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EFFECTS OF QUANTITATIVE AND NON-QUANTITATIVE LITERACY ON THE KNOWLEDGE AND ADOPTION OF TECHNOLOGICAL INNOVATIONS

By

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ABSTRACT

EFFECTS OF QUANTITATIVE AND NON-QUANTITATIVE LITERACY ON THE KNOWLEDGE AND ADOPTION OF TECHNOLOGICAL INNOVATIONS

By

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Literacy has been used extensively in the study of factors influencing knowledge and adoption of technological innovations. The results have been mixed but generally show positive correlations.

This study's literature review revealed two omissions in prior explications of literacy which have prevented a more thorough test of the relative impact of literacy on knowledge and adoption of technological innovations, particularly in Developing Countries. These are quantitative literacy, which refers to the skill in the use of quantitative symbols and concepts, and literacy in English in those areas such as Africa where English is frequently not the dominant language.

The importance of both quantitative and non-quantitative (English) literacy is discussed. The study notes that the change agents and their rural clients of innovations generally differ in their linguistic repertoires with respect to the "language" of diffusion. While the former are generally college graduates who are generally educated and trained in English, the latter are not only generally illiterate in their native languages but, more importantly, most of them do not speak nor read and write in English--the language of

technology; and generally they have an unelaborate numbering system in their native languages or dialects. The implications for these problems are discussed.

The study reconceptualizes literacy into four levels: Level I comprising illiterate individuals; Level II for literacy in native language only; Level III being literacy in both a native language and in English (i.e., biliteracy), and Level IV which adds literacy in quantitative symbols and concepts to the Level III standard.

The study's basic purpose was to explore, through stepwise multiple regression analysis: the relative effects of quantitative and non-quantitative literacy in predicting awareness/knowledge and adoption of innovations; and the relative effects of non-quantitative literacy types and education measures on quantitative literacy. In addition, the study explores the correlations among literacy types, education, and awareness/knowledge and adoption of innovations; the relationship between education and propensity of adoption of complex technological innovations; and the relationship between the four constructed levels of literacy and knowledge and adoption of technological innovations. The study's data derived from two sample spaces; viz., Nigeria - Ilewo (N = 364), and the USA - Michigan (N = 230). The latter sample space was subdivided into the native English-speaking group (N = 169), and the native Spanish-speaking group (N = 61) for purposes of analysis.

Overall, the results indicated generally strong positive correlations among the measures of literacy and education. In predicting quantitative literacy, awareness/knowledge and adoption of innovations, literacy in English tended to be a stronger predictor than non-English native language; and in predicting knowledge and adoption, quantitative literacy tended to be a stronger predictor than literacy in English.

With the Spanish-speaking respondents, bilateracy was stronger than either Spanish or English literacy in predicting quantitative literacy, knowledge and adoption of innovation. Relatively low percentage of the variance in adoption was explained in all of the tests.

The Chi square tests indicated that level of education is generally positively related to the propensity to adopt those innovations which are more complex. Finally, the relationships between the four constructed levels of literacy and knowledge and adoption of innovations were not statistically significant, using one-way ANOVA, although the means were higher with higher levels of literacy.

Applications of the findings and ideas for future research were suggested.

My father, the late Benjamin Ogule
who initiated and inculcated into me
the norm of questioning and whose
determination was always to propel me
as far as humanly possible along the
formal road to truth; and my mother,
Kolobina Nakiria who continued this
process undaunted despite greater
social and economic problems, to them
I dedicate this dissertation.

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CHAPTER I

THEORETIC RATIONALE AND HYPOTHESIS

A. INTRODUCTION

Literacy has been used extensively in the study of factors influencing knowledge and adoption of technological innovations. The results have been mixed but generally show positive correlations. For instance, Rogers with Shoemaker (1971) report, among other generalizations in diffusion studies, that 24 (63%) studies support but 14 (37%) studies do not support the generalization that "earlier adopters are more likely to be literate than are later adopters" (p. 357); 61 (76%) studies support but 19 (24%) studies do not support the generalization that "earlier adopters have greater knowledge of innovations than later adopters" (p. 374); 32 (74%) studies support but 11 (26%) studies do not support the generalization that "change agent contact is positively related to higher education and literacy among clients" (p. 381); 17 (71%) studies support but 7 (29%) do not support the generalization that "earlier knowers of an innovation have more education than later knowers" (p. 347), and 203 (74%) studies support but 72 (26%) studies do not support the generalization that "earlier adopters have more years of education than do later adopters" (p. 354).

The literature reviewed revealed two omissions in prior explications of literacy, which, to this author, have prevented a more thorough test of the relative impact of literacy on individual's knowledge and adoption of technological innovations particularly in Developing Countries.[1] The two omissions[2] included: (a) literacy in quantitative symbols and concepts, and (b) literacy in English in those areas or communities where English is not the dominant language in daily discourse of the majority of the people.

Literacy in quantitative symbols and concepts refers to the skill in the use of quantitative symbols and concepts. A quantitative symbol or concept derives from number,[3] proportions of numbers (e.g., fractions, ratio, percent, etc.), and any statistical and mathematical structures and abstractions (e.g., symmetry, transitivity, ordinality, cardinality, probability, etc.) which are used to express the quantitative or conceptual character of phenomena such as technological innovations.

In contrast, a non-quantitative symbol or concept, by definition, includes that portion of spoken or written natural language which is devoid of the quantitative or conceptual character of number. Numerals may, however, be associated with a non-quantitative symbol or concept such as in denoting a technological innovation. In that case, the numerals so used merely denote the technological innovation rather than the quantitative nature or number abstraction of

the innovation; e.g., Aphex 70. Accordingly, it was conceived that literacy in English, which refers to the ability to read and/or write the English symbol system, is a subset of non-quantitative literacy. In areas or communities where English is not the dominant language in daily discourse, other subsets of non-quantitative literacy would include literacy in native languages or dialects in those areas or communities.

The purpose of this study therefore is to explore the relative potential effects of the two omissions noted above on predicting and explaining the knowledge and adoption of technological innovations. This exploration will involve a reconceptualization of literacy, the development of a quantitative literacy test instrument, and the test of the reconceptualization of literacy in two different settings, viz.: in Nigeria - Ilewo and USA - Michigan.

B. LITERATURE REVIEW

There is a plethora of documented reports and expressions of scholars and leaders throughout the world on the impact of literacy[4] on modernization and development variables.[5] A complete review of such literature would be superfluous (if not impossible) for the purpose of this study. Hence, this author will review in this section only some of the representative literature on literacy, and this will be done along four general headings: (a) Literacy

correlates, (b) Literacy function, (c) Skewed regional distribution of literacy, and (d) Prior conceptualizations of literacy.

1. Literacy Correlates

A cursory review of the literature on literacy indicates that literacy appears to affect the processes which manifest themselves in more modern attitudes and behaviors (see Lerner, 1958; Frey, 1964; Doob, 1961, 1965; Mendez and Waisanen, 1964; Lassey, et al., 1965; Rogers and Herzog, 1966; Herzog, 1967; Wright, et al., 1967; etc.). Schuman, Inkeles, and Smith (1967) found significant correlations in East Pakistan between literacy attainment and both the level of political identity and willingness to consider change. Lerner (1964) in Turkey, Rogers and Herzog (1966) in Colombia, and Rahim (1961) in Pakistan, all found highly significant correlations between literacy and exposure to mass media channels (radio, newspapers, and film) and awareness of new opportunities.

Summarily, significant positive correlations have been observed between literacy and five indices of modernization:[6] empathy (Lerner, 1958; Rogers and Herzog, 1966); achievement motivation (Rogers with Neill, 1966); cosmopoliteness (Lerner, 1964; Rogers and Herzog, 1966); mass media exposure (Rogers, 1966; Lerner, 1963; Deutschmann, 1963), and political knowledge (Lerner, 1958; Rogers and Herzog, 1966).

Studies involving industrial labor productivity have also shown significant positive correlations with literacy. Investigations in the USSR show that elementary literacy attained during each year of primary schooling increases labor productivity by an average of 30 per cent, and that one year of formal education is twice as effective as one year of on-the-job training in terms of productivity (Adiseshiah, 1970). Desai and Punalekar (1971) studied the relationship between literacy and economic productivity of industrial workers in Bombay, India. In general, they found that compared to illiterate workers, literate workers: (1) consistently performed day-to-day factory duties more efficiently, (2) showed a far greater understanding of the production process and a more developed sense of responsibility toward their work, (3) were more self-sufficient and more apt to join modern types of social organizations outside the world of the factory, (4) considered themselves much more self-reliant in the important domestic and civil activities, and (5) were much better acquainted with the co-operative credit society and medical benefits.

Hoiberg, Hysham and Berry (1974) sought to determine the neuropsychiatric implications of illiteracy among the U.S. Navy recruits in the Naval Training Center in San Diego, California. They found substantially more discharges for neuropsychiatric reasons among the illiterate enlistees who had been assigned to an Academic Remedial Training

Division (ART) than in a matched control group of literate men who had not been assigned to ART. They concluded that the enlistee who needs academic remedial training is a four times greater neuropsychiatric risk to the Navy than is the literate. The investigators noted that the conclusions drawn over 20 years ago by Hunt and Wittson (1951) are still valid. That is, individuals who need academic remedial training continue to be a greater neuropsychiatric risk to the military than are literates.

Recently, Stauffer, et al., (1978) investigated the abilities of literates and nonreaders to recall and use information from a national network television news program. The study involved 67 literates from a small, private college in suburban Boston and 61 adult basic education (ABE) students as nonreaders from Philadelphia Adult Basic Education Academy and the Adult Basic Learning Centers in Worcester and Brockton, Massachusetts. Among other findings, they observed that: (1) the literates recalled 55 per cent more stories than the nonreaders, (2) the literates gained 63 per cent more information from the news program than the nonreaders, (3) the two groups were virtually identical in their use of and opinions about television news, and (4) among the ABE students, significantly higher knowledge scores were achieved by younger students with more formal education and higher reading achievement levels.

These findings led the investigators to conclude that the remarkable memories of nonliterates in tribal societies, which have been noted by many scholars (e.g., Riesman, 1956; Junod, 1927; Cole, et al., 1971; etc.) should not be assumed on the part of nonliterates in a technological society such as the U.S.

Secondly, they argued that despite observations of compensatory "common sense" developed by functional illiterates in technological societies, this characteristic may not extend to an ability to recall and use information from television news with the same efficiency as literates. The study indicated that these populations cannot obtain information from television with equal ease.

The investigators speculated that one reason for this difference may be that the educational process that develops reading and writing skills also enhances the ability to decode visual and oral information. Test scores of ABE students were positively related to higher levels of reading achievement and formal education. In addition, the researchers reasoned that one other reason for the difference may be due to the difficulty of the language used by network news writers. Their analysis of random samples of transcripts of the newscast used in the study yielded a rating of "fairly difficult" (a category above "standard") on the Flesch Formula (Flesch, 1952) and a grade level rating of 13.0 on the Gunning Formula (Gunning, 1952).

Although these two techniques are an imperfect measure of the difficulty of spoken English, nevertheless the investigators argue that the findings from the analyses of the transcripts suggest that the oral difficulty of television news (complex sentence structure, multisyllabic words, use of highly specialized vocabulary) may constitute a considerable problem for the functional illiterate.

2. Literacy Function

Extensive use of literacy has generally been based on two interrelated convincing arguments for literacy.

First, it is argued that if a person is not literate, he/she cannot access print information. Second, literacy has a profound consequence for the cognitive structure and, ultimately, on the communication behavior of the persons endowed with it. That is, literacy alters the individual's perceptions of the symbol-referent relationship. This second aspect of literacy is noted to be more important than just the mechanical ability to read and write (see Rogers with Svenning, 1969; Herzog, 1967; Doob, 1966; Burnet, 1965; Lerner, 1963).

