligent "laypeople" alike is the best way to ensure mutually comprehensible items.

<u>2) Construct elicitation</u>. A sample of the target population creates the pool of constructs from which the final selection will be drawn. Because this small group will to some extent speak for the whole, care must be taken that the range of qualities found within the target population is as fairly represented as possible. Using the same core of elements, subjects work through the Repertory Grid Technique using PLANET, and provide as many or as few constructs or additional elements as they wish. Each person works in a form of isolation, with no feedback of the patterns being created by the ratings, nor any indication of other people's constructs or ratings. This isolation offers freedom from other people's expectations that may otherwise inhibit the expression of original forms of expression.

<u>3) Construct analysis and selection</u>. The goal of construct analysis is to identify the constructs which are either common to the majority of the group or important discriminators for specific elements. The way that constructs "physically" group together in space provides an indication of those which are similar to each other and those which stand apart. Those constructs which are different are equally important to include as are those which are common,

as these may provide important insights into distinctions between elements.

This step may be accomplished using either the SOCIOGRIDS procedure of the PLANET package or a commercially available cluster analysis package such as BMDP, or a combination of both. This largely depends on the number of constructs and grids to be analyzed and the degree of overlap of elements in the different grids. Obviously, due to hardware limitations, the power of a program such as PLANET implemented on an Apple II Plus with 48k of memory is inherently limited. The smaller the number of constructs and grids and the greater the degree of overlap, the less there is a need to augment the process with recourse to more powerful programs.

The particular constructs selected out of a cluster is ultimately a subjective decision on the part of the researcher. What seems to "make sense" is one criterion; others can be the simplest words which are used as pole labels, and labels which recur over constructs in the same cluster. Even though the researcher is forced at this point into a subjective stance, at least she or he may be subjective about constructs coming from a source other than an expert speaking <u>ex cathedra</u>. One may be generous at this stage in including constructs--if two constructs seem semantically different even though they are in the same cluster, it is better to err on the side of caution. This is not a final cut, and different wordings may evoke more useful discriminations. It is also reasonable to include a construct if it explicitly addresses a concern of the researcher.

4) Pilot test. A complete paper and pencil version, including all definitions and instructions, as well as specific questions regarding the presentation and comprehensibility of the questionnaire, should be distributed to as many of the construct elicitation group as possible. In addition, other members of the target population who did not participate in the construct elicitation process and who are unfamiliar with Personal Construct Theory and Repertory Grid Technique should be included. Directions which may be very clear to those somewhat familiar with the elements, constructs, and general procedure may be less so for newcomers. The inclusion of outsiders at this point will also alert the researcher to the possibility that one (or more) construct(s) is meaningless to someone who did not go through the process personally.

5) Pilot evaluation and revision. The easiest part of this step consists of clarifying any instructions or definitions that were identified (or can be seen to have been) problematic. The more difficult part is that of analysing the constructs to eliminate redundancy. If the policy of caution advocated in step 3 was followed, there is doubtless redundancy built in. If the time taken to complete the

questionnaire was acceptable (for both the researcher and the participants), then no modification is necessary. The risk is of having more than one way of expressing the same idea, but this is not a risk with serious consequences. If, however, as is more likely to be the case, the time required is unacceptable, a decision guide for construct elimination must be used. At this point, the interest is no longer in the physical proximity of constructs, but rather in accounting for the space between them with the fewest number of constructs. This involves another analytical tool based on a distance model, principal components analysis.

A principal components analysis is run on each element rated in the questionnaire. Following appropriate rotations, the loadings of each construct on each element are tabled, and the relative importance of each construct can then be assessed with respect to each element and the group of elements as a whole. A construct may turn out to be minimally implied in all of the elements, an important contributor to many of the elements, or important to only a few of the elements.

The researcher is faced at this stage with conflicting goals. On the one hand, the aim is to eliminate as many constructs as possible to reduce the amount of time required. On the other, the aim is to sacrifice the minimum amount of information possible. The amount of reduction possible may be related to the number of elements involved:

it would seem intuitively reasonable that five related elements may be described with fewer constructs than would fifteen; however, if those five represent the same continuum as the fifteen, this may not be the case. Again, caution must be the governing influence. If too many constructs are included, and fatigue becomes a factor in the number of constructs used, as long as constructs have been presented in a random order to raters, the effects of fatigue will result only in a reduction of n size. If, however, too many constructs are eliminated, there is a risk of losing information across the board.

Result of the Development Phase

At this point, the researcher has a powerful tool with which to begin large-scale research. The elements are those which are of specific interest to the project, and the constructs are ones of meaning to the target population. By using members of the target population as a touchstone, the researcher avoids the otherwise unavoidable imposition of her or his own personal constructs onto the population.

## Analysis Phase

The previous section discussed criteria for choosing a PCT Questionnaire approach and described the process of developing such a questionnaire. This section will both describe the analysis procedure and results with the specific questionnaire and case involved in this study, and then restate the procedure in comparable generic terms to those of the Development Phase section.

<u>Questionnaire Assessment</u>

Upon receiving the completed questionnaires, the first step was to examine the instrument to assess the contribution of each of the constructs to the composite picture of each element. A similar procedure to the one carried out after the pilot administration was tried to check for possible redundancy. Fifteen separate principal components analyses, one for each element, calculated the loadings of the fourteen constructs on each of the fifteen elements separately.

<u>Principal components analyses</u>. The results were examined and from them one could see that in order to be left with a manageable number of factors (i.e. not more than five), a cut-off of 60% of the variance accounted for would have to be used. When one compares this with the reduction procedure from the pilot questionnaire, in which the first five factors accounted for more than 90% of the variance, one may already infer that there is less redundancy between these fourteen constructs than there was with the twenty. Nevertheless, an attempt was made to examine the contribution of each construct using the same criterion employed previously, namely that any construct which did not load significantly (defined in this case as loading between -.60 and +.60) on any element would be considered to be less important and perhaps suitable for elimination. Table 9 provides information as to the number of factors and per-

Table 9--Number of Factors and Variance Accounted For (Admin.1)

| Element | No. of Factors | Variance (%) |
|---|---|---|
| Computer Literacy | 4 | 61.4 |
| Demonstration | 3 | 60.1 |
| Artificial Intelligence | 3 | 63.2 |
| Computer Based Testing | 4 | 60.2 |
| Word Processing | 4 | 61.5 |
| Programming | 5 | 66.2 |
| Drill and Practice | 4 | 61.0 |
| Graphics | 5 | 65.0 |
| Problem Solving | 4 | 62.7 |
| Simulation | 3 | 63.5 |
| Creative Writing | 4 | 64.9 |
| Computer Managed Instruction | 4 | 64.2 |
| Games | 5 | 66.4 |
| Tutorial | 4 | 65.0 |
| Information Retrieval | 5 | 64.4 |

centage of variance accounted for in the factors examined.

In order to arrive at the most accurate factor loadings, the principal components analyses were run again with oblique rotations as this rotation relaxes the requirement of orthogonality. As well, the number of factors required to account for at least 60% of the variance was specified. The problem of determining the number of factors to extract in a factor analysis is one for which there is no hard and fast rule (Ajar, 1982). The cut-off of 60% is less arbitrary than it may first appear. For the majority of cases, it corresponded to what the results would have been if the Scree test (Cattell, 1966) or the default criterion of SPSS of eigenvalues of less than one had been employed as the sole criterion.

As the goal here was to assess if each construct was being used by each group (in other words, had the pilot sample provided an adequate and accurate cross-section of people), the principal components analyses were run on the group as a whole, and split by language group. Complete results are presented in Appendix F. No construct could easily be described as redundant.

<u>Selected MANOVA comparisons</u>. Because no constructs were identified as redundant by the analysis approach followed previously, another approach to reducing the data was explored. This consisted of performing a series of MANOVAs using the between-subject Hotelling's program of SPSS to

check for differences between constructs that could be expected to be similar on semantic grounds. This represented an attempt to check statistically for redundancies on the level of apparent meaning; for example, one might assume that if something was desirable, it was therefore useful. However, before eliminating one or the other of these two constructs, an objective test of the researcher's necessarily subjective decision was desired. Ten separate MANOVAs were performed, each looking for a multivariate difference using the fifteen elements as dependent measures. The following comparisons were made:

| | | |
|---|---|---|
| Desirable--Not Desirable | vs. | Very Useful--Useless |
| Satisfying--Frustrating | | I Feel At Ease With--I Do Not Feel At Ease With |
| Needs Involvement--Does Not Need Involvement | | Active--Passive |
| Needs Involvement--Does Not Need Involvement | | Needs Commitment--Does Not Need Commitment |
| Active--Passive | | Needs Commitment--Does Not Need Commitment |
| Child Oriented--Adult Oriented | | Appropriate for School Use--Appropriate for Home Use |
| Complicated--Simple | | Useless--Very Useful |
| Complicated--Simple | | Very Useful--Useless |
| Complicated--Simple | | I Feel At Ease With--I Do |

| | |
|---|---|
| | Not Feel At Ease With |
| Complicated--Simple | I Do Not Feel At Ease With--I Feel At Ease With |

All of the MANOVAs had F values that were significant at an alpha level of .01 (see Appendix G for the results of each analysis). It should be noted that when the pole ends were opposite to each other (e.g. Desirable (1)--Not Desirable (5) vs Useless (1)--Very Useful (5)), the ratings were reversed. It was clear from this analysis that different constructs were resulting in different placements in space of the elements. At this point, analysis of the questionnaire itself stopped, and analysis of the questionnaire data began.

Missing Data

At this point, it is important to mention the way that missing data was dealt with in the MANOVA analyses. As was mentioned above, Tabachnik and Fidell (1983) point out that missing data may in and of itself provide important information. This possibility was explored in the general examination of how the questionnaire was responded to in the first section of this chapter. Once it had been established that there were no patterns to the missing data, it could safely be ignored for the earlier analyses. However, given the nature of MANOVA, i.e. a multivariate analysis, the question of how to treat missing data required consideration. One option was to eliminate all missing data. This would mean, however, that any time a person left out one construct for an element, all of the person's ratings for that element would be eliminated. This seemed to be unnecessarily conservative, implying a substantial loss of data. Following the recommendations of Tabachnick and Fidell (1983), the decision was made to substitute missing values with the means of the group from which the subject came (i.e. Logo or BASIC, Administration 1 or Administration 2). This approach follows a regression-type model of the data set.

This solution was not, however, applied across-the-board. There is an obvious difference between someone who leaves out a few constructs for one element and someone who leaves out a substantial number. The cut-off point of one-half was chosen: if someone left out less than half of the constructs for an element, her or his scores would be substituted by the mean; alternatively, if more than half were left out, that person's ratings for that element would be eliminated. This strategy seemed to be a balanced approach to missing data, resulting in minimal distortion of the data. If one looks back at Table 5, which gives the percentage of constructs on which elements were rated, one sees that all elements were rated by the group at least 90% of the time. This indicates that the quantity of missing data was not a problem, the concern was only to eliminate the relatively few cases where an element was not rated on most of the constructs.

## Data Analysis

Given the use of a new technique, there was no established analytic strategy to assist in the interpretation of the data. Therefore, the question of how to analyze these data to extract the most and the most meaningful information possible was not trivial. It would have been very easy to have been overwhelmed by the sheer volume; ways of structuring the questionning and interactions with the vast quantity of numbers had to be found. It is a measure of the richness of the data that the problem was never one of finding questions that could be answered, but rather limiting the investigations to a single, cohesive path. Many other questions besides the one regarding differential effects of programming languages are answerable, and other approaches to answering these questions besides the one taken here should be explored. The questions not answered and paths not taken will be examined in the final chapter of this document.

Matrix analysis. Since attitude had been defined as multivariate, and since the fifteen different uses of the computer could be considered multivariate by virtue of their presumed low correlation, a first thought was to perform an overall 14 x 15 (constructs by elements) MANOVA. This was rejected on several grounds. First of all, the size of the matrix meant that it literally could not be done. There is a hard limit of 200 dependent variables with SPSS MANOVA (Hull & Nie, 1981); however, even an IBM with virtual memory could not handle more than a 7 x 14 matrix (C. Gilley, personal communication, February 7, 1986).

The second reason for rejecting this approach stemmed from the question of how could one interpret such an analysis, assuming for a moment that it could be run. Basically, for the purposes of the research question of this study, it would be uninterpretable. It would have been useful in providing an error term which would more accurately reflect the underlying variance, and if it could have been run, it would have for that. However, as the coherence provided by the element on constructs structure would be lost, it would not help in the comparisons desired in this research. If one were interested in pursuing the concept of reduction of dimensionality, touched on briefly above and discussed further in the last section of this document, an analysis of the whole matrix of data would serve to identify redundancies of constructs across elements, and vice versa.

Element by element comparisons. The governing principle in the analysis phase had to be the preservation of the meaning built into the procedure by the development process. This meant that the ratings for each element had to be considered in their entirety. As the original question had concerned changes in attitudes towards the different uses of computers, and not comparisons among them, the decision was made to make the comparisons between language groups and administrations on an element by element basis. This implied running fifteen different 2 x 2 MANOVAs (language by administration) with the 14 constructs as the multiple dependent variables. This procedure answered a number of questions simultaneously, as each analysis checked not only for interactions, but also for significant main effects of language and/or administration.

It could be argued that Administration should have been treated as a within-subject factor, and a repeated-measures MANOVA with only one between-subject factor (Language) should have been run. This would have resulted in a reduction of the n-size by half, a considerable loss of data. The decision to treat Administration as a between-subject factor, thereby doubling the n-size, was compensated for by the fact that in treating Administration as a between-subject factor rather than a within-subject factor (as would have been the case if a repeated-measures had been run), the error term was of course increased, thus making any results more conservative.

Missing data. It should be mentioned that missing data were dealt with here in the same way that they were in the analysis of the constructs: when less than half of the constructs for a particular element were missing, the mean value for the group (by language and administration) was substituted; when more than half of the values were missing, that subject was eliminated for that element.

Follow-up analyses. How to interpret significant multivariate differences on elements by language or administration was the next problem. When there were none, it was easy; all that one had to do was describe the group as a whole. But when there were differences, the natural tendency was to try to interpret the univariates. However, the problem of univariates is a bit of a Catch-22: the reason that one does a MANOVA instead of a series of ANOVAs is because the dependent variables are not uncorrelated; however, the correlation of the dependent variables means that it is difficult to attribute the difference to one of two (or more) correlated dependent variables. As Tabachnick and Fidell (1983) point out, "to say that two correlated [dependent variables] are both 'significant' mistakenly suggests that the [independent variable] is affecting two different behaviors" (p.253). Finn (1974) cautions that "separate F statistics for variables that are correlated are not independent of one another and should not be used as partial tests of multivariate hypotheses" (p.320).

One way of dealing with this is by adjusting the alpha level for the univariate F's to reduce the probability of committing a type I error, and that was done in this study. (Only univariate F's with $p<.01$ were reported.) However, this is not a complete solution. Extreme caution must be exercised in interpreting univariates, and certainly no decisive claims may be made for specific constructs. However, as Finn (1974) also points out, "separate F statistics for each of the outcome measures provide useful descriptive data" (p.320). It is in this spirit that the univariate Fs were approached.

<u>Generic Strategy</u>

How one would structure the analysis in another study would necessarily depend on the specific research question being asked; however, there is a generalizable strategy that can be extracted from the one followed here.

<u>Construct verification</u>. The first steps concern verification of the contribution of the different constructs. Both principal components analysis and MANOVA, used as above, will help to identify if any constructs are redundant.

<u>Group comparison</u>. The simplest approach to follow here is using MANOVA with as many independent variables as needed, keeping in mind, however, that more than three will be difficult if not impossible to interpret if there is an interaction. This approach is very flexible, and can be used to examine pre-stated areas of interest, such as language in this case, as well as for <u>post hoc</u> comparisons (for example, age or experience could have been used as an independent variable rather than being controlled for). More detailed discussion of other analysis strategies may be found in the last chapter of this document.

# CHAPTER 5

## CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

A number of conclusions that may be drawn from this research, as well as suggestions for future activities, will be discussed below.

### The Language Debate

The importance of attitudes in a process of change and the various reasons why Logo and BASIC might have had differential effects on teacher attitudes towards uses of computers in education were dealt with earlier in this document. If differential effects had been found, an argument would have been made that, regardless of other considerations, one or the other of the languages was useful to teach because of its affective influence. However, given that teacher attitudes towards the different uses of computers in education seem to be relatively unaffected by courses in programming languages, where does this leave those responsible for curriculum decisions? The issue of language will not quietly just go away; for example, Cameron and Craighead (1984) and Moore (1984), in discussing teacher education curricula, suggest varying levels of programming competence in one or more programming languages, leaving the choice as to which open. If anything, the language debate has heated up recently, with other contestants joining the contest to become "the" language for education.

<u>BASIC vs. Logo revisited</u>. BASIC is still being taught, and the primary rationale still seems to be its pervasiveness. "BASIC isn't really the best language for writing AI programs, but it is the most popular language on micros and this fact makes it worth the inconvenience of using it." (James, 1984, p.8) Substitute "educational software" for "AI" and you'll have the current state of the argument for BASIC: almost no-one will say that it's good on its merits, only that it's around. However, this prevalence may be deceptive. As Self (1985) comments, versions of BASIC abound; unfortunately, as many of these are nonstandard versions, the availability does not translate into portability as programs must be translated between machines.

There are, however, those willing to make the argument against BASIC loudly and clearly, not to mention passionately. After discussing the technical reasons for his views, Bork (1985) comes out unequivocally against BASIC.

> The arguments for teaching BASIC because of the widespread availability of BASIC are similar to the "arguments" for an exclusive diet of junk foods: they are easy to get and everyone is using them! In fact, it is a good analogy to describe BASIC as the junk food of computer programming languages. The analogy works even further. If a person has spent a lot of time eating only junk food, it is

> difficult for the person to resume a normal diet. The same situation obtains with BASIC. One can fairly say that BASIC poisons many students, producing bad habits that are extremely difficult to overcome, if they can be overcome at all. (p.29)

He concludes by stating: "My very strong recommendation is 'DON'T TEACH BASIC!'" (p.31), leaving no doubt as to his position.

Self (1985), also after a discussion of its technical limitations, describes BASIC as "such a limiting language that few professional programmers would seriously contemplate using it for a program of any size" (p.152) and indirectly blames BASIC for both the present and future poor quality of educational software.

Given that a course in BASIC does not seem to have much effect on how teachers think about educational computing, and given that BASIC is the target of such fundamental (and substantiated) attacks, perhaps the inclusion of BASIC in teacher training curricula at all ought to be seriously reconsidered.

Does this leave Logo as the default language of choice? Certainly Logo has many eloquent champions (the programs for the Logo 84 and Logo 85 conferences alone testify to the amount of activity this programming language cum educational software has engendered). But should it be taught as a programming language *per se*? That Logo is not just a kid's language was clearly demonstrated by Abelson and di Sessa's 1981 book which used Turtle geometry for university-level mathematics concepts. The technical considerations of Logo are dealt with by Abelson (1982) and Harvey (1982), although Bork (1985) disagrees with them on two points, namely that requiring data typing is bad, and on the efficacy of the control structures in Logo.