With literacy, change occurs in a number of mental abilities, such as a loss of eidetic ability, which becomes unnecessary according to Doob (1964) in his early research among Africans. Doob (1966) argues that eidetic imagery (a "photographic" ability to remember stimuli) "must reflect a human ability which has survived from some earlier

evolutionary state and which has become virtually functionless in modern (literate) adults."

According to Rogers with Svenning (1969), ". . . literacy seems to be a key for unlocking more complex mental abilities. Whereas the illiterate is largely dependent on memorization of details, the literate individual is able to manipulate symbols, which allows counterfactual thinking. The ability to generalize through symbolization, the faculty of restructuring reality via the manipulation of symbols, and the ability to empathize with strange roles are all mental capacities that facilitate one's effective functioning in a complex, rapidly changing urban-industrial world. Thus, one might view literacy as development of the fundamental skills of reading and writing, which leads to or is accompanied by growth of a set of mental abilities that are necessary to modernization" (p. 71).

This view of literacy has some support in research on literacy. For example, Carothers (1959), a psychiatrist, has reported a psychological impact of literacy among rural African tribes. Summarily, Carothers (1959) noted that in non-literate societies, no clear distinction is made between thought and reality. The spoken word is much more closely identified with reality for the non-literate and has, what Carothers termed a "majic power." What is heard and what is spoken is more important for the rural African than what is seen. The effect of literacy is to reduce this magic

efficacy of the word, to make words represent thought symbols, and thus to create a mental distinction between symbol and reality. This distinction enables literates to think in terms of symbols.

Following Carothers' (1959) work, McLuhan (1962) claims that when use of one of the senses predominates, as does the aural among illiterates, the other senses become to some degree anesthetized. With literacy comes an arousal of the visual sense, thereby attuning the individual to both the audio and the visual messages being transmitted. Indeed, McLuhan's (1964) thesis that "the medium is the message" implies that the psychological impact or meaning of a message depends on the channel by which it is transmitted.

Moreover, in formal education programs, reading experts have also noted the cognitive impact of literacy. Gray (1940), for example, has written broadly on the effects of learning to read in broadening one's outlook, deepening one's understanding, changing one's behavior, and stimulating one's emotional and individual growth.

Rogers (1969, p. 72), who has done extensive work on literacy programs in Developing Countries, has concluded that: "Literacy, . . . , contributes to the modernization process by (1) providing the means for print media exposure, (2) allowing the receiver to control the rate of message input, (3) facilitating the retrieval of print messages for delayed use, and (4) unlocking more complex mental abilities."

Since literates seem better able to manipulate symbols and to think abstractly, one therefore expects literacy to have instrumental relevance in predicting and explaining peasant modernization. Literacy must be appreciated as an important facilitator of modernization, a process which requires the absorption and comprehension of a vastly increased amount of complex information. The individual who becomes literate has learned to learn for himself (Burnet, 1965:14).

3. Skewed Regional Distribution of Literacy

Given the profound impact of literacy on modernization and development variables and on the cognitive structures of individuals, the disturbing fact, however, is that the distribution of literacy rates between the major regions of the world is very skewed. That is, while the Developed Countries of the world enjoy high literacy rates, the Developing Countries are severely plagued with a high incidence of illiteracy among their populations of potential productive ages.

Because of the general lack of credible statistics, it is difficult to assess confidently the extent of world literacy. However, the estimates by the Statistical Office of the United Nations (1977) are shown in Table 1 showing the breakdown by continent of the total number of adults, literate adults, and the number and percent of illiterates in 1960 and 1970. These estimates show that in 1960 approximately 735 million (39.3%) of the persons aged 15 years and above were illiterate. By 1970, the estimated percentage

Table 1. World and Regional Distribution of Adults, Literate* Adults and Illiterate Adults (aged 15 years and over) in Millions for 1960 and 1970.

REGION	1960				1970			
	Total Adults	Literate Adults	Illiterate Adults		Total Adults	Literate Adults	Illiterate Adults	
			No.	%			No.	%
World#	1,869	1,134	735	39.3	2,287	1,504	783	34.2
Africa	153	29	124	81.0	194	51	143	73.7
North America	137	133	3	2.4	161	158	2	1.5
Latin America	123	83	40	32.5	163	125	39	23.6
Asia#	982	440	542	55.2	1,237	658	579	46.8
Europe & USSR	464	439	24	5.3	521	502	19	3.6
Oceania	11	9	1	11.5	13	12	1	10.3

*Literacy was defined as the ability to both read and write.

#Excludes People's Republic of China, Democratic People's Republic of Korea, and former Democratic Republic of Vietnam.

Source: Statistical Office of the United Nations, New York, N.Y., World Statistics in Brief, 1977.

had decreased to 34.2, but the absolute figure had increased to 783 million people.

Meanwhile, the estimated number of literate adults (aged 15 years and above) in the world increased from 1,134 million in 1960 to 1,504 million in 1970.

The majority of the illiterates are in Africa (81.0% in 1960 and 73.7% in 1970), Asia (55.2% in 1960 and 46.8% in 1970) and Latin America (32.5% in 1960 and 23.6% in 1970). The Developed Countries in North America, Europe and the USSR, and Oceania continued to enjoy high literacy rates throughout the same periods.

UNESCO (1965) analysts have estimated that the increase in the number of illiterates in a given country is related to the illiteracy rate by a correlation coefficient of 0.55. That is, countries with high rates of illiteracy (70 per cent or more) have a propensity for increasing the absolute numbers of adult illiterates while countries with relatively low illiteracy rates (35 per cent or less) tend to lower both the rate and absolute number of illiterates. Since Developing Countries are the ones with high rates of illiteracy, these figures clearly demonstrate the magnitude of illiteracy problems which these countries face.

Furthermore, the proportion of female illiterates generally exceeds that of males, often significantly. In at least three countries--Saudi Arabia, Somalia, and Yemen--the total adult female populations are reported to be

illiterate while in many others the figure is over 90 per cent (UNESCO, 1965).

The International Institute for Adult Literacy Methods which was established by UNESCO and the Government of Iran in 1968 reported in 1974 that there are ". . . more than 800 million illiterates throughout the world . . . . Despite what has been done and what is being done, the number of illiterates is not decreasing. In fact, there are more illiterates today than there ever have been and by the eighties they are likely to total more than 800 million" (p. 3).

Although the figures indicate that illiteracy is most prevalent in Developing Countries, it must be noted that they do not show that by far the greatest number of uneducated come from rural areas in those countries where agriculture forms the backbone of the national economy.

It is strongly argued that the debilitating effects of illiteracy are very complicated but lucid:

> . . . it is precisely in the areas where illiteracy rates are highest (parts of Africa, Asia, and Latin America) that development lags farthest behind the rest of the world. Here we find lowest per capita income rates, most rapid increases in population, and least developed systems of communication and transportation. Illiteracy is a part of the vicious cycle that hobbles underdeveloped nations: without literacy, special skills cannot be taught; without special skills, agriculture cannot be modernized or industry developed; without a modernized agriculture and industry, production and income will not increase; without income, there are no resources to develop education and literacy. Literacy is viewed as a possible input to

> alter the inertia of the system and break out of the cycle (Herzog, 1967, p. 2).

Thus, from the above and similar assertions, one surmises that illiteracy prevents many of the segments of populations of productive age in the Developing regions of the world from participating and enjoying the benefits of technological advances in several fields such as agriculture, health, child welfare, industry, social development, etc., to mention only a few.

Lack of ability to make use of technological knowledge in these fields means that many nations in the so-called Developing regions are not developing as rapidly as might otherwise be the case. "Gunnar Myrdal, in his important study of social and economic conditions in countries in Southeast Asia, Asian Drama, makes it quite clear that technological development is greatly slowed down, and may even make little or no headway in raising the standards of life for the people in a number of countries in this area, simply because of the weight of illiterate numbers in the populations" (World Education, 1970, p. 11).

4. Prior Conceptualizations of Literacy

The purpose of this section is to review some of the available representative literature in which literacy has been explicated. From this review will derive a new and more rigorous explication of literacy. This new explication is based on the contention that the traditional

conceptualizations of literacy have been inadequate since they have generally conceived literacy in terms of individual ability to read and/or write only in some natural native language, and have not attempted to provide uniform classification of literacy levels.

Although the measurement of literacy is much in vogue today among educationalists, scholars, and social-change engineers, its historical origins and interest seem to be unknown. That is, it is not clear when and why man first became interested in the measurement of literacy.

However, in the United States, early interest in the measurement of literacy seems to have developed in association with immigration laws of this country. In his thesis on The Literacy Test for Immigrants, 1886 - 1917, Houdek (1957) attributes the early literacy test in the United States to Edward W. Bemis, an economist, who proposed that the United States "Admit no single person over sixteen, and no man over that age who cannot read and write his own language" (Bemis, 1888, p. 263). Bemis argued that his proposal would help to maintain America's high standard of living and aid American labor by shutting out fifty per cent of the Polish, Hungarian, and Italian immigrants.

Although most of the poeple who discussed the test during the early years of its history favored both a reading and writing test, the proposal was later modified to a simple test of reading skill, and as to the language in

which the immigrant was to prove his literacy, it was usually agreed that it should be in "English or some other language" (House Report, No. 140, 1913). Level of literacy in terms of reading skill then became the key determinant of allowing immigrants from Europe to the United States. However, Houdek (1957, pp. 4-5) states:

> Where these workers got the idea of an educational test is a matter of question, for Bemis supposedly only lectured on the idea as far back as 1887. Thus it seems quite possible that either someone else had promulgated the idea before him or that the idea had been in existence for some time, but had not become as popular as other restrictive and selective proposals.

The questions of who initiated the idea of a literacy test and the purpose for which it was developed are not particularly significant. However, it is important to know that over the years the measurement of literacy has been conceived in a number of different ways. This is important because, as it was noted earlier, literacy bears great utility in practical and research endeavors in modernization and development activities.

Various literacy definitions seem to fall into two rather general categories:[7] (a) planning-census-type definitions and, (b) empirical-type definitions.

a. Planning-Census-Type Definitions of Literacy. A planning-census-type definition of literacy is here conceived as literacy by fiat of the interviewer or a self-report of

the interviewee on his/her literacy skills such as reading and writing. A fiat definition of literacy usually uses grades of school (years of school) with which to estimate an individual's literacy skills (reading and writing). As the name implies, planning-census-type definitions of literacy are usually applied during population census to get information quickly on literacy estimates for national planning. Some examples and related discussions of planning-census-type definitions follow.

Discussing "The measurement of literacy in Pre-industrial England," Schofield (1968) reports that literacy was conceived as the ability to sign one's name. This method of literacy test was very much in use in pre-industrial England particularly " . . . when large numbers, or whole classes, of people were required to attest their approval of a document by signing their names if they could, or if they could not sign by making a mark. These could be situations, analogous to a census, in which virtually everyone was required to attest his approval of a document" (Schofield, 1968, p. 319).

According to Schofield (1968), the occasions on which this occurred in pre-industrial England included: (1) the Protestant Oath of 1624, which had to be taken by all males over the age of eighteen to the effect that they would "maintain and defend the true Reformed Religion expressed in the Doctrine of the Church of England against all Poperie

and Popish Innovations," (2) the Test Oath of 1723, promising allegiance to George I and renouncing the jurisdiction of the Pope, which had to be sworn by everyone over the age of eighteen and, (3) the Anglican Marriage Register, which from 1754 contained entries of all marriages other than those of Jews, Quakers, and members of the royal family. This register was due to an act of Parliament of 1753 which accorded legal validity only to marriages registered in Anglican registers and signed by the parties and two witnesses. In 1837, other denominations were licensed to register marriages and a state system of registration was begun.