But should Logo, given its accompanying philosophy of education, really be taught as a programming language for creating educational software? Logo is arguably not a "toy" language, given its powerful list-handling heritage from Lisp. However, consider Self's (1985) statement that "there has been no suggestion that educational software packages should be written in Logo (as they have in BASIC). The Logo interpreter is the educational software package." (p.100) This means that rather than considering Logo as a programming language, it would probably be more useful to consider it as one of the possible uses of computers in education. This places Logo outside considerations based on computer science criteria alone, but puts it squarely within the context of educational criteria. Much more emphasis must be placed, then, on how to use Logo within a class in a way faithful to the vision set out by Papert, if that is what is desired. Logo as a curriculum innovation runs a serious risk of going the way of other curriculum innovations if this problem is not addressed. Bork (1985) and Self (1985) both point to examples where Logo has been divorced from its original intentions: sometimes in obvious ways, such as students entering only programs given to them by their teachers, and other times in more subtle ways, such as an implementation which did not separate the defining of a procedure from its execution, thereby disallowing the top-down programming style which is valued within Logo.

All of this indicates that Logo has an important place within education, although care must be taken to place it within a context suitable to exploit its potential without placing unfair expectations for it to serve as a multipurpose tool for all educational computing applications.

Other programming languages for and in education. Other general-purpose programming languages (as distinct from authoring languages such as NATAL, PILOT, etc. which were conceived specifically for the development of computer-based learning materials) are being promoted for use in education. Godfrey and Sterling (1982) support Pascal for developing computer-aided learning; Bork (1985) also considers Pascal the language of choice for many serious educational software development applications.

Prolog has also been heralded as an important language for use within education, in much the same words as Logo. "The major goal of this research is to provide children with a rich computational environment for doing interesting natural language projects." (Kahn, 1984, p.178) If one substitutes "mathematics" for "natural language", one could be talking about Logo. Kowalski (1984) presents Prolog as the operationalization of logic and "logic as a computer language for children" (p.121). Ennals (1983) presents Prolog as the best way to have computers aid in "developing logical thinking in children, which has been central to academic learning of all centuries, using a computer-intelligible form of logic" (p.13). Given an increased move towards applying artificial intelligence techniques within educational computing (for example: O'Shea & Self, 1983; Schank, 1984; Self, 1985; Vázquez-Abad & Larose, 1984; Yazdani, 1984), and given the use of Prolog for artificial intelligence, notably by the Japanese, perhaps more attention should be paid to the appropriateness of this language for certain educational ends.

The main point to remember in this discussion about languages is that the issue must be kept in context. As Schank (1984) points out:

> Programming languages are not simply highly stripped down versions of human or 'natural' languages. Programming languages allow only one way to say things, with a specified syntax and a very limited vocabulary, allowing no ambiguity. Programming languages enable the computer to understand instructions for moving various symbols around, and to decide the order in which such com-

> mands should be executed. It is not possible, in a programming language, to discuss something, voice an opinion, or elaborate a point. The representation of abstract ideas and of concrete events is the province of natural languages alone. (p.14)

Self (1985), in discussing the relative merits of different programming languages, points out that "all programming languages are equivalent, in that any program which can be written in one language can be rewritten in another, in principle" (p.99). The question, then, which must be kept in mind is why one wants to teach any language at all. Bork (1985) points out one of the common misassumptions in the area of computer programming.

> Often in teaching programming, it seems implicitly assumed that <u>everyone</u> will be a programmer in some distant future....While it is a fact that everyone will be a computer user, that is not to say that everyone will be a computer programmer. (p.18)

If curriculum designers for teacher training are able to articulate what the instructional objectives are which will be met by teaching programming, this should go a long way to help in the rational selection of appropriate languages. A criterion suggested by Bork (1985) for selecting a language to be taught to students is equally applicable one level up:

> Educators must always ask what the students are ex-

> pected to do with programming skills once they have them. We could teach a five-year-old to run a machine lathe, but it is not a wise thing to require in the educational process because it is not useful for such a student. (p.19)

Languages in their educational context. There are a number of reasons one can imagine for wanting to teach programming languages to teachers. If the goal is to teach programming so that teachers learn how to program for its own sake, one must consider the criteria developed within the discipline of computer science. This implies systems analysis as an important part of the curriculum and certainly an emphasis on structured programming techniques.

One may also have the goal of wanting to give teachers a tool for "quick and dirty" applications; for example, a quick drill for students who are falling behind in a given topic or a simple interest rate calculation program. In that case, one is not particularly interested in teaching computer science, but rather the use of a tool--and then an authoring language, such as Pilot or Scénario, may be the most appropriate. Self discounts BASIC for "programs of any size", but one can imagine useful applications of computers which need programs that are small enough to avoid the injunction, and BASIC may be useful, as it is prevalent.

Other serious applications for education will clearly require serious programming, and the "teacher cum programmer" or tcp as Self (1985) labels her or him, will not be able to create the kinds of applications needed without the aid of serious programming expertise. The creation of the final product is probably best left to a computer scientist. However, what of languages for development applications, the creation of a prototype which can then be turned over for reprocessing into a more efficient package? A number of languages have been suggested as useful for this activity: Lisp (Kraft, 1986), Prolog (Cabrol, 1985), and Logo (A. Keller, personal communication, December 13, 1985). However, if one is teaching a language with the goal of software development, this must be both conscious and explicit, and appropriate techniques must accompany the language.

One argument made for teaching programming to teachers was to allow them to "massage" software to suit their particular needs (Winer & Vázquez-Abad, 1983). This argument, which had particular relevance for BASIC, has become obsolete with the increased protection of software from modification. This protection is sometimes achieved by the sheer complexity of the program combined with a lack of documentation; in other cases programs are effectively closed to outsiders by sophisticated copy protection techniques.

However, it is becoming increasingly apparent that many serious educational applications can be done using tools that were conceived for other purposes, for example, word processing, spreadsheets, and data bases. In these cases, in addition to teaching the use of the package itself, one needs to stress the development of the instructional activity which will optimize its eductional usefulness. If one is teaching a programming language for a use other than simply programming, then attention must be paid to its implicit pedagogical environment--if you teach Logo to teachers, one must include a consideration of the development of microworlds for educational purposes (cf David, 1985); if one teaches Prolog to teachers, one must include the development of instructional activities for logical data bases (cf. Nichol & Dean, 1984), etc.

Quite simply, either one is teaching a programming language to allow for a kind of application to be developed, in which case one should follow computer science criteria to select the most appropriate language, or one is teaching a programming language for its potential as an educational environment for students, in which case one must include the educational context with the language.

<u>The Quebec Context</u>

The preceeding discussion was not placed specifically within the Quebec context. It is important to consider its relevance to Quebec. In the spring of 1985, a revised version of the 1983 <u>Proposition de dèveloppement</u> of the Ministry of Education in Quebec was issued, the <u>Micro-informatique Plan de dèveloppement</u>. It clearly identified teacher training as a priority.

> La formation et le perfectionnement des personnels, particulièrement des enseignants, constituent le volet le plus important du plan d'action. Toute démarche ou initiative nouvelle, si prometteuse soit-elle, qui entraîne un changement dans les stratégies d'enseignement ou les pratiques pédagogiques, doit être étroitement conjuguée à des mesures touchant les autres personnels si l'on veut qu'elle prenne un bon départ et soit durable. Les nombreuses exprériences vécues ces dernières années dans le système scolaire québécois comme ailleurs démontrent à l'évidence la nécessité de ressources humaines compétentes et motivées pour l'implantation d'une innovation pédagogique de cette envergure. C'est pourquoi, il importe au plus haut point, que le ministère de l'Education et les commissions scolaires, selon leurs responsabilités propres, fassent tous les efforts nécessaires pour sensibiliser et former adéquatement les enseignants et les autres personnels de l'éducation qui touche déjà l'implantation de la micro-informatique dans le système scolaire. (p.22)

A variety of training programs, offered directly by the Ministry (the Programme d'introduction and the Programme de formation légère), school boards (as pedagogical day workshops), and universities (ranging from the Octo-Puce series coproduced by Télé-Université and TVOntario, to on- and off-campus credit courses offered by all Quebec universities except one) have been created or expanded since 1983. According to results of a study carried out by the CEQ, approximately 51% of teachers have received some kind of training, however minimal or informal (they include self-teaching). It is interesting to note that more than 10% of reported users of microcomputers report having received no training whatsoever (CEQ, 1985).

The satisfaction levels reported with the various training programs range from 79.4% satisfied or very satisfied (with Octo-Puce) to 63.5% satisfied or very satisfied (with the Programme de formation légère); the universities had a satisfaction rate of 70.2%. While certainly acceptable, there is room for improvement, and it falls therefore to university curriculum designers to consider suggestions from the teachers themselves. It is important to remember that specific university courses were not identified, therefore each university program must try to extract from the data those aspects which are most relevant to it.

According to the CEQ, "Les besoins quant au contenu de la formation ont été clairement exprimés: connaissance des diverses applications pédagogiques de l'ordinateur, de ses impacts psychopédagogiques et sociaux, de ses diverses utilisations en classe, des logiciels existants et des critères pour leur choix." (CEQ, 1985, p.43) The main criticism of existing programs was their overemphasis on technical aspects of the computer and programming. "Plusieurs programmes de formation sont encore beaucoup trop centrés sur les aspects techniques de l'ordinateur et sur la programmation." (CEQ, 1985, p.43)

That there is an interest in learning about a range of possible uses of computers in education was clearly demonstrated. Teachers were asked explicitly if they were interested in learning about general teaching support applications, enrichment activities, simulations, exercises for remediation as well as general usage, test construction, problem analysis and solving, educational games, and record-keeping. Only record-keeping (at 63%) and educational games (at 69.3%) did not have more than 70% of the teachers very interested or interested. This level of interest in a wide range of applications supports the concerns of this dissertation in two specifc, and related, ways.