There are, however, serious methodological drawbacks in the use of signatures and marks as testimony of literacy in wills, allegations and bonds for marriage licenses, and the deposition of witnesses in ecclesiastical courts (for details, see Schofield, 1968, pp. 320-325).

In general, it is to be noted that the ability to sign one's name or to make marks for attesting approval of a document are conceptually very imprecise measures of literacy since they do not consider the extent to which the individual has acquired literacy skills (reading and/or writing). Schofield (1968) convincingly states:

> . . . historians have . . . made the problem worse for themselves by being imprecise as to what they mean by literacy. This has meant that the level of literacy skills considered appropriate in any historical context has rarely been adequately specified. This is perhaps not surprising as it is

> seldom easy to decide what this level should be. For example, in a discussion of the role of literacy in the history of politics, is the ability to write relevant? or is the ability to read sufficient, and if so to what level? enough to understand a simple handbill, or the works of Locke? For economic history the difficulties are even greater. For example, any assessment of the relationship between literacy and industrialization entails decisions as to the levels of literary skills necessary to the introduction of the new techniques in agriculture and a wide variety of industries on the one hand, and to the replacement of traditional patterns of consumption and the generation of a mass market demand on the other. At least for the English industrial revolution it would seem that these necessary levels of literary skills varied widely in different sectors of the economy. The meaning of literacy therefore changes according to the context, and it is the responsibility of the historian to specify the appropriate level of literary skills consistent with his understanding of the context (pp. 313-314).

Other examples of planning-census-type definitions of literacy may be noted.

Until the 1940 decennial census in the United States, illiteracy was determined by asking adults whether they could read and write. Later, literacy was defined as equivalent to having completed six grades of school (Rogers with Svenning, 1969). Harman (1970) reports that the U.S. Bureau of the Census defines illiteracy as "the ability to read and write a simple message either in English or any other language" (cited from Current Population Reports, 1963, p. 20).

In the Colombian census, literacy is measured on the basis of an individual's ability to write his name. Other

national censuses determine literacy by asking individuals if they can read a newspaper and write a letter (Rogers with Svenning, 1969).

Illiteracy is defined as inability to read or write in Portuguese in Angola and the Republic of Cape Verde; to read and write either French or Arabic in Chad; to read and write French in Gabon and Senegal; either to read or write Sesuto in Lesotho; both to read and write English in Swaziland; persons with no schooling are defined as illiterates in Sudan, Uganda, Hong Kong, and Japan; both to read and write a simple letter in any language in West Malasia; and to read or write in any native language in Oceania (Cook Islands, Gilbert Island, Niue Island, and West Samoa) according to UNESCO's Statistical Yearbook (1976, pp. 43-59).

Finally, there is a wide disparity in the age groups included in national rates of literacy. For example, Indonesia calculates its literacy rate for persons between 13 and 45 years of age; Cuba and Malaysia report literacy rates for those 10 years of age and over, and Bulgaria includes only people who are more than 15 years old (Rogers with Svenning, 1969).

b. Empirical-Type Definitions of Literacy. Unlike the planning-census-type definitions of literacy which are by fiat and/or self-reporting, empirical-type definitions of literacy are here conceived as literacy measures which are usually task-oriented. That is, they usually have an

a priori set of measures or instrument through which the level of literacy of an individual may be determined by the individual's performance on the instrument. Consequently, they are more rigorous than the planning-census-type literacy "tests." They usually consider individual's reading and/or writing skills and understanding of what is read. Some consider even the actual application of what is read in programs currently known as "functional literacy." Some examples of the empirical-type definitions of literacy are worth noting.

More than four decades ago, Huse (1933) in discussing the reading needs of citizens of a democracy, gave vigorous emphasis to the importance of a clear grasp of the meaning of what is read. In his judgment, reading for understanding is to be contrasted with mechanical reading. It involves the translation of the meaning represented by the symbols into understandings that can be expressed in the reader's own words. Equally important is their translation "into terms of purpose, authority and validity" (p. 8). Unless this is done, "the public is the inevitable victim of fraud both commercial and literary," and "the mental life of the people may be corrupted" (p. 9). In Huse's view, a high level of capacity to translate is an indispensable requisite of a literate citizen. Compelled by their interest in the concept of functional literacy during World War II, the U.S. Army defined illiterates as "persons who were incapable of

understanding the kinds of written instructions that are needed for carrying out basic military functions or tasks" (Current Population Reports, 1963, p. 23). A 1970 conference on planning strategies for a national adult "right to read" movement decided that adult literacy assessments should be made independent of grade equivalents:

> The challenge is to foster through every means the ability to read, write and compute with the functional competence needed for meeting the requirements of adult living (Conference on Strategies for Generating a National 'Right to Read' Adult Movement, Raleigh, North Carolina, 1970).

UNESCO (1969) has been involved in a literacy teaching program which has been worked out to reduce the normal time of reading lessons by half using a computer which determines the frequency of words and syllables used by local workers. UNESCO reports one such program in a Brazilian mining company:

> The use of a computer in a Brazilian project is expected to cut by half the amount of time needed to learn to read. The CVRDC Mining Company, Brazil, which has started a functional literacy programme for its staff with UNESCO-assistance, has used a computer to determine the frequency of words and syllables used by local workers. This literacy programme is closely linked to the technical promotion and vocational training of the staff.
>
> The computer has shown that the basic vocabulary of 2,300 words is made up of a total of 540 different syllables. Sixty per cent of the words use as little as 9 per cent of the syllables, meet 80 per cent of the speaking requirements. On the basis of these data, a teaching programme has been worked out which should cut the normal duration of reading lessons by half (p. 15).

Other UNESCO conceptions of literacy falling under the purview of empirical-type definitions of literacy may be noted. In 1951, a UNESCO committee conceived that a person is literate when he can "both read, with understanding, and write a short simple statement on his daily life" (Gillette, 1972, p. 22). In their interest in the concept of functional literacy, another UNESCO committee came up with a definition of literacy in 1962 when they stated:

> A person is literate when he has acquired the essential knowledge and skills which enable him to engage in all those activities in which literacy is required for effective functioning in his group or community, and whose attainment in reading, writing and arithmetic make it possible for him to continue to use these skills towards his own and the community's development (Gillette, 1972, pp. 23-24).

In a Final Report of the Regional Workshop for Specialists and Officials Concerned with the Preparation of Reading and Follow-up Materials in Asia, Bangkok, 25 November-13 December, 1968, UNESCO (1969) asserts that the Workshop felt the need for adopting some workable standard of literacy in terms of three R's. The Workshop discussed the Literacy Scale used in Laos for drafting a work-oriented literacy project in Laos. The scale establishes six levels of literacy:

LEVEL I

1. Able to hold a pencil___
2. Copies simple figures___
3. Tells time by the clock___
4. Writes one-figure numbers___

LEVEL II

5. Adds and subtracts one___
6. Writes his/her name___
7. Reads separate letters___
8. Writes from dictation numbers with two figures___

LEVEL III

9. Adds, subtracts and multiplies numbers of two figures___
10. Writes separate letters___
11. Reads usual words___
12. Writes from dictation numbers with 3 figures___

LEVEL IV

13. Knows the square, the diameter___
14. Reads simple words___
15. Writes phonetically words___
16. Writes from dictation numbers with 5 digits___

LEVEL V

17. Adds, subtracts, multiplies, and divides with 3 figures___
18. Reads sentences word by word___
19. Writes simple sentences___
20. Writes any number___

LEVEL VI

21. Knows geometrical figures___
22. Reads fluently___
23. Drafts a text___
24. Does simple operations in metric system___

Number passed = $\frac{\text{\_\_\_\_\_}}{4}$ = _____ Level_____

Source: UNESCO (1969), Work-Oriented Functional Literacy; Reading and Follow-up Materials: Final Report of the Regional Workshop for Specialists and Officals Concerned with the Preparation of Reading and Follow-up Materials in Asia, Bangkok, 25 November-13 December 1968 (Appendix D).

This scale was devised for testing individuals to be employed in factory work. The Workshop participants correctly observed that "Level VI, which is supposed to correspond to a level of proficiency equal to the level of a sixth grade school leaver does not consider the mastering of the

simple calculations needed for agriculture.

The Workshop suggested that other countries might adapt this Literacy Scale--taking into account the level of instruction required by a particular development programme--or evolve a new one to suit their requirements . . ." (pp. 6-7).

As may be noted above, UNESCO's literacy measures seem to vary not only over time but also over space. Elsewhere, for instance, UNESCO (1971) uses what its experts call "Attainment Tests" for determining the level of literacy:

> These have been used, on the one hand, for evaluating the level of literacy proper, especially in four aspects: rapid calculation, solution of easy vocational problems, understanding of another person's thoughts expressed in writing (e.g., a technical leaflet), and ability to express oneself in writing. On the other hand, and concurrently, they are utilized in the Experimental World Literacy Programme for evaluating the knowledge acquired in the specific field covered by each programme deal - that is, technical and vocational knowledge and socio-economic knowledge of vocational relevance (p. 7).

In his work on "Literacy and Community Economic Development in Rural Brazil," Herzog (1973) reports that "literacy, the dependent variable, was measured by the farmer's score on a 50-word oral reading test derived from the final lesson of an adult literacy primer used in Minas Gerais" (p. 332).

In evaluating Pilot Projects, UNESCO has also made use of "Attainment Tests" in an attempt to determine literacy levels among the populations concerned. "These have been

used, on the one hand, for evaluating the level of literacy proper, especially in four aspects: rapid calculation, solution of easy vocational problems, understanding of another person's thoughts expressed in writing (e.g., a technical leaflet), and ability to express oneself in writing. On the other hand, and concurrently, they are utilized in the Experimental World Programme for evaluating the knowledge acquired in the specific field covered by each programme deal--that is to say, technical and vocational knowledge and socio-economic knowledge of vocational relevance" (UNESCO, 1971, p. 7).

In general, the following problems are to be noted in prior conceptualizations of literacy.

First, prior measures of literacy depend both on the honesty of the respondent and his/her ability to assess accurately his/her own competence in reading and writing. However, in situations where individuals think that it is not acceptable to be illiterate, such as in Urban areas (see Burnet, 1965: 11; Freeman and Kassenbaum, 1956), or where they have little opportunity to maintain a former competence in reading and writing, as in peasant communities (see Rogers with Svenning, 1969; Singh, 1970; Ahmed, 1973), self-defined literacy is likely to be a relatively less accurate measure.

Second, prior conceptualizations of literacy have generally been concerned with literacy only in some natural native language. However, in diffusion practices involving

technological innovations such as in the African and Asian countries, such measures may be inadequate in predicting and explaining knowledge and adoption of technological innovations since the native languages in those countries are frequently not associated with the technological symbols and concepts. The language of technology is frequently English in which the clients of technological innovations are generally illiterate. This point will be elaborated in the next section. Note further that even the measures of literacy in native language per se have been imprecise since they do not provide a clear understanding of the extent to which the individual has acquired literacy skills in the language concerned.

Third, prior literacy conceptualizations which have attempted to use quantitative symbols and concepts have been less rigorous since they have generally tended to assume that the individuals concerned already possess an elaborate numbering system in their native languages, and that they can use it properly in the solution of their development problems. But this may be a far cry from reality as it will be shown in the next section.

Finally, prior conceptualizations of literacy have generally not been uniform. That is, they have not attempted to provide one classification scheme or typology of literacy levels on which to array all people over time and space. Such a scheme would be more useful in predicting and explaining an individual's knowledge and adoption of technological

innovations particularly in Developing Countries. This study will provide later in this chapter (see section C. 4) a scheme which reconceptualizes literacy.