First, the CEQ findings underline the need to ask questions which go beyond the broad, now somewhat "motherhood" term of educational computing in general. When one adds to the nine applications identified by the CEQ questionnaire those which users identified as current (namely drill-and-practice, simulation, educational games, tutorials, general learning activities, word processing, data bases, spreadsheets, and telecommunications applications), one can see that the range of actual uses is broad enough to warrant the complexity derived from asking about specific applications.

Secondly, the results of the CEQ study support the original concern of this dissertation with programming languages. Given that learning either language per se does not have a significant side-effect of influencing attitudes, what language would it make most sense for teachers to learn in the present context? As Bork (1985), among others, points out, computer literacy is not defined by being a programmer, and teachers may be effective tool users without being able to create the tools themselves. If teacher training is to include programming, it must be as a means to a predetermined end, rather than an end in itself.

This implies the promotion of a variety of instructional applications of computers. Therefore, the general trends discussed in the previous section seem to be explicitly supported within Quebec, and of signficant interest to Quebec teachers.

Issues Other than Language

This research began with a question about programming languages, and therefore the interest in other variables which might influence attitude, such as age, sex, subject matter expertise, level of teaching, years of experience, computer use, etc. was limited to ensuring that these variables would not confound the study. This was done by establishing their equal representation in the groups under study. This is not to say, however, that further investigation of these variables might not give interesting results.

Similar analysis procedures to those reported above could be followed, examining alternative possible sources of difference. Gilligan (1982), for example, presents a number of examples where men and women have significantly different conceptual frameworks for approaching areas with affective components. Turkle (1984) discusses differences between hackers and "normal" users--the amount of computer use may be correlated with differing perceptions. C.P. Snow (1959) discussed the two cultures--humanism and science--long before the emergence of the microcomputer. Do these cultures exist within the area of educational computing--it would be interesting to contrast teachers with Arts backgrounds against teachers with Science backgrounds.

These are some suggestions for further variables which could be explored as potentially important in the attitude formation of teachers.

Other Analysis Possibilities

The previous section made some suggestions for variables other than language which might be important in the ongoing development of teacher attitudes towards computers in education. These variables could be studied by the procedure described above, as they are all concerned with identifying differences between groups in ratings of computer uses. However, there are other questions which one might want to ask about teacher attitudes which would touch more on the underlying structure of the attitudes or the classifications implied by these structures. To answer these questions one would employ different analysis techniques to the one employed in this study. One strength of the PCT Questionnaire is that the development procedure of the questionnaire would still be the same, only the analysis procedure would change to fit the question.

<u>A factor analytic approach to attitude change</u>. Alternative approaches to the analysis of the data may warrant further research. For example, because of the multidimensional nature of attitude, change in attitude could also be defined as a change in dimensionality; i.e., if a larger or smaller number of factors is needed to "explain" the variance after treatment than before, or between groups, one could then infer that there has been a change or that there is a difference in attitude. The concept of dimensionality encompasses both the number of constructs involved (implying a larger or smaller conceptual framework) and elements (more or less variability in perceptions of computer use). This approach would require a different model of statistical analysis than the one used in this study; for example, factor analysis techniques.

A method such as J-factors (Jöreskog, 1967; Jöreskog &

Sorbőm, 1979), which uses the Maximum Likelihood Method for fitting the model matrix to the sample covariance matrix, would be applicable. With this approach, one begins with the hypothesis of one common factor and proceeds in an iterative manner adding one factor at a time until significance tests indicate that a given factor model does not deviate significantly from the observed data.

Results of dimensionality analysis. This reduction of dimensionality by factor analysis could be extended to looking at the composition of the underlying structure. As mentioned above, both the constructs and the elements may be examined using this approach. If the reduction is done on the constructs, then conclusions could be made on the overlapping of allegedly different constructs within the context studied. The existence of unexpressed contructs composed of a combination of the expressed ones could also be investigated. If, on the other hand, the reduction process is carried out on the elements, then conclusions could be made on the perception of the different uses of the computer. This could have direct implications for teacher training curriculum planners, by identifying areas which need attention to clarify potential misconceptions; for example, if Tutorial is seen to be equivalent to Drill-and-Practice, then specific emphasis must be given to their differences, and the distinctions must be made clear.

A cluster analytical approach. A different approach to the question of reduction of dimensionality, namely cluster analytical techniques, might also provide useful results. The question of typologies of educational computing applications was touched on briefly earlier in this document. However, even a brief look is sufficient to show that there are different ways of classifying the same range of uses. If one contrasts Coburn et al. (1982) and Rushby (1979) one can see the differences: Coburn et al. are concerned with what the computer is doing--is it testing, is it teaching, is it being programmed; Rushby emphasizes the role of the learner--is the user testing hypotheses, being instructed, etc. These classifications, and others in the literature, appear useful. But are they useful to the teacher? Finding what clusters obtain in the field, and working backwards from those clusters to identify the constructs and/or factors which discriminate one from the other, would be an empirical way to establish a typology, one based on the teacher's perspective.

<u>The PCT Questionnaire Method</u>

The most important aspect of this work was the marriage between an implementation of a theory and a practical application. The techniques of Personal Construct Theory were used, and can be used again, as a means to an end, namely establishing the content of an attitude questionnaire. The validity of the process of developing a questionnaire in this way comes from the validity of the source; in other words, Personal Construct Theory. The PCT Questionnaire capitalizes on the fact that both the theory and its accompanying techniques are inherently suited to the task at hand, namely the elicitation of constructs and their subsequent use to discriminate among a group of related items and between groups of people. PCT is useful in this case because one wants information from a specific population which can be considered the best source of information about itself. The characteristics of both the object of inquiry and the target population must combine to allow for the choice of this method--this case qualifies on both counts.

Within self-report techniques, the method developed and tested allows the researcher to step outside herself and not be forced to rely solely on one person's perspective, however well-intentioned and comprehensive that may be. The theoretical validity of PCT is strong; the method proposed respects that and points out a new area to which it may be applied.

<u>Summary</u>

Two areas were of concern in this dissertation: one of content and one of methodology. The content was the effects of learning two programming languages on teachers' perceptions of uses of computers in education; this question is addressed throughout this document. The methodological concern was to develop a method for creating questionnaires which would reduce the potential for experimenter bias while increasing the contextual relevance of the resulting instrument. The procedure outlined in detail is an approach which worked in this case, and would work in other contexts. The method not only provided a means of answering the specific question of this study, but is capable of answering other kinds of questions, as illustrated in the above suggestions. What has been created, then, is another tool for the educational technologist's toolbox. As practitioners and applied researchers, we are constantly faced with answering new questions, ones that are new in both substance and kind. To do this, we need a variety of tools at our disposal, tools that we must choose wisely, but must then serve us well.

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# Appendix A

## Pilot Version of Questionnaire

# Computers in Education

## An Attitude Questionnaire

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This questionnaire is designed to explore your attitudes about different uses of computers in education. All information will be kept strictly confidential, so please feel free to give your honest opinion.

Age _____ Male ____ / Female ____ Last 4 digits of telephone number _______ (For administrative purposes only.)

Teaching Experience:

Years ______ Subject(s) ____________________

Level ______ Current Occupation ____________________

Computer Experience:

Do you use a computer on a regular basis? ________
If yes, for what? ____________________

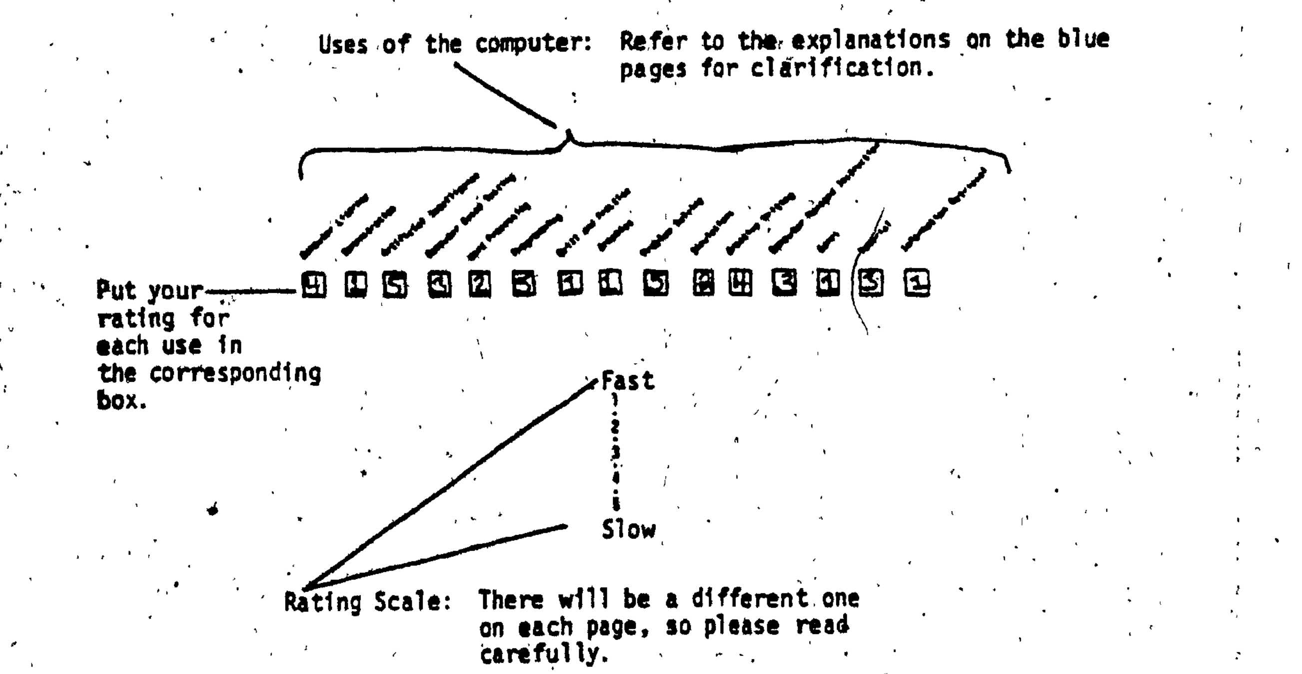
What computer languages (if any) do you know, and in what order did you learn them?