5. Symbolism in Diffusion-Adoption Processes

This section is concerned with the general types of symbol systems in diffusion-adoption processes and with the specific types of symbol systems which are potentially critical in diffusion-adoption processes of technological innovations involving Developing Countries. The latter symbol systems are concerned with literacy in quantitative symbols and concepts and with literacy in English which, as noted earlier, is a subset of literacy in non-quantitative symbols and concepts. Both of these aspects of literacy were identified earlier in this chapter as the two aspects of literacy which have generally been overlooked in diffusion practices.

a. General Types of Symbol Systems in Diffusion-Adoption Processes. To determine the extent to which literacy in quantitative symbols and concepts and in English are both important in the diffusion-adoption processes in Developing Countries, requires first the identification of the general types of symbol systems which may be present among the change agents and the clients of innovations in these areas. From these general symbol systems will be selected the specific types of symbol systems which are particularly germane to the diffusion and adoption of technolgoical

innovations in Developing Countries. Here, a change agent is to be conceived as a professional who influences innovation-decision in a direction deemed desirable by a change agency (Rogers with Shoemaker, 1971). An agricultural extension worker is an example of a change agent. An agricultural department or ministry of agriculture may be the change agency.

Writing from an African context, Mwanika (1978) has identified two types of symbol systems by relating them closely to the speech communities which use them for communicating about technological innovations. The two general types of symbol systems include, firstly the symbol system of the clientele community and, secondly, the symbol system of the change agents.

The first symbol system comprises the natural native language, or that which is often crudely referred to as the "mother-tongue." There may be 1, 2, 3, . . . , N mother-tongues in a community where N expresses the cardinality of the mother-tongues. Developing Countries frequently have multiple languages and/or dialects. This is certainly the case in Africa the context which this author is writing from.

The second symbol system involving the change agents may be subdivided into three different symbol systems. One such symbol system is the natural native language or mother-tongue of the change agent. Besides his/her mother-tongue a change agent <u>may</u> of course speak other native languages in

his/her area of jurisdiction. The second symbol system is the natural language in which the change agent was educated and trained. This is usually English although it may be some other European language such as French, German, or Russian. Since the change agents often have their own mother-tongues, a language such as English is an adopted natural language in this context. The third symbol system is concerned with the artificial language of mathematics. The change agents had to learn this language not only for communicating quantitative information, but more so for encoding, decoding, and communicating more precise information which is a fundamental characteristic of this language. Individuals endowed with this language can deal with (analyze and synthesize) complex relationships among the phenomena of their environment as will be demonstrated shortly. By virtue of their education and training, change agents are therefore expected to be more adept in this language relative to their clients.

b. Specific Types of Symbol Systems Important in Diffusion-Adoption Processes. This section focuses on two of the three symbol systems identified above as related to the speech community of change agents. More specifically, it focuses on the quantitative symbols and concepts of the artificial language of mathematics and on the English symbol system. The importance of literacy in each of these sets of symbol systems in diffusion-adoption processes is to be discussed below.

i. The Importance of Literacy in Quantitative Symbols and Concepts in the Diffusion-Adoption Practices. Basically, there are two reasons for the importance of literacy in quantitative symbols and concepts in the diffusion and adoption of technological innovations; viz., the specifications of technological innovations are quantitative in nature, and the economic decisions involved in the use of technological innovations are also frequently quantitative.

With respect to the quantitative specifications of technolgoical innovations, it is to be noted that many important technological innovations come in specific calibrations, formulations, rates of application, and so forth. An agricultural extension worker, for instance, very frequently recommends to a farmer to apply so many pounds/kilograms of a given chemical per gallon/litre of water or per given surface area; to plant a given crop at so many feet (inches) or meters (centimeters) between rows and between plants in a row; to plant a certain number of seeds per hole or per surface area where seeders or planters are not a suitable or available choice; etc., etc. To be sure, these recommendations may be conceived as lessons which the extension workers teach the farmers. The farmers must learn them in order to apply properly the technological innovations to their farm enterprizes. However, since the quantity demanded of such an innovation as a chemical fertilizer is frequently a variable among farmers, it must then be understood that extension

lessons or recommendations are but sets of standards taught for the proper application of the innovation. Each farmer must determine his/her own fertilizer requirements using the rate of application as the standard, and the area of his/her farm which needs fertilizing. This may involve fractional amounts which may not be present in the native language of the clients as it will be documented shortly below.

The importance of quantitative symbols and concepts in the economic decisions involved in the use of technological innovations is based on the fact that "the reception given to a new idea is not so fortuitous and unpredictable as sometimes appears to be. The character of the idea is itself an important determinant" (Barnett, 1953, p. 313). That is, the characters of innovations or "attributes of innovations,"[8] according to Rogers with Shoemaker (1971, p. 13) are important predictors of the adoption of innovation.

One important attribute of an innovation is relative advantage which refers to the degree to which an innovation is perceived as being better than the idea it supercedes (Rogers with Shoemaker, 1971, p. 133). This attribute has been found to be positively related to the rate of adoption of innovations (see Kivlin, 1960; Fliegel and Kivlin, 1962a, 1962b; Tucker, 1961; Fliegel and Kivlin, 1966; Patrini, 1966; Kivlin and Fliegel, 1967a, 1967b; Fliegel, et al., 1968).

The degree of relative advantage is often expressed in economic profitability. However, there are ". . . a number of subdimensions of relative advantage: The degree of economic profitability, low initial cost, lower perceived risk, a decrease in discomfort, a savings in time and effort, and the immediacy of the reward" (Rogers with Shoemaker, 1971, p. 139).

Quantitative comparisons become very important in determining the relative advantage of any innovation particularly in farm enterprize substitution or combination. Economists in general and agricultural economists in particular would assert that a farmer who is thinking of substituting one farm practice with a new one must naturally compare the relative advantage or economic profitability which is anticipated from the new practice to that observed in the old one. This, however, requires only a simple substitution decision. Otherwise, a farmer may (as is often the case) be faced with more complex comparative and substitution decisions. Such decisions may arise if a farmer is considering combining certain farm enterprises in some way on the basis of current and future market prices for farm inputs in general, and for farm outputs (produce). For example, given three crops, viz., corn, peanuts, and soybeans, a farmer may decide to grow, say, only two of these crops in a given cropping season. In this case, such a farmer will be faced with three different groups (pairs) of relative

advantages to compare and choose from. More specifically, the three possible pairs or combinations of crops for this farmer will be either to grow:

1. Corn and Peanuts,
2. Corn and Soybeans, or
3. Peanuts and Soybeans.

Each crop in each of these pairs is a bundle of economic profitability, risk, and the effort to grow it. Hence, each of these pairs is really a bundle of bundles. In considering economic profitability, for example, this farmer will have to consider several variables: the current market prices for seed, labor, fertilizer, pesticides, etc., as well as the expected selling price for each produce to be able to determine which combination of bundles of crops to grow. To do this, he/she will have to apply some basic quantitative or mathematical structures or models of equality/inequality (reflexive, symmetry, and transitivity) which will enable him/her to make the necessary comparisons. All such comparisons require that the farmer be literate in quantitative symbols and concepts.

The preceding paragraphs have attempted to show the use of quantitative symbols and concepts in diffusion-adoption processes. In addition, it is to be noted that this use is not by default but rather by design. The natural numbering system (1, 2, 3, 4, 5, 6, 7, 8, 9, 0) is well known to have important practical and scientific utility in

our lives as Judd (1927, p. 107) states:

> The number system which the race has developed is a complex of symbols and of rules of combination. Some mental effort is necessary for the mastery of the system itself. In so far as this is true, arithmetic is a content subject. Equally true is the statement that the number system is a means of arranging the facts of experience in such a way that they can be dealt with precisely although they are quite chaotic in their own quality and order of presentation. Because the number system helps the individual to arrange his experience, it is the indispensable instrument of all science and of commerce where facts must be dealt with not in a chaotic way but in such a way that relations are defined and clearly recorded (emphasis added).

This arrangement of the facts of experience in order to process them more precisely is a quantitative behavior or "quantitative thinking" which "takes place when an individual uses numbers in some way in dealing with the elements of a situation that lend themselves to mathematical analysis or description" (Grossnickle and Brueckner, 1959, p. 308).

The natural number system is frequently assumed to be a universal language (see Kramer, 1970; Alcksandrov, et al., 1969; Judd, 1927; Smith, 1923; Urban, 1939; Hogben, 1951; Dantzig, 1954; Menninger, 1970; Grossnickle and Brueckner, 1959; Langbehn, et al., 1972; Cassirer, 1953; etc.).

Unfortunately, however, not all people (particularly those from the rural areas in Developing Countries) may be able to use this language adequately. Evidence in the literature indicates that some cultures and subcultures of

human populations have a very limited numbering system in their natural languages or dialects. Such people have developed categorical (nominal) quantity labels or number analogues for expressing the "quantitative" nature of objects (see, for example, Dantiz, 1954; Cassirer, 1953; Weitheimer, 1967; Menninger, 1970). Menninger (1970) reports that "some primitive peoples have completely fused the number and the object into a single entity. The Fiji Islanders, for example, call 10 boats bola, 10 coconuts koro and 1000 coconuts saloro. Naturally this does not hold for any arbitrary number (such as 5 nuts or 23 nuts). . . . The examples given show that the primitive people of the Fiji Islands have no number sequence, at least not an extensive one, that has been consciously and clearly detached from objects and thus become abstract" (pp. 11-12).

The Detroit Free Press (December 21, 1976) reported under the "Guinness World Records" column that "least number-conscious people are the Nambiquara of the North West Moto Grasso section of Brazil who lack any system of numbers. They do, however, have a verb which means 'they are two alike.'"

Moreover, besides the presence of unintelligibility and limitation in number qua number among some of the cultures or subcultures of the world, some people of other cultures also lack in their native languages or dialects equivalent concepts for the number concepts of proportion

such as per cent, fractions, to say nothing of the decimals. This author, for instance, observed the absence of equivalent concepts for all the rational numbers (fractions) except for one-half in five Ugandan languages and dialects with which he is most familiar. In these languages, any measure of magnitude or capacity which is less than unity is always expressed as a "half" even if the actual measure may be greater or less than one-half. That is, the native speakers of those languages do not have equivalent concepts in their languages for the various rational numbers such as 1/3, 2/3, 1/4, 3/4, 4/5, 7/8, etc. Therefore, they do not seem to understand the fact that between any two distinct (different) rational numbers, no matter how close, there are infinitely many other rational numbers. Between 0 and 1, for example, there are infinitely many new "units" of 1/N since an arbitrarily large denominator (N) may be selected. In other words, an indefinitely small quantity (i.e., a quantity as small as you please) may be selected. In mathematical jargon, this infinite number of new units refers to the concept of "density." That is, rational numbers are pretty dense or thick.

Other evidence indicates that limitations or unintelligibility in number has some connection to level of literacy. For example, from a series of experiments in a pilot study among rural illiterate and semi-literate Africans in Zambia, Fuglesang (1969) it was observed that the conservation of

substance (mass), quantity, number, and area; the concept of a straight line; special representation, concept of horizontality and verticality, and elementary logical concepts, i.e., concept of class, all do not exist or are unstable in illiterates.

According to UNESCO (1972), "As a general rule, illiterates are vague and imprecise about measures of length, area, weight and time. When they know how to count, it is hardly likely to be more than a hundred. Even if they know to add, subtract, or even multiply (by repeated additions), they are normally unable to divide" (p. 2).