| | Knowledge of | Order Learnt |
|---|---|---|
| BASIC | ____ | ____ |
| LOGO | ____ | ____ |
| FORTRAN | ____ | ____ |
| Other (specify) | ____ | ____ |

This questionnaire asks you to rate a variety of different uses (or potential uses) of computers in education on a number of different rating scales. Each page has a list of the uses and a new scale. Explanations of the different uses are provided on the blue pages following the instructions. Please read them carefully before you begin and refer to them at any point when filling in the questionnaire.

On each of the remaining pages you will find a different rating scale. Please read it carefully and then rate each different use on that scale. Your rating should consider 1 to be the meaning at the top, 5 the bottom, and 2, 3, and 4 equally divided points along the line. Indicate your rating by placing a number in the corresponding box. Feel free to adjust your ratings, but please make sure your final rating is clearly indicated.

A sample page follows.



EXPLANATIONS OF THE DIFFERENT USES OF COMPUTERS IN EDUCATION

Computer Literacy: The general range of skills and understanding needed to function effectively in a society increasingly dependent on computer and information technology.

Demonstration: Using the computer to illustrate principles or processes, either as proof or supporting evidence.

Artificial Intelligence: A branch of computer science that has the aim of developing machines capable of carrying out functions normally associated with human intelligence such as learning, reasoning, self-correction, and adaptation.

Computer Based Testing: Using the computer to store test questions, generate tests, administer tests, and/or analyze and store results.

Word Processing: The use of a computer to facilitate the production, design, revision, reformatting, and storage of textual material.

Programming: The process by which a set of instructions is produced for a computer to make it perform specified activities; carried out in languages such as BASIC or LOGO.

Drill and Practice: A learning technique in which the student is presented with a structured succession of exercise questions designed to give him or her practice in a particular subject area.

Graphics: Arrangements of characters or other symbols on an output device to represent a visual pattern such as a map or diagram.

Problem Solving: The analysis of a situation and the application of appropriate skills and knowledge for the realization of a specified goal.

Simulation: The use of the computer to allow students to manipulate certain aspects of a model of a real or imaginary system.

Creative Writing: The use of the computer to allow students to create and revise compositions, either individually or in groups.

Computer Managed Instruction: The use of the computer to manage the process of learning by routing students through non-computerized learning material, testing their progress, keeping records of their performance, etc.

Games: The use of the computer for an activity in which one or more players strive toward the attainment of a goal within prescribed rules.

Tutorial: A use of the computer in which the student is led through the learning material via a structured question and answer dialogue, with remediation provided when necessary.

Information Retrieval: The searching of a data base (an organized and structured collection of data) to elicit useful information.

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Desirable

1
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2
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3
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4
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5

Not Desirable

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| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Guided Instruction

1
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2
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3
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4
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5

Free Exploration

If you're not absolutely certain that you're filling out this questionnaire correctly, please reexamine the sample page.

| Computer Literacy | Administration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Impersonal

1
2
3
4
5

Personalized

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Child Oriented

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2
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3
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4
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5

Adult Oriented

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| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Used for Teaching

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2
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3
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4
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5

Used for Administration

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Satisfying
1
2
3
4
5
Frustrating

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| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Would Use With Young Children
1
2
3
4
5
Would Use With High School Students

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Active
1
2
3
4
5
Passive

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| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

School Use
1
2
3
4
5
Home Use

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | |

Pictorial

1
2
3
4
5

Non-Pictorial

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | |

Does Not Need Commitment

1
2
3
4
5

Needs Commitment

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Useless

1
2
3
4
5

Very Useful

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| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Not Essential

1
2
3
4
5

Essential

Co... eracy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval

Colourful

1
2
3
4
5

Not Colourful

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Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval

At Ease With

1
2
3
4
5

Not At Ease With

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Product Oriented

1
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2
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3
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4
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5

Process Oriented

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| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Complicated

1
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2
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3
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4
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5

Simple

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Fun

1
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2
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3
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4
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5

Boring

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| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Involvement

1
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2
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3
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4
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5

No Involvement

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Creative Learning

1
2
3
4
5

Not Creative Learning

---

COMMENTS

Time taken to complete (approximately) ____________

Were there any rating scales that you did not understand or were not applicable to all of the uses? Please specify. ______________________________

______________________________

(You may go back and write directly on the page concerned.)