Evidently, the linguistic handicaps in number noted above should not be construed as these populations' inability to learn or comprehend the more complete numbering system which may be found in common use in some other natural languages. It is a matter of language, and a more advanced facility in the use of language. Given a medium which facilitates the acquisition of literacy as a more advanced facility in the use of language, such populations should be able to acquire a more elaborate numbering system, i.e., literacy in quantitaitve symbols and concepts. This author contends that such a medium is formal education. This point will be developed later in this chapter (section C-3).

ii. <u>The Importance of Literacy in Non-Quantitative Symbols and Concepts of English Language in the Diffusion-Adoption Practices</u>. The importance of literacy in non-quantitative symbols and concepts of the English language in

the diffusion and adoption of technological innovations is based on three reasons.

First, the "objects of diffusion" (i.e., technological innovations) particularly those of great importance in most of the Developing Countries are generally cast in scientific symbols and concepts whose nonmenclatural mold derives from the English[9] language. For instance, today's change agent's kit is impregnated with such tools as perenox, gammalin, Aphex 70, aldrin, dieldrin, fertilizer, hybrid seed, IUD (Intra-Uterine Devices), Ariana, AI (Artificial Insemination), baby bottle, and so on, and so on, ad nauseam. It will be a rare case for such technological innovations to bear the nomenclature from the native languages or dialects of the clients in most of the Developing Countries particularly those in Africa and Asia.

Second, the change agents are generally college or university graduates who, as noted earlier, are educated and trained generally in the English language. Thus, they are expected to be literate in English--the language of technology. Through their education and training, the change agents are naturally expected to be familiar with the (1) conceptual or denotative meaning (nomenclature), (2) intuitive meaning of the non-quantitative symbols and concepts and (3) to be familiar with the numbering system and, hence, the quantitative specifications and economic decisions associated with the technological innovations, and (4) intuitive meaning

of the quantitative symbols and concepts of the innovations.

For example, given some quantity of a chemical fertilizer such as sulphate of ammonia ($(NH_4)_2SO_4$), the change agent should know: that sulphate of ammonia is a specific name which is given to a particular category of fertilizers. It is distinct, on certain physical and chemical features or properties from, say, a potassium sulphate (K_2SO_4) or a potassium nitrate (KNO_3) fertilizer or, indeed, from any other technological innovations such as those which were stated above.

Finally, unlike the change agents who are generally college or university graduates, the rural clientele audiences in Developing Countries are not only generally illiterate in their native languages, as it was documented earlier, but most of them do not speak nor are literate in English. The rural clientele audiences are mostly limited to their native languages for interpersonal communication among themselves and with the change agents if the latter can speak the native languages or dialects in their areas of jurisdiction.

The clients who speak English, if any, would of course be expected to understand, to some extent, and to communicate directly with the change agents by virtue of the linguistically shared symbol system. However, for those clients who cannot speak this language (usually the majority), the change agents will either cognitively transform and

translate the English symbol system they are endowed with into the native symbol system of the clientele (if they can speak the latter) or they will have to seek the services of an interpreter to be able to "communicate" with their target audiences.

Like the acquisition of quantitative literacy, the acquisition of literacy in English can also be facilitated through the channels of formal education as will be discussed in the next section.

C. THEORETIC FRAMEWORK AND HYPOTHESES

Following the preceding discussions, a more rigorous explication of literacy is needed. Such explication would include both literacy in quantitative symbols and concepts, and literacy in the non-quantitative symbols and concepts of English language if diffusion practices involving technological innovations among the generally illiterate populations are to be effective.

Literacy itself is to be conceived as a behavioral aspect in the use of language by which persons endowed with it can access and manipulate symbols and concepts in a language for the messages they convey. Therefore, the theoretic explanations for reconceptualizing literacy as a conveyer of linguistic symbols and concepts must be concerned with the behavioral aspects of language.

1. Theoretic Relation Between Language and Behavior

Many scholars have for many years theorized and studied the development of symbol systems by humans and the relation of these systems to overt behavior.

The theoretic explanations in those considerations which are important in the ordering of variables in this study are those which account for: (a) the human ability to acquire language, (b) the learning of language, (c) the role of meaning in communication, (d) human linguistic competence, and (e) the role of language in human communication.

This author contends that the theoretic explanations in these areas most appropriately account for the clients' differences in awareness or knowledge and adoption of or propensity of adopting technological innovations. Hence, those explanations will be the bases for this author's reconceptualization of literacy and, subsequently, the formulation of theoretic hypotheses.

a. Human Ability to Acquire Language. Scholars whose considerations have focused on human ability to acquire symbol systems (languages) contend that humans have a biologically innate ability to learn language--not a particular language, but any language whatsoever (see, for example, Chomsky, 1965; Katz, 1966; Lenneberg, 1964, 1969, and McNeill, 1966, 1971). Moreover, even children who are isolated for long periods of time are able to acquire language with minimal effort (Lenneberg, 1964).

These scholars convincingly argue that language acquisition is possible only if some biological built-in mechanism that predisposes humans to speech is postulated. In addition, they posit that language acquisition is a product of these innate structures as well as maturation and experience. Thus, the language of a given speech community is the result of the individuals' innate structures and of their maturation and experience.

These postulates imply that the mature speaker in a speech community has a highly distinctive and complex set of linguistic rules at his/her command. However, these rules are not so abstract that they cannot be acquired by the members of other speech communities. On the contrary, with appropriate training, the language rules in one speech community can be acquired by the members of any other speech community. This implies that in diffusion practices involving technological innovations among those populations whose dominant language is not English and/or whose native languages do not have an elaborate numbering system, such populations have the ability to learn the English and more elaborate number symbols and concepts given proper training.

b. Learning Language. Those scholars who have been concerned with the development and use of symbol systems by humans and the relation of these systems to overt behavior have included: at one extreme, the behavioral theorists; somewhat in the middle, the mediational theorists, and at

the other extreme, the cognitive psychologists.

The behaviorists (e.g., Watson, 1924, 1930; Bloomfield, 1933; Bousfield, 1953, and Skinner, 1957) contend that the behavior of any organism can be described and explained in terms of the organism's response to the stimuli presented by the features of environment. That is, they look outside the actor (to the environment) for the explanatory cues of behavior. Thus, this perspective explains the development and use of language and its relation to overt behavior by using the classical stimulus-response (S.R.) or motion theory in which the stimuli are assumed to have a direct effect on the behaviors of the perceivers of the stimuli and discount inferring behavior from any state of consciousness or internal meaning.

Skinner (1957), for instance, argues that all human behavior can be explained by examining the ways in which the behavior was first conditioned, and that future behavior is dependent on the ways that past behavior was rewarded when it occurred. To Skinner (1957), an acceptable theory of any behavior, including language, must be able to accurately predict the observable responses an individual will make to a particular set of stimuli. Thus, Skinner (1957) takes operant conditioning rather than cognitive processes as the basis for learning language. In operant conditioning, when the organism correctly responds to a stimulus, the organism is rewarded or reinforced for that behavior.

He conceives language as an utterance which is to be considered as an aspect of behavior in general. The language itself consists of functional units[10] whose importance can be strengthened or weakened by the application of rewards. Such rewards increase the probability of repeating the behavior until the behavior becomes firmly fixed; and, in case of symbols, until the symbols come to be firmly associated with the object or action as referents.

In sum, Skinner's (1957) analysis views verbal behavior as a way of controlling the environment and for classifying environmental events (objects and actions). That is, the speaker of a language attempts to control the behavior of the others for his/her benefit by using language.

From the above discussions, it is to be noted that behavioral theorists recognize the relation between symbols and referents and between language and overt behavior. In diffusion practices involving technological innovations, this implies that the clients of such innovations must first be aware or have the knowledge (i.e., have learnt) of the symbol sets which denote the innovations (referents) if they are to adopt (overt behavior) any innovation at all.

Note, however, that awareness or knowledge of symbol sets assumes that one has <u>meaning</u> for those symbol sets. For effective communication, it is important that the speakers have meaning for the symbol sets being used. The behavioral perspective is, however, inadequate to account for

this importance since it discounts inferring behavior from any state of consciousness or internal meaning. Another theoretic framework is therefore needed to account for the importance of meaning in human communication so as to better understand the relation between language and behavior.

c. The Role of Meaning in Human Communication. Mediation theory, noted earlier, accounts for the importance of meaning in the development and use of language by human beings, and its relation to overt behavior. This theory was proposed by Osgood (1963) who offers a position different from Skinner's (1957) in that he considers both the expression system and the content system--the meaning system of language. He postulated that meaning is an internal process, which is a learned relationship developed between an external stimulus and an internal ("mediated") response state. This internal response itself stimulates internal behaviors which may then lead to overt behavior.

Thus, Osgood's (1968) conceptions of language and its relation to overt behavior are founded on the stimulus-organism-response (S.O.R.) or action theory which looks inside the actor for the explanatory cues of behavior. These inside cues are assumed to pose intervening variables between the stimulus (referent of a symbol) and overt behavior. That is, mediation theory attempts to account for the different ways by which message recipients construe the world of their experience (perceive and process messages from symbols) and,

subsequently, how they may respond (behave) to that world.

In sum, mediation theory attempts to relate language and thought (meaning). It attempts to explain how humans learn the meaning of a word in relation to objects since, in addition to those stimuli and responses which are external and observable, there are those involving internal mental processes which occur as a result of perceiving words. The theory is also able to explain cases where one's response is so well-learned that one does not have to go through the complex procedures of re-learning. These cases involve complete internalization of meaning to the point where mediation is automatic.

What mediation theory implies is that for effective communication to occur between the speakers, such speakers must share the meaning of the symbol system in use. In diffusion practices involving technological innovations, this implies that these practices will be effective only if the change agents and their clients share meaning for the symbol sets which denote the technological innovations.

Note, however, that both the behavioral and mediational theories do not explain the extent to which a user of a language or languages has adequate competence to use the languages. Another theoretic framework is therefore needed to account for this.

d. Human Linguistic Competence. One alternative to the behavioral and mediational theories is cognitive theory

which was noted earlier. Cognitive theories have been set forth by several psychologists who often adopt the work of Chomsky (1957, 1965, 1968) as a basis for their conceptions of language development and use. Cognitive theories differ from both the behavioral and mediational theories in that they focus on the things a speaker of a language would need to know in order to use a language appropriately. That is, they focus on linguistic competence--one's knowledge of language, rather than on linguistic performance--one's use of language.

Cognitive theorists contend that humans think in kernel sentences which are stored and abstracted in their heads. For example, if one perceives in one's head the sentence, "Didn't the farmer plant corn?," cognitive theorists would argue that one stores the kernel sentence, "The farmer planted the corn." In addition, they would assert that somewhere along the line one must account for one's ability to reproduce the sentence as stated rather than just the kernel sentence form. Their explanation for this ability is that along with the kernel sentence, one abstracts and stores certain cues from the original sentence which remind one that it was negative, interrogative, and so forth. Humans are able to make these transformations by using specific sets of transformation rules[11] which are appropriate for the grammar of the language in use. Thus, proper use of a language presupposes knowledge of the grammar of the language.

Linguists note that one's knowledge of the grammar of a language comprises the basic linguistic elements of phonemes (sounds) and morphemes (words, or parts of words as meaning units), i.e., vocabulary or lexicon, and the rules for combining words into sentences. These elements and the appropriate rules of combinations are noted to be important for effective communication and understanding. More succinctly:

> When you know a language you learn the sounds used in that language, the basic units of meaning, such as words, and the rules to combine these to form new sentences. The elements and rules constitute the grammar of a language. The grammar, then, is that we know; it represents our linguistic competence. To understand the nature of language we must understand the nature of this internalized, unconscious set of rules which is part of every grammar of every language.
>
> Every human being who speaks a language knows the grammar. When linguists wish to describe a language they attempt to describe the language which exists in the minds of its speakers. There may of course be some differences between the knowledge that one speaker has and that of another. But there must be shared knowledge because it is this grammar which makes it possible for speakers to talk to and understand one another (Fromkin and Rodman, 1978, p. 9).