Did you find the boxes for the numbers too small? ____________

ANY other comments? ______________________________

______________________________

______________________________

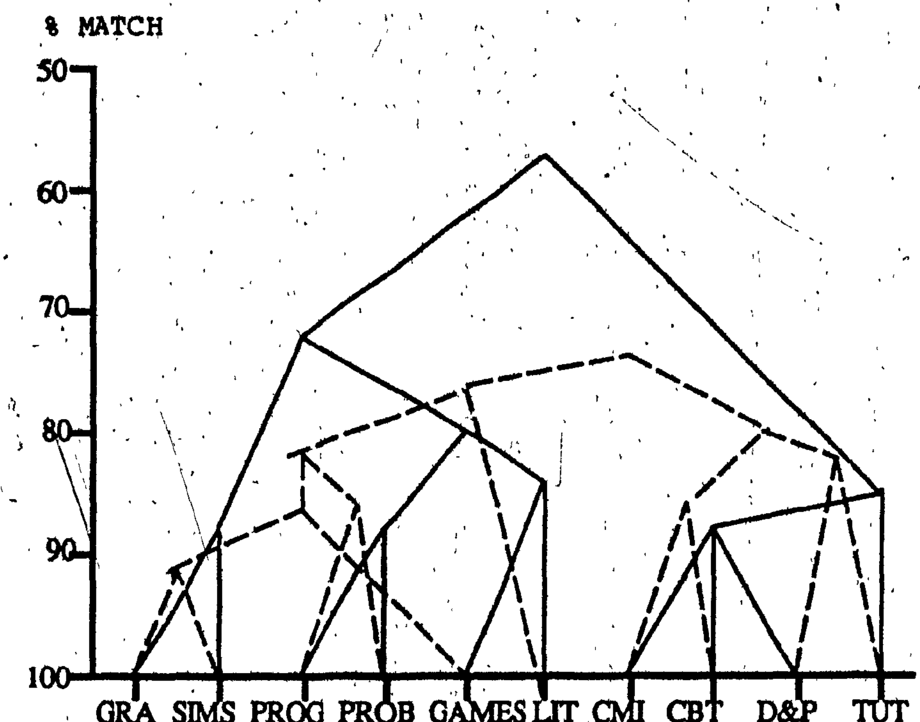
______________________________

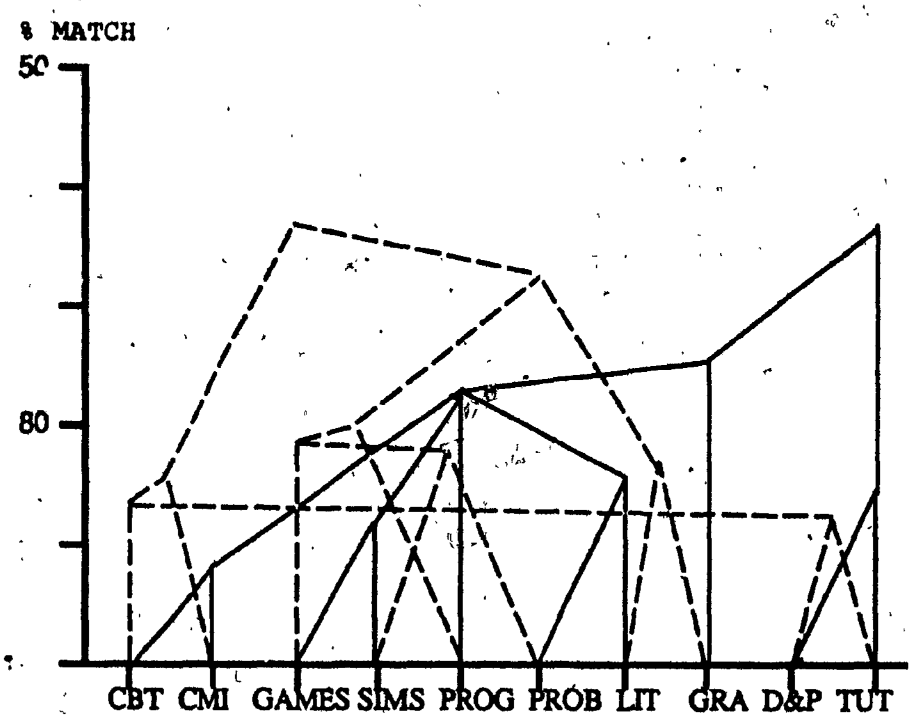
# Appendix B

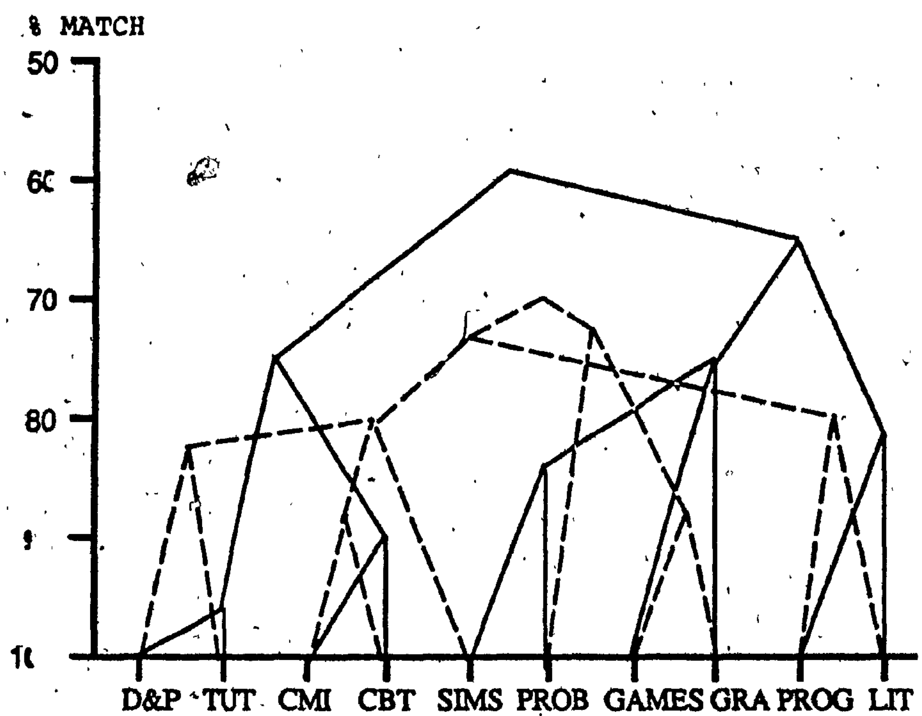
## Comparisons of Element Clusters for Individuals who Completed Elicited Grids and Pilot Version of Questionnaire

LEGEND

| | |
|---|---|
| CBT | Computer Based Training |
| CMI | Computer Managed Instruction |
| D&P | Drill and Practice |
| GAMES | Games |
| GRA | Graphics |
| LIT | Computer Literacy |
| PROB | Problem Solving |
| PROG | Programming |
| SIMS | Simulations |
| TUT | Tutorial |
| ——— | Clusters from elicited grids |
| – – – | Clusters from pilot version |




% MATCH
50
80
CBT CMI GAMES SIMS PROG PROB LIT GRA D&P TUT


% MATCH
50
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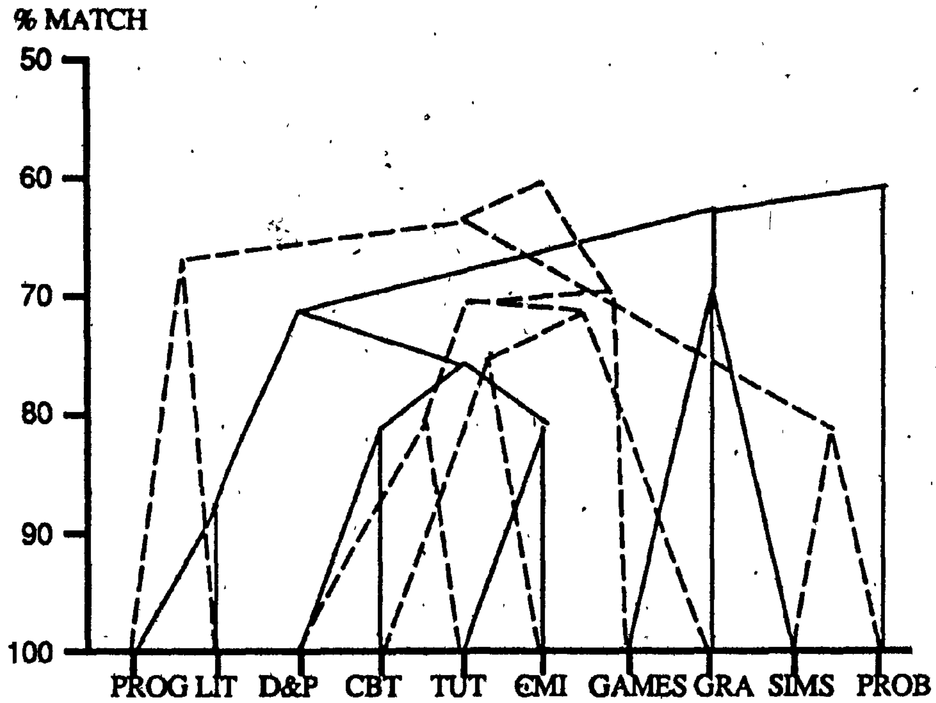
80
D&P TUT CMI CBT SIMS PROB GAMES GRA PROG LIT


% MATCH
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90
100
PROG
LIT
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CMI
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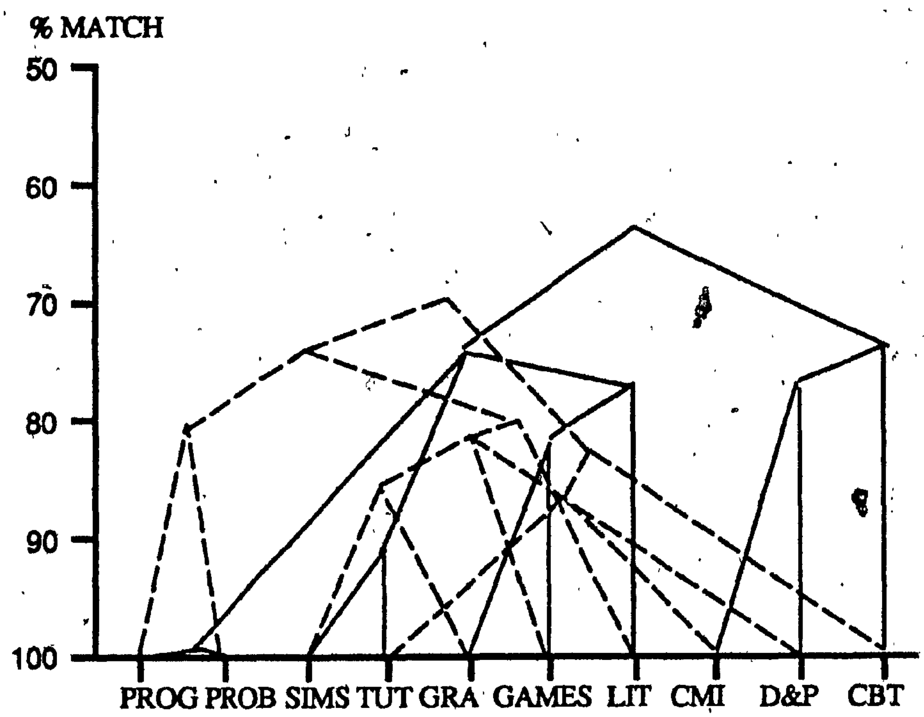
PROB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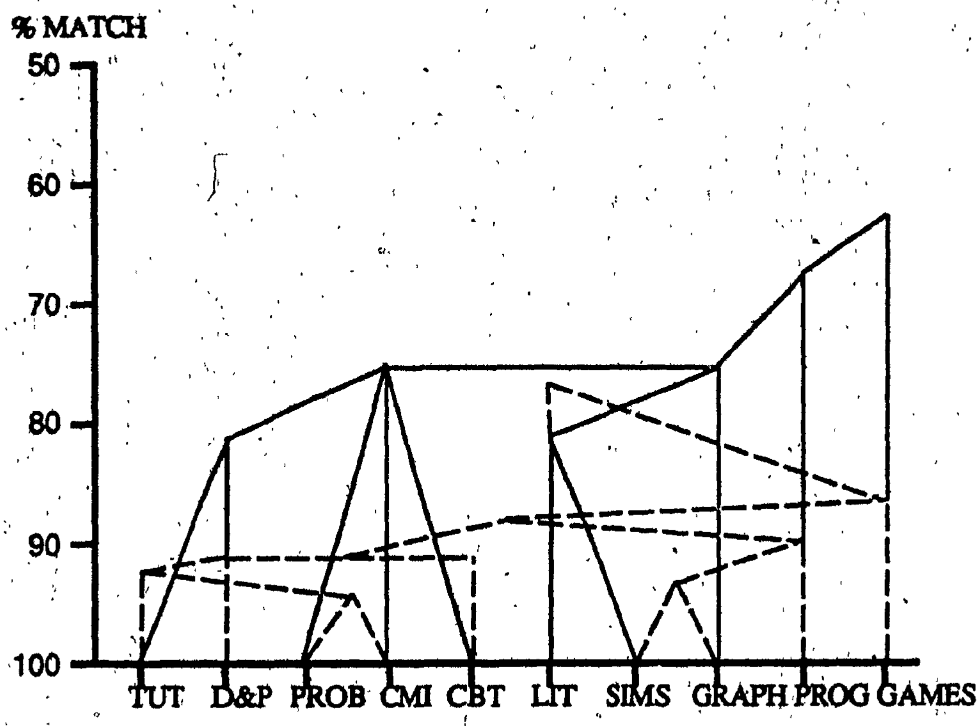
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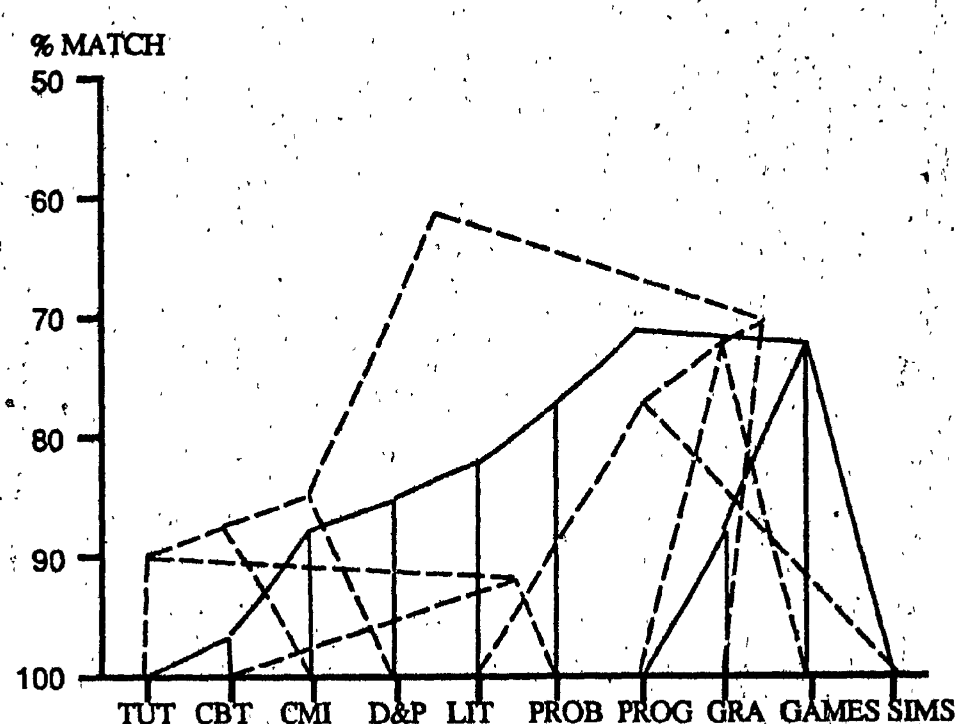
GAMES


% MATCH
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CMI
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GRA
GAMES
SIMS

# Appendix C

## Principal Component Loadings for Construct Elimination Process after Pilot Test

CONSTRUCTS

1 - Not Essential--Essential
2 - Desirable--Not Desirable
3 - Needs Involvement--Does Not Need Involvement
4 - Creative Learning--Not Creative Learning
5 - Active--Passive
6 - Guided Instruction--Free Exploration
7 - Colourful--Not Colourful
8 - Fun--Boring
9 - Pictorial--Non-Pictorial
10 - Product Oriented--Process Oriented
11 - Would Use with Young Children--Would Use with High School Students
12 - Child Oriented--Adult Oriented
13 - Complicated--Simple
14 - Does Not Need Commitment--Needs Commitment
15 - Impersonal--Personalized
16 - Satisfying--Frustrating
17 - Used for Teaching--Used for Administration
18 - Appropriate for School Use--Appropriate for Home Use
19 - Useless--Very Useful
20 - I Feel At Ease With--I Do Not Feel At Ease With

ELEMENTS

1 - Computer Literacy
2 - Demonstration
3 - Artificial Intelligence
4 - Computer Based Testing
5 - Word Processing
6 - Programming
7 - Drill and Practice
8 - Graphics
9 - Problem Solving
10 - Simulation
11 - Creative Writing
12 - Computer Managed Instruction
13 - Games
14 - Tutorial
15 - Information Retrieval

| Construct Number | Element Number 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | x | | | x | | x | x | | x | x | x | x | x | |
| 2 | x | x | x | | x | | x | x | | x | x | x | | x | x |
| 3 | | x | x | | | x | x | x | x | x | | x | x | x | |
| 4 | | x | x | x | | x | x | x | x | x | x | x | x | x | x |
| 5 | x | x | x | x | | x | x | x | x | x | | x | x | x | |
| 6 | | x | | | | x | | | | | x | | | | x |
| 7 | | | x | x | | x | x | | | x | x | x | | | |
| 8 | x | | x | x | x | x | x | x | x | x | | | x | x | |
| 9 | x | | | x | | x | x | | | | x | x | | x | |
| 10 | x | | x | x | x | | | x | x | x | x | x | x | | x |
| 11 | | | x | | x | | x | x | | | x | | x | | |
| 12 | x | | | | | | x | | | x | x | x | x | x | x |
| 13 | | x | | x | | x | x | | | | | x | x | x | x |
| 14 | | | | x | x | x | | x | | | x | x | x | | x |
| 15 | x | x | | x | | x | x | | x | x | x | | | x | x |
| 16 | x | x | x | x | x | x | x | | x | x | | x | | x | x |
| 17 | | x | x | | x | x | | | x | | x | x | | | x |
| 18 | | x | x | | x | | | x | x | x | | | x | x | x |
| 19 | x | x | x | x | x | | x | x | x | | | x | | x | x |
| 20 | | x | | x | | x | | | x | x | x | | x | | x |

Each x represents a loading between -.60 and +.60 of the construct on the element.

# Appendix D

## Final Version of Questionnaire

# Computers in Education

## An Attitude Questionnaire

### Final Assessment

Peter Burpee
Educational Media Program
Faculty of Education, McGill University

This questionnaire is designed to explore your attitudes about different uses of computers in education. All information will be kept strictly confidential, so please feel free to give your honest opinion.

Age ____ Male ___/ Female ___ Last 4 digits of telephone number
_______ (For administrative purposes only.)

Teaching Experience:

Years _______ Subject(s) ____________________

Grade Level(s) _________ Current Occupation _______________

Computer Experience:

Do you use a computer on a regular basis? Never____ Sometimes____ Frequently____

If yes, for what? ________________________________________

What computer languages (if any) do you know, what order did you learn them in, and with which do you feel most comfortable?

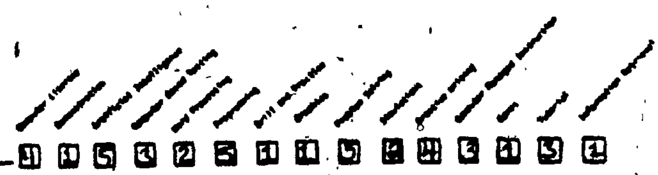
| | Knowledge of | In what order did you learn them | Ranked in order of which you feel most comfortable with |
|---|---|---|---|
| BASIC | ____ | ____ | ____ |
| LOGO | ____ | ____ | ____ |
| FORTRAN | ____ | ____ | ____ |
| Other (specify) | ____ | ____ | ____ |

As you may remember, this questionnaire asks you to rate a variety of different uses (or potential uses) of computers in education on a number of different rating scales. Each page has a list of the uses and a new scale. Explanations of the different uses are provided on the blue pages following the instructions. Please read them carefully before you begin and refer to them at any point when filling in the questionnaire.

On each of the remaining pages you will find a different rating scale. Please read it carefully and then rate each different use on that scale. Your rating should consider 1 to be the meaning at the top and 5 the meaning at the bottom. Indicate your rating by placing a number in the corresponding box. Feel free to change your ratings, but please make sure they are all clearly marked. If you think no rating is meaningful, please leave the box empty.

A sample page follows.

"Do you think that": ← Ask yourself this question for each use. For example, do you think that word processing is fast (1), slow (5), or somewhere along the scale (2, 3, or 4)?



Uses of the compute… Refer to the explanations on th… blue pages for clarification.

Put your rating for each use in the corresponding box.

is
Fast
1
2
3
4
5
Slow

Rating Scale: There will be a different one on each page, so please read carefully. You may find some of the uses difficult to rate, but please try to interpret the scale in a meaningful way. If you find it impossible to assign a rating, please leave the box empty.

EXPLANATIONS OF THE DIFFERENT USES OF COMPUTERS IN EDUCATION

Computer Literacy: The general range of skills and understanding needed to function effectively in a society increasingly dependent on computer and information technology.

Demonstration: Using the computer to illustrate principles or processes, either as proof or supporting evidence.

Artificial Intelligence: Using a computer to carry out functions normally associated with human intelligence such as learning, reasoning, self-correction, and adaptation.

Computer Based Testing: Using the computer to store test questions, generate tests, administer tests, and/or analyze and store results.

Word Processing: The use of a computer to facilitate the production, design, revision, reformatting, and storage of textual material.

Programming: The process by which a set of instructions is produced for a computer to make it perform specified activities; carried out in languages such as BASIC or LOGO.

Drill and Practice: A learning technique in which the student is presented with a structured succession of exercise questions designed to give him or her practice in a particular subject area.

Graphics: The process of developing arrangements of characters or other symbols on an output device to represent a visual pattern such as a map, diagram, or picture.

Problem Solving: The analysis of a situation and the application of appropriate skills and knowledge for the realization of a specified goal.

Simulation: The use of the computer to allow students to manipulate certain aspects of a model of a real or imaginary system.

Creative Writing: The use of the computer to allow students to create and revise compositions, either individually or in groups.

Computer Managed Instruction: The use of the computer to manage the process of learning by routing students through non-computerized learning material, testing their progress, keeping records of their performance, etc.

Games: The use of the computer for an activity in which one or more players strive toward the attainment of a goal within prescribed rules.

Tutorial: A use of the computer in which the student is led through the learning material via a structured question and answer dialogue, with remediation provided when necessary.

Information Retrieval: The searching of a data base (an organized and structured collection of data) to elicit useful information.