In diffusion practices involving technological innovations, this implies that the change agents and their clients must, to some extent, share the grammar of the language or languages in the diffusion process if they are to communicate to and understand each other. In particular, they must, to some extent, share the words (vocabulary)

since these are usually the most important in diffusion practices involving technological innovations.

e. The Role of Language in Human Communication. The postulates of innate structures for language and the behavioral, mediation, and cognitive theories noted in the preceding paragraphs have been attempts to provide foundations for our understanding of human development and use of symbol systems. Implicit in those attempts is the concern for the presumed role which language plays in human communication. This section briefly discusses some of the theoretic considerations in this regard.

The concern for language is based on the convincing argument that language is fundamental in all human discourses, and it is well-established that language is the "bearer of meaning" and a "medium of communication." That is, language functions not simply as a device for reporting experience (medium), but more so as a way (method) of defining experience for its speakers (see Urban, 1939, p. 37). It ". . . is the means by which man symbolizes and orders his concepts of his universe" (Whatmough, 1956, p. 83; emphasis added).

These conceptions of language are mirror images of Sapir's (1931: 578) notion that language actually shapes the way in which we perceive, think, and therefore act. Specifically, he states:

> Language is not merely a more or less systematic inventory of the various items of experience which seem relevant to the individual, as is so often naively assumed.

> But also a self-contained, creative symbolic organization, which not only refers to experience largely acquired without its help but actually defines experience for us by reason of its formal completeness and because of our conscious projection of its implicit expectations into the field of experience. In this respect language is very much like a mathematical system which also records experience in the truest sense of the word, only in its crudest beginnings, but, as time goes on, becomes elaborated into a self-contained conceptual system which previsages all possible experience in accordance with certain accepted formal limitations. . . . Meanings are not so much discovered in experience as imposed upon it, because of the tyrannical hold that linguistic form has upon our orientation in the world.

The same position is taken by Sapir's most famous student, Benjamin Lee Whorf (1952: 5) who states:

> . . . that the linguistic system (in other words, the grammar) of each language is not merely a reproducing instrument for voicing ideas but rather is itself the shaper of ideas, the program and guide for the individual's mental activity, for his analysis of impressions, for his synthesis of his mental stock in trade. . . . we disect nature along lines laid down by our native language. The categories and the types that we isolate from the world of phenomena we do not find here because they stare every observer in the face; on the contrary, the world is presented in a kalcodoscopic flux of impressions which has to be organized by our minds--and this means largely by the linguistic systems in our minds.

Sapir and Whorf's notions of language have generally come to be collectively known as "linguistic relativity hypothesis" or "Sapir - Whorf hypothesis." In short, the hypothesis posits that (1) without language we cannot think,

(2) language influences perception, and (3) language influences thinking patterns. The individual's language is thus seen as the factor which determines the way the individual perceives the world. That is, language determines the community's view of the world or, what Whorf (1956) refers to as the Weltanschauun.

The implication is that if a speech community has developed an elaborate language or extensive vocabulary (i.e., linguistic competence), people in such speech community will be able to perceive far more things in the world around them than will the speech community which has a limited or unelaborate language or vocabulary. In diffusion practices involving technological innovations, this implies that those clients who have a more elaborate symbol system germane to diffusion will perceive more technological innovations than those with unelaborate symbol system.

Other scholars have conceived human language as a signal system which influences human behavior. Pavlov (1927), for instance, distinguished between what he called the first and second signal system. He noted that man has physical structures and reflexes similar to those of other animals. For example, man reacts to intense light by pupillary constriction and to a sudden loud sound by the startle reflex; when man is severely threatened, his heart, blood-sugar levels, perspiration, and breathing all increase as adaptive devices. Pavlov called these built-in mechanisms the first signal system.

This first signal system functions on a biological level, but language also functions as a signal system. It enables man to regulate his own behavior or someone else's behavior. Language, then, radically changes behavior of a biological organism. In Pavlov's terms, it forms the second signal system. As Pavlov (1927) said, "The word created a second system of signals of reality which is peculiarly ours, being the signal of signals. On the one hand, numerous speech stimuli have removed us from reality. . . . On the other, it is precisely speech which has made us human" (p. 357).

Influenced by Pavlov's views, the Russian psychologist Luria (1961) set up an experiment to demonstrate that, with increasing language experience, the child comes to have increasing control of his/her own behavior--that words control behavior. In the initial stages of development, the child comprehends the meaning of words such as "go" and "stop" but they have no effect on his/her behavior. When he/she is told to "go," which in Luria's experiment meant to press a bulb, the child does so. But when the child is told to "stop," in Luria's experiment, the child continues to press the bulb. The command "stop" does not control the child's motor behavior until the child has further experience.

With increasing development, however, the child eventually learns to stop, or to release the bulb, on command. In this experiment, Luria emphasized the meaning of

words in invoking behavior.

The implication for these findings is that meaning and the vocabulary (i.e., linguistic competence) are very important in human communication and, ultimately, for human behavior. In diffusion practices involving technological innovations, this implies that the potential clients of such innovations must first have the meaning and adequate vocabulary or symbol sets for the technological innovations if they are to adopt such innovations at all.

Summarily, whatever else language is and what it does, it is in the first instance the tool for meaningful communication between and among its users since it is only through communication that language comes into being and only via language that communication can occur. This author finds it superfluous to delve into this chicken-egg argument. Rather, he wishes to emphasize that language qua language is meaningless until it is used for communicating. This meaning derives in a speech or language community of its users whom it provides with habitual modes of analyzing the phenomena of their experience into perceptual categories (Hoijer, 1954). Hence, fundamentally, "it is the method of adaptation to and control of environment" (Urban, 1939, p. 31).

Insofar as emphasis is on meaning or semantic structures in vocabulary or lexicon, the philosophy of language is therefore necessarily grounded on the philosophy of symbolism since a symbol is the basic linguistic element which

bears meaning to its users. To talk of the differences between or among languages is ipso facto to talk of differences in symbols. In other words, if there are no shared symbols between or among languages, such languages will be said to differ. Subsequently, users of such languages will be said to speak different languages. To the extent that languages differ significantly from each other, so would we expect to find significant and formidable barriers to meaningful, and effective communication (with respect to overt behavior) between the speakers of such languages. These barriers are expected to prevail whenever members of one speech community attempt to communicate with those of another speech community for whatever reasons. As a medium of communication and method of directing the perceptions of its speakers, language must therefore have a set of shared symbols among its users.

In diffusion practices involving technological innovations, this implies that communication barriers are to be anticipated between the change agents and their rural clients since these speech communities generally differ in their linguistic repertoires with respect to the "language" of diffusion as noted earlier (section B. 5). Such barriers are expected to be reflected in low awareness or low knowledge and, subsequently, low adoption of or low propensity of adopting technological innovations among the potential clients of these innovations.

To establish the strength of the relationship between literacy and knowledge or adoption of innovations, some uniform and precise conceptualization and operationalization of literacy is needed. As noted earlier, the conceptualization and operationalization have generally lacked both precision and uniformity.

This suggests that a reconceptualization of literacy as a conveyor of linguistic symbols and concepts is needed. Such a reconceptualization would include the linguistic repertoires (viz., quantitative and non-quantitative English symbols and concepts) along which change agents and their clients were noted earlier to differ. However, such a reconceptualization requires first specifying clearly the relationship between language and literacy.

2. Theoretic Relation Between Language and Literacy

Hitherto, the relationship between literacy and language has not been specified. An explication of this relationship is necessary before considering how to reconceptualize literacy. This explication requires an understanding of how we use language qua language and an understanding of the specific skills which are associated with this use.

Following the previous conceptualizations of language, two modes may be identified at which language may be used. Firstly, we may use language at the intrapersonal mode of communication. The specific skills associated with this mode include thinking/reasoning and internalization of

meaning. These skills are to be conceived as internal skills to the person as a processing system. The speaker of a language performs these skills using the symbols and concepts germane to the language the speaker has been able to acquire. Thinking/reasoning and internalization skills are, however, covert. That is, they are not easily observable behaviors. In addition, these skills are characteristic of all normal human beings. Thought is merely inaudible speech or, "talking with concealed musculature" (Watson, 1924, 1930).

Secondly, and more importantly, we use language at the interpersonal mode of communication. By definition, the interpersonal mode of communication implies exchanging messages with those others who, by virtue of the shared symbol system, are or may be involved in the communication process. The specific skills which are associated with this mode include speech (face-to-face or broadcast), reading, and writing. These skills are to be conceived as external skills. That is, they are overt or directly "observable" skills by which we can influence the behavior of others and, to be sure, by which others can also influence our behavior.

These two modes of communication and their respective skills are summarized in Figure 1.

Clearly, there is a transition from the intrapersonal to the interpersonal skills of using language. This transition is in effect a transition from how people construe

	Mode of Using Language	Type of Skills
1.	Intrapersonal Communication	Thinking/Reasoning, Internalization of Meaning
2.	Interpersonal Communication	Speech, Reading, Writing

Figure 1. Modes of Language Use and Their Respective Skills

their world of experience to the ways by which they communicate about it.

Consequently, the intrapersonal and interpersonal modes of communication are not independent; they are interrelated. This interrelationship, however, is recursive rather than non-recursive since the acquisition of external skills at the interpersonal mode of communication presupposes the acquisition of the internal skills at the intrapersonal mode of communication. Moreover, to be able to perform the internal skills associated with the intrapersonal mode of communication, presupposes that the person has already acquired the symbols and concepts germane to a language as noted earlier in the review of the theoretic foundations of language.

However, although there is a transition from the intrapersonal to interpersonal mode of communication, nevertheless the acquisition of speech, reading, and writing skills associated with the latter mode is to be conceived as an evolutionary rather than an automatic process. This evolution begins with speech by which man is able to make "audible" at the interpersonal mode the linguistic symbols and concepts which were before inaudible at the intrapersonal mode. This is a unique human ability which is well-established as the basic characteristic which distinguishes man from other animals.

Through his innovative use of language, however, man has also been able to develop more specialized skills of writing and reading by which he can respectively store and retrieve speech from symbols wiggled on surfaces such as parchment, slate, chalkboard, paper, tape, film, etc. The ability to store and retrieve speech from these surfaces implies yet more sophistication in the use of language; an ability which is a significant part of the scientific process, and in the diffusion of technology.

Clearly, a special facility is needed for the speakers of a language to be able to store and/or retrieve speech from such surfaces. Literacy is here conceived to be such a facility. The acquisition of this facility therefore implies more sophistication in the use of a language by the persons who possess it. Here then lies the relationship between

language and literacy. Literacy facilitates the storage and/or retrieval of linguistic symbols and concepts from surfaces.

3. Theoretic Relation Between Literacy and Education

Recall, it was noted earlier that humans have a biologically innate ability to learn language--not a particular language, but any language whatsoever. In addition, it was observed that in diffusion practices involving technological innovations among those populations whose dominant language is not English and/or whose native languages do not have an elaborate numbering system, the postulate of innate linguistic structures implies that these populations have the ability to learn the English and a more elaborate number symbols and concepts given proper training.

Similarly, since there is a clear connection between language and literacy as noted earlier, these populations have the ability to acquire literacy in English (non-quantitative literacy) and literacy in number symbols and concepts (quantitative literacy) given proper channels or media for training.

It is therefore important to know the channels or media through which a literacy facility may be acquired. It is here speculated that individuals' access to those channels and the extent to which they have been exposed to them, would explain their literacy levels (both in quantitative and

non-quantitative symbols and concepts) and, subsequently, their level of awareness or knowledge and adoption or propensity of adoption of innovations.

This author contends that formal education (years of school) is the channel or medium through which literacy may be acquired. That is, literacy may be acquired from the learning processes which are frequently provided for by the curricula of formal education institutions. From historical times, formal education institutions have always provided opportunities for developing skills in the so-called "three Rs" (Reading, 'Ritin', and 'Rithmetic), among other skills.

Some people may of course acquire literacy through the non-formal education programs such as "continuing education," "adult extension education," "functional literacy," and so forth; or through informal channels such as friends, relatives, etc. However, these are generally subordinate literacy channels. The main literacy channel is frequently to be sought in the modern formal education institutions.

Unfortunately, however, not every modern man has the opportunity, nor the desire, to say nothing of the resources, to attend the modern education institutions.

If this inequity is true, then we would expect the adult segments of populations in the Developing Countries to differ significantly in their levels of literacy (both quantitative and non-quantitative) when they are arrayed on the continuum of formal education. Individuals without formal

schooling, are expected to be illiterate in any natural language, unless they have had non-formal literacy training.

In those areas where English is not the dominant language of discourse (e.g., Africa and Asia), individuals with some minimum of formal schooling should be literate in their native languages. Those with more years of schooling, where English is the official language, should be literate in both English and native language (i.e., biliterate). As the years of schooling increase, the probability of literacy in both languages (i.e., biliteracy) as well as quantitative literacy, increases.

Since the English language uses a well developed numbering system, and many other languages do not (see section 5.b.i), we should expect individuals who are literate in English to be relatively more sophisticated in quantitative symbols and concepts compared to those literate only in native language or illiterate. From this line of reasoning, it appears there is interdependence among years of formal schooling and literacy in the quantitative and non-quantitative symbol systems.

In sum, it is expected that:

1. When individuals go to school, they acquire new symbol systems.
2. As individauls' levels of formal education increase, their chance of acquiring more efficient symbol systems (quantitative and

non-quantitative/English) increases.

3. Subsequently, the higher the individual's level of formal education, the more complex the individual's symbol system (language) becomes, and
4. Higher levels of formal schooling require more complex symbol systems; thus recognizing the interdependence of literacy and schooling.

Further, the acquisition of more complex symbol systems is believed to be necessary to engage effectively in problem solving situations involving complex relationships such as those found in the diffusion-adoption processes involving technological innovations as noted earlier (section 5.b.i). Thus, the more sophisticated symbol users (i.e., higher literacy and school grade completed) will be more likely than less sophisticated symbol users to adopt or to have the propensity to adopt innovations which are more complex.

4. Reconceptualization of Literacy

The preceding sections have developed materials to show the relation between: language and behavior, language and literacy, literacy and education, and the presumed connection between literacy and formal education on one hand, and awareness or knowledge and adoption or propensity of adoption of technological innovations on the other.

Clearly, a reconceptualization of literacy is needed. The reconceptualization proposed includes the addition of uniform measures of English as well as native language literacy (in areas where English is not the dominant language of discourse, e.g., Africa and Asia), and the development of measures of quantitative literacy to be included in the overall assessment of levels of literacy. This would involve more precise indicators of levels of literacy within each of the three components of literacy (viz., native language, English language, and quantitative symbols and concepts), and it would eventually lead to a composite measure of the three components. The aim is to have at least interval levels of measurement for each of the indicators.

At some point, it may be possible to establish a uniform norm for saying that a person is literate (or not literate) in any of those three components. When that is possible, a composite set of levels as shown in Figure 2 may be constructed for classifying individuals on their literacy levels particularly in Developing Countries.

The four levels of literacy in the below scheme are stated in an increasing order of language sophistication with respect to the number and types of symbols an individual is able to access and process at the level of literacy at which he/she is located. That is, individuals located on Level I access and process the least number and type of symbols. These are the illiterate individuals. Individuals located

LITERACY LEVEL	TYPE OF LITERACY: Illiterate	Literate in Native Language	Literate in English	Literate in Quantitative Symbols and Concepts
Level I	X			
Level II		X		
Level III		X	X	
Level IV		X	X	X

Legend: The "X" indicates the type of literacy associated with each level of literacy.

Figure 2. A Schematic Ordering of Literacy Levels Among Adult Populations in Developing Countries

on Level IV are able to access and process the greatest number and types of symbols at the interpersonal mode of communication involving reading and writing skills. Levels II and III are intermediate levels at this mode. However, individuals located on Level III (biliterates) are able to access and process more types of symbols than those individuals located on Level II (Monoliterates).

Thus, as one increases reading and/or writing skills with respect to native language, English and quantitative symbols and concepts, then one will be more able to deal with (analyze and synthesize) complex relationships such as among technological innovations in the diffusion-adoption process.

It is therefore to be assumed that relative to individuals located on the first three levels of literacy, individuals located on Level IV can handle more effectively the more precise and fairly complex relationships among the phenomena in their environment. They are able to do this by virtue of their literacy in quantitative symbols and concepts which are natural means of arranging the facts of experience in such a way that such facts can be dealt with (analyzed and synthesized) precisely.

Subsequently, since diffusion-adoption processes frequently involve complex relationships in which quantitative symbols are germane, the level of awareness or knowledge and adoption or propensity of adoption of technological innovations is expected to follow the order of the four levels of literacy noted above. That is, Level I literacy should be associated with the least level of awareness or knowledge and adoption or propensity of adoption of technological innovations, and Level IV should be associated with the highest level of awareness or knowledge and adoption or propensity of adoption of technological innovations. The level of awareness or knowledge and adoption or propensity of adoption of technological innovations should be intermediate on Levels II and III. However, Level III should be associated with higher awareness or knowledge and adoption or propensity of adoption of technological innovations compared to Level II literacy.

An effort will be made to obtain samples from the USA population which will include representatives of each of the four levels of literacy. This may be extremely difficult in a setting where English is the native language. One step in this reconceptualization process is to test some measures of the three components of literacy and to determine their individual and joint contributions in explaining the variance in levels of knowledge and adoption of technological innovations. Their inter-relationships will also be available for inspection in this process. The specific instruments and procedures for measuring each of the three components will be described in the next chapter on methodology. The specific hypotheses which this study was designed to test are stated in the following section.

5. Theoretic Hypotheses

Following the theoretic expectations of behavioral, mediation, and cognitive theories, the assumptions on the role of language in human communication, and the subsequent reconceptualization of literacy, the following theoretic hypotheses will be tested with the data from this study's two sample spaces; viz., Nigeria - Ilewo and the USA - Michigan:

a. Nigeria - Ilewo

H_1: As last grade of school completed (LGRADE) increases, there is a parallel increase in:

a. literacy in native language (YORUBA),
b. literacy in English (ENGLIT),
c. awareness (AWARE) of technological innovations, and
d. adoption (ADOP) of technological innovations.

H_2: In predicting the awareness (AWARE) of technological innovations, the following three regressors, or some subset of them, will explain significant variance:
a. last grade of school completed (LGRADE),
b. literacy in native language (YORUBA), and
c. literacy in English (ENGLIT).

H_3: In predicting the adoption (ADOP) of technological innovations, the following four regressors, or some subset of them, will explain significant variance:
a. last grade of school completed (LGRADE),
b. literacy in native language (YORUBA),
c. literacy in English (ENGLIT), and
d. awareness (AWARE) of technological innovations.

b. USA - Michigan. This sample space comprises a native English-speaking group and a native Spanish-speaking group. This study seeks to test the following theoretic hypotheses in each of these groups.

i. Native English-speaking Group.

H_4: As last grade of school completed (LGRADE) increases, there is a parallel increase in:
a. literacy in English (ENGLIT),
b. quantitative literacy (QLIT),
c. knowledge (KNOW) of technological innovations,
d. adoption (ADOP) of technological innovations, and
e. the propensity of adopting complex technological innovations.

H_5: In predicting quantitative literacy (QLIT), the following regressors independently, or together, will explain significant variance:
a. last grade of school completed (LGRADE), and
b. literacy in English (ENGLIT).

H_6: In predicting the knowledge (KNOW) of technological innovations, the following three regressors, or some subset of them, will explain significant variance:
a. last grade of school completed (LGRADE),
b. literacy in English (ENGLIT), and
c. quantitative literacy (QLIT).

H_7: In predicting the adoption (ADOP) of technological innovations, the following four regressors, or some subset of them, will explain significant variance:
a. last grade of school completed (LGRADE),
b. literacy in English (ENGLIT),
c. quantitative literacy (QLIT), and
d. knowledge (KNOW) of technological innovations.

ii. Native Spanish-speaking Group.

H_8: As last grade of school completed (LADRADE) increases, there is a parallel increase in:
a. literacy in Spanish (SPANLIT),
b. literacy in English (ENGLIT),
c. biliteracy (BILIT),
d. quantitative literacy (QLIT),
e. knowledge (KNOW) of technological innovations,
f. adoption (ADOP) of technological innovations, and
g. the propensity of adopting complex technological innovations.

H_9: In predicting quantitative literacy (QLIT), the following four regressors, or some subset of them, will explain significant variance:
a. last grade of school completed (LGRADE),
b. literacy in Spanish (SPANLIT),
c. literacy in English (ENGLIT), and
d. biliteracy (BILIT).

H_{10}: In predicting the knowledge (KNOW) of technological innovations, the following five regressors, or some subset of them, will explain significant variance:
a. last grade of school completed (LGRADE),
b. literacy in Spanish (SPANLIT),
c. literacy in English (ENGLIT),
d. biliteracy (BILIT), and
e. quantitative literacy (QLIT).

H_{11}: In predicting the adoption (ADOP) of technological innovations, the following six regressors, or some subset of them, will explain significant variance:
a. last grade of school completed (LGRADE),
b. literacy in Spanish (SPANLIT),
c. Literacy in English (ENGLIT),
d. biliteracy (BILIT),
e. quantitative literacy (QLIT), and
f. knowledge (KNOW) of technological innovations.

H_{12}: As the level of literacy (LITLEV) increases, the level of:
a. knowledge (KNOW) of technological innovations, and
b. adoption (ADOP) of technological innovations increases.

CHAPTER II

METHODOLOGY

The preceding chapter identified two aspects of literacy which have generally been overlooked in diffusion-adoption research involving technological innovations particularly in Developing Countries. The two aspects included quantitative and non-quantitative English literacy.

The chapter reviewed the literature on the correlates of literacy, function of literacy, regional distribution of literacy, prior conceptualizations of literacy, and identified the range of symbol systems in diffusion-adoption processes. The chapter noted the theoretic expectations of behavioral, mediation, and cognitive theories, and the assumptions of the role of language in human communication as bases for reconceptualizing literacy and, subsequently, for formulating theoretic hypotheses. Literacy was reconceptualized in terms of four levels in which literacy in English and quantitative symbols and concepts were included. In addition, the chapter also explicated the theoretic relations between language and literacy, literacy and education and the presumed connection between literacy and formal education on one hand, and awareness or knowledge and adoption or propensity of adoption of technological innovations on the

other. Finally, from the theoretic frameworks and related conceptualizations, the chapter concluded with a list of the theoretic hypotheses which will be tested with data sets from this study's sample spaces; viz., Nigeria - Ilewo and the USA - Michigan.

The purpose of the current chapter is to (a) operationalize the variables, (b) describe the samples, (c) describe data collection procedures, (d) describe the data processing, and (e) describe methods of analysis.