Do you think that:

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

is

Appropriate for School Use

1
.
2
.
3
.
4
.
5

Appropriate for Home Use

12

Do you think that:

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

is

Desirable

1
.
2
.
3
.
4
.
5

Not Desirable

1

If you're not absolutely certain that you're filling out the questionnaire correctly, please reexamine the sample page.

Do you think that:

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

is

Fun

1
2
3
4
5

Boring

Do you think that:

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

is

Child Oriented

1
2
3
4
5

Adult Oriented

7

---

Do you think that:

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

is

Active

1
2
3
4
5

Passive

4

Do you think that:

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Needs Involvement

1
.
2
.
3
.
4
.
5

Does not Need Involvement

2

Do you think that:

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

is

Complicated

1
.
2
.
3
.
4
.
5

Simple

8

Do you think that:

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

is

Impersonal

1
2
3
4
5

Personalized

10

For each of the following:

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

I Feel At Ease With

1
2
3
4
5

I Do Not Feel At Ease With

14

Do you think that:

Computer Literacy, Demonstration, Artificial Intelligence, Computer Based Testing, Word Processing, Programming, Drill and Practice, Graphics, Problem Solving, Simulations, Creative Writing, Computer Managed Instruction, Games, Tutorial, Information Retrieval

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

is

Useless

1
2
3
4
5

Very Useful

13

---

Do you think that:

Computer Literacy, Demonstration, Artificial Intelligence, Computer Based Testing, Word Processing, Programming, Drill and Practice, Graphics, Problem Solving, Simulations, Creative Writing, Computer Managed Instruction, Games, Tutorial, Information Retrieval

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

is

Product Oriented

1
2
3
4
5

Process Oriented

6

Do your think that:

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

is

Satisfying
1
2
3
4
5
Frustrating

11

---

Do you think that:

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

promotes

Creative Learning
1
2
3
4
5
Not Creative Learning

3

Do you think that:

| Computer Literacy | Demonstration | Artificial Intelligence | Computer Based Testing | Word Processing | Programming | Drill and Practice | Graphics | Problem Solving | Simulations | Creative Writing | Computer Managed Instruction | Games | Tutorial | Information Retrieval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Does Not Need Commitment

1

2

3

4

5

Needs Commitment

9

______________________________

COMMENTS

Time taken to complete (approximate) ____________

Were there any uses that you were unclear about? Please specify. ____________

______________________________________________________________

Were there any rating scales that you did not understand or were not applicable to all of the uses? Please specify. ____________

______________________________________________________________

(You may go back and write directly on the page concerned.)

What do you think has most influenced your attitudes towards computers? ______

______________________________________________________________

______________________________________________________________

Please feel free to make any other comments about either this questionnaire or the general issue of computers in education. ____________

______________________________________________________________

______________________________________________________________

(Use back if necessary.)

# Appendix E

## Cover Letter for Questionnaire Distribution

To: All Instructors of BASIC and LOGO courses

The enclosed questionnaire is part of a project which is investigating teachers' attitudes towards a variety of uses of computers in education. Please distribute it to your students and ask them to complete it at home and return it to you in class NEXT WEEK. Please also fill one of them out yourself and mark "Instructor" on the front. For each class, put all the completed questionnaires in the envelope provided, make sure that your class and section are clearly marked, and return it to me at the Faculty of Education as soon as possible.

This process will be repeated at the end of term, and the results will then be made available to you and interested students. Please assure your students that all responses are strictly confidential and that their participation is <u>essential</u> to the success of this research project. Your help with this study is greatly appreciated; if you have any questions, please do not hesitate to contact me.

Thank you

Peter Burpee
Director, Educational Media Program
Faculty of Education

# Appendix F

## Principal Component Loadings on Constructs for Group as a Whole and by Language

CONSTRUCTS

1 - Desirable--Not Desirable
2 - Needs Involvement--Does Not Need Involvement
3 - Creative Learning--Not Creative Learning
4 - Active--Passive
5 - Fun--Boring
6 - Product Oriented--Process Oriented
7 - Child Oriented--Adult Oriented
8 - Complicated--Simple
9 - Does Not Need Commitment--Needs Commitment
10 - Impersonal--Personalized
11 - Satisfying--Frustrating
12 - Appropriate for School Use--Appropriate for Home Use
13 - Useless--Very Useful
14 - I Feel At Ease With--I Do Not Feel At Ease With

ELEMENTS

1 - Computer Literacy
2 - Demonstration
3 - Artificial Intelligence
4 - Computer Based Testing
5 - Word Processing
6 - Programming
7 - Drill and Practice
8 - Graphics
9 - Problem Solving
10 - Simulation
11 - Creative Writing
12 - Computer Managed Instruction
13 - Games
14 - Tutorial
15 - Information Retrieval

Table of loadings for BASIC and Logo combined.

| Element Number | Construct Number 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | x | x | | x | | | x | x | x | x | x | x | x |
| 2 | | | | x | x | x | | | x | x | x | | x | |
| 3 | | x | x | | x | x | | | x | x | x | | x | |
| 4 | x | | | x | x | x | | | x | x | x | | x | x |
| 5 | | x | | | | | | x | x | x | x | x | x | |
| 6 | | x | x | x | x | | | x | x | x | x | | x | x |
| 7 | x | x | x | | x | x | | x | x | x | | x | x | x |
| 8 | | x | x | x | x | | | x | x | | x | x | x | |
| 9 | x | x | x | | x | x | | | | | x | x | x | x |
| 10 | x | x | x | x | x | | | | x | x | x | x | x | |
| 11 | | x | x | | x | x | x | | | x | x | | x | x |
| 12 | x | | x | x | | x | | | x | x | x | x | x | |
| 13 | x | | x | | x | x | | x | | x | x | x | x | x |
| 14 | x | x | x | x | x | x | x | | | x | x | x | x | |
| 15 | | x | x | | | x | x | | x | x | x | | x | |

Each x represents a loading between -.60 and +.60 of the construct on the element.

Table of loadings for BASIC group only.

| Element Number | Construct Number 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | x | x | x | | | | | x | | x | x | x | x | x |
| 2 | | | | x | x | x | | x | x | x | x | x | x | |
| 3 | | | | | x | x | x | x | x | x | x | | x | |
| 4 | x | | | x | | x | | | x | x | x | | | |
| 5 | x | x | x | | x | | x | x | x | x | x | x | x | x |
| 6 | x | x | | x | x | x | x | x | | x | x | x | x | x |
| 7 | x | | | | x | x | x | x | | x | x | x | x | x |
| 8 | | | | | x | x | | x | x | x | x | x | x | |
| 9 | x | | x | | x | | | x | x | x | x | x | x | x |
| 10 | x | x | x | | x | | | x | x | x | x | x | x | x |
| 11 | x | | x | x | | | x | x | | x | x | x | x | x |
| 12 | x | | x | x | x | x | x | x | | x | x | | | x |
| 13 | x | x | x | | x | x | | x | | x | x | | x | x |
| 14 | x | x | | x | x | x | x | x | | | x | x | x | x |
| 15 | | x | x | | | x | | x | | x | x | x | x | x |

Each x represents a loading between -.60 and +.60 of the construct on the element.

Table of loadings for Logo group only.

| Ele Num | Construct Number 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | x | x | x | | x | | x | x | x | x | x | | x | |
| 2 | x | x | x | x | x | x | | | x | x | x | x | x | |
| 3 | x | x | x | | x | | | | x | | x | | x | x |
| 4 | x | x | | x | x | x | x | | x | x | x | | | x |
| 5 | | x | x | | x | x | | x | x | x | x | | | x |
| 6 | x | x | | x | | | x | x | x | x | x | | x | x |
| 7 | | x | | | x | x | x | x | x | x | x | | x | |
| 8 | | x | x | x | x | x | x | x | | x | | x | | x |
| 9 | | x | | x | | | x | x | x | x | x | x | x | x |
| 10 | | x | | x | x | x | | x | x | x | x | x | x | x |
| 11 | x | x | x | | x | | x | x | | x | x | | x | x |
| 12 | | x | x | | x | x | x | x | | x | | | x | x |
| 13 | | x | x | | | | x | x | x | x | x | x | x | x |
| 14 | | x | | x | | x | x | x | | x | x | x | x | |
| 15 | | x | x | x | | | x | x | x | | x | x | x | x |

Each x represents a loading between -.60 and +.60 of the construct on the element.

# Appendix G

## Results of MANOVAs on Selected Constructs

Results of MANOVAs on selected construct pairs.

1) Desirable--Not Desirable vs. Very Useful--Useless
F=2.37 (15,99) p<.006

2) Satisfying--Frustrating vs. I Feel at Ease With--I Do Not Feel At Ease With
F=6.75 (15,96) p<.001

3) Needs Involvement--Does Not Need Involvement vs. Active--Passive
F=4.01 (14,95) p<.001

4) Needs Involvement--Does Not Need Involvement vs. Needs Commitment--Does Not Need Commitment
F=2.36 (14,96) p<.007

5) Active--Passive vs. Needs Commitment--Does Not Need Commitment
F=7.31 (14,96) p<.001

6) Child Oriented--Adult Oriented vs. Appropriate for School Use--Appropriate for Home Use
F=21.76 (15,88) p<.001

7) Complicated--Simple vs. Useless--Very Useful
F=23.97 (15,96) p<.001

8) Complicated--Simple vs. Very Useful--Useless
F=9.92 (15,96) p<.001

9) Complicated--Simple vs. I Feel At Ease With--I Do Not Feel At Ease With
F=10.79 (15,95) p<.001

10) Complicated--Simple vs. I Do Not Feel At Ease With--I Feel At Ease With
F=5.99 (15,96) p<.001