A. OPERATIONALIZATION OF VARIABLES

1. Variables in the Nigeria - Ilewo Data Set

a. The Independent Variables:

i. Education: This was measured in terms of years of school, i.e., last grade of school completed. The ranked categories and the frequencies and percentages in each category are shown in Table 2 below.

ii. Literacy: In Native Language (Yoruba)-- The skills included (a) reading Yoruba, and (b) writing of Yoruba. Individuals were self-rated on these skills using the categories: Not at all; small-small, and well which were coded 0, 1, and 2 respectively. An individual's literacy score in Yoruba derived from the summation of his scores from the two literacy skills.

Table 2. Frequency and Percent of Respondents in Each Education Category in the Nigeria - Ilewo Sample Space

Level of Education	Frequency	%
None	264	72.5
Primary incomplete (1-5 years/ still schooling)	32	8.8
Primary complete (6 years)	25	6.9
Secondary incomplete (7-10 years)	34	9.4
Secondary complete (11-12 years)	6	1.6
Post secondary (13^{+} years)	3	0.8
Total	364	100.0

In English language--The skills included (a) speaking of English; (b) reading of English, and (c) writing of English. Like literacy in Yoruba, literacy in English was also based on respondent's self-rating on the literacy skills, and the same response categories and codes were used. An individual's literacy score in English derived from the summation of his scores on the three skills. The frequency and percent of respondents in each level of literacy category in both Yoruba and English are shown in Table 3.

Table 3. Frequency and Percent of Respondents in Each Level of Literacy Category in Yoruba and English for the Nigeria - Ilewo Sample Space

Type and Level of Literacy		Frequency	%
Level of Reading Yoruba			
Not at all		232	63.7
Small-small		53	14.6
Well		79	21.7
	Total	364	100.0
Level of Writing Yoruba			
Not at all		248	68.1
Small-small		44	12.1
Well		72	19.8
	Total	364	100.0
Level of Speaking English			
Not at all		285	78.3
Small-small		25	6.9
Well		54	14.8
	Total	364	100.0
Level of Reading English			
Not at all		290	79.7
Small-small		18	4.9
Well		56	15.4
	Total	364	100.0
Level of Writing English			
Not at all		295	81.1
Small-small		15	4.1
Well		54	14.8
	Total	364	100.0

b. The Dependent Variables are awareness and adoption of 13 technological innovations shown in Table 4.

i. Awareness[12] was operationalized by asking for the number of years ago the respondent

Table 4. Frequencies on Years Ago Respondent First Heard About Each of the Agricultural and Health Innovations in the Nigeria - Ilewo Sample Space (N=364)

YEARS AGO FIRST HEARD	AGRICULTURAL INNOVATIONS								HEALTH INNOVATIONS				
	Improved cocoa	Ferti-lizer	Improved chickens	Pere-nox	Gamma-lin	Maize treat-ment	ESI maize	Cocoa spray	Babies' feeding bottles	Mater-nity deliv-ery	Babies' powered milk	Qui-nine	Latrine
Never	2	157	22	148	2	251	4	3	76	2	34	278	2
1	1	62	6	2	1	32	46	1	3		101		3
2	1	43	13	3		28	115		15		35	4	74
3	4	28	41	9	9	18	56	11	24	3	27	5	57
4	1	15	34	32	14	7	23	25	18	3	35	6	8
5	19	27	77	45	34	9	47	40	61	5	56	7	13
6	33	8	33	50	48	1	19	48	55	10	19	13	12
7	17		22	42	27	1	11	34	29	10	7	10	10
8	51	6	41	18	75	3	23	76	48	30	21	15	24
9	13	1	6	3	16	2	6	31	6	11	8	5	14
10	125	8	30	8	99	3	6	69	17	106	10	7	45
11	13		3	1	10	1		7	3	31	1	1	4
12	39	3	9		17	1	2	10	1	42	3	2	22
13	4		2	1	8	1	1	1	2	6	1	2	6
14	2							3		3		1	7
15	33	2	12	2	4		3	5	4	74	3	3	12
16			2			1	1			10	1	1	10
17			1										3
18	1		1						1	1			5
19												1	1
20	3	1	8			2				13	2	1	17
21													1
22		1					1						1
23													1
24		1											3
25	1	1								1			2
26	1											1	1
30			1			1			1				5
33												1	1
35						1							
40						1							
41						1				1			
	364	364	364	364	364	364	364	364	364	364	364	364	364

first heard about each of those innovations. The ordered response categories included: Never, one year ago, two years ago, three years ago, etc. The respondent's level of awareness derived from a summation of his scores (years ago first heard) along those categories for both the agricultural and health innovations. The higher the sum of years ago first heard, the higher the awareness. Table 4 shows the distribution of the respondents on their awareness of each of the innovations.

ii. Adoption of the technological innovations was measured by the years ago the innovation was first tried and the continued use of it. The ordered response categories for first tried included: (a) never, one year ago, two years ago, three years ago, etc. Never received a value of zero; one year, a score of one, etc.

Continuation of use was rescored either as no or yes and received a value of zero or one respectively. The individual's level of adoption was then derived from the summation of the scores on the two indicators, viz., "first tried" and "continued use."

The distribution of respondents on years ago respondent first tried each of the agricultural and health innovations is shown in Table 5, and Table 6 shows their distribution for continued use of each of the agricultural and health innovations.

2. Variables in the USA - Michigan Data Set

a. The Independent Variables

i. Education: This was measured in terms of years of school. For individuals who were not in school at the time of this study, their level of education was taken to be the last grade of school completed. For those in school at the time of this study, their last grade of school completed was computed by adding their current school classification to the general last grade of school they must have completed to be in their current level of classification. Accordingly, the last grade of school completed by the high school respondents was computed by adding eight years of elementary school to the respondent's present high school classification, and the last grade of school completed by the college respondents was computed by adding twelve years of high school to the respondent's current classification in college. The resulting distribution

Table 5. Frequencies on Years Ago Respondent First Tried Each of the Agricultural and Health Innovations in the Nigeria - Ilewo Sample Space (N=364)

	AGRICULTURAL INNOVATIONS								HEALTH INNOVATIONS				
YEARS AGO FIRST TRIED	Improved cocoa	Ferti-lizer	Improved chickens	Pere-nox	Gamma-lin	Maize treat-ment	ESI maize	Cocoa spray	Babies' feeding bottles	Mater-nity deliv-ery	Babies' powered milk	Qui-nine	Latrine
Never	169	300	304	235	140	322	140	150	205	142	201	301	41
1	1	29	3	1	3	8	103	2	12	6	63	2	19
2	7	15	4	13	8	12	54	9	17	3	15	2	94
3	12	5	14	34	21	6	33	23	26	15	17	7	33
4	22	1	13	30	57	2	11	49	19	14	16	3	11
5	36	2	13	23	48	3	13	42	23	12	17	7	16
6	23	2	9	11	30	2	3	33	24	26	5	13	14
7	17	1	1	8	17		1	19	6	17	7	8	12
8	32	3	2	4	21			22	16	28	9	8	20
9	5			3	5		1	4	7	22	4	2	10
10	21	2	1	1	13	2	2	10	5	36	4	6	25
11	5		1	1				1		8	1		7
12	7					1	1		1	10	3		9
13	1								1	4	1		5
14	2					1	1			4		1	3
15	1	1				2	1		1	9			12
16	1									4		1	8
17										1			1
18						1							2
19									1				
20	2					1				2	1		10
21													1
22												1	1
23													1
24													3
25						1							2
26						1						1	1
28													1
30													1
33												1	1
52										1			
	364	364	364	364	364	364	364	364	364	364	364	364	364

Table 6. Frequencies on Continued Use of Each of the Agricultural and Health Innovations in the Nigeria - Ilewo Sample Space (N-=364)

	AGRICULTURAL INNOVATIONS								HEALTH INNOVATIONS				
IF STILL USING	Improved cocoa	Ferti-lizer	Improved chickens	Pere-nox	Gamma-lin	treat-ment	ESI maize	Cocoa spray	Babies' feeding bottles	Mater-nity deli-ery	Babies' Powdered milk	Qui-nine	Latrine
No	193	308	316	248	206	327	203	202	229	177	217	314	188
Yes	171	56	48	116	158	37	161	162	135	187	147	50	176
	364	364	364	364	364	364	364	364	364	364	364	364	364

of the respondents on this variable is shown in Table 7.

Table 7. Distribution of the USA - Michigan Respondents on Last Grade of School Completed

Last Grade of School Completed	Frequency	%
0	8	3.3
2	3	1.2
3	1	.4
4	4	1.7
5	4	1.7
6	6	2.5
8	28	11.6
9	10	4.1
10	18	7.4
11	15	6.2
12	78	32.2
13	36	14.9
14	13	5.4
15	9	3.7
16	9	3.7
Total	242	100.0

ii. Literacy in English and in Spanish

The respondent's level of literacy was determined by the Slosson Oral Reading Test (SORT) instrument (see Appendix A) which consists of a list of 200 words ranging from very easy words to more difficult ones. The "same" instrument was used to determine the level of literacy among Spanish speakers after translating the English words in the SORT instrument into "equivalent" Spanish words. In either type of literacy (Spanish

and English), the respondent's level of literacy was determined from the number of words he/she was able to read from the list. Biliteracy: Both the English and Spanish versions of the SORT instrument were administered to the bilingual cases to determine their level of biliteracy (i.e., literacy in both Spanish and English). The score for biliteracy was derived as a multiplicative function between English and Spanish literacy scores. This method of score transformation was based on some empirical and theoretical considerations.

Research indicates that bilinguals are generally superior in their mental and creative abilities compared to monolinguals. For example, bilinguals (English-French) outperform their monolingual counterparts on all verbal and non-verbal tasks (Peal and Lambert, 1962); bilinguals (among English, Greek-American, Spanish-American, and Czech-American speakers) are more creative and score higher on non-verbal "uses" test than monolinguals (Jacobs and Pierce, 1966); bilinguals (English-Spanish) outperform monolinguals on all such tasks as object

constancy, naming, and sentences (Feldman and Shen, 1969); bilinguals (English-Spanish) have higher school achievement and self-concept than monolinguals (Del Buono, 1971); bilingual (English-Spanish) children have as high IQs as monolingual children if not higher ones in some respects (Gezi, 1974); bilinguals (Persian-English) have greater flexibility in writing coordination compared to monolingual Persians (Hoosain, Atai, and Salili, 1975), and research on semantics and structure among monolingual and bilingual (English-French) shows that classical coding measures (latency, reaction time, number of words, number of syllables, and interpersonal agreement) correlate with each other for both monolinguals and bilinguals. However, the intensity of meaning is inversely correlated with the coding measures only for the monolinguals. For the bilinguals, intensity of meaning is directly related to the coding measures (Russ, Gold, and Cherulnik, 1975). This led Russ and his colleagues to speculate that although coding measures do hold up between monolinguals and bilinguals, they may mean different

things. Words that have intense meaning for bilinguals may be those that elicit a host of associations; while for the monolinguals, the semantically intense words elicit few associations.

Given the theoretic connection between language and literacy noted in the previous chapter (see section C. 2), the superiority of bilingualism noted above implies superiority of biliteracy. Recall, biliteracy which includes literacy in English (i.e., Level III literacy) implies superior ability to construe the environment by those endowed with it. That is, as one increases reading and/or writing skills in native language (i.e., Spanish in this case) and in English, then one increases one's capacity to deal with (analyze and synthesize) the phenomena in one's environment.

Moreover, there is also empirical evidence indicating that literacy in English is acquired faster if persons are already literate in their native languages. Modiano (1966), for example, found in her research in three Mexican tribal areas that persons who were already literate in their tribal

languages acquired greater facility in reading comprehension in English. In such areas as Africa and Asia where English is not the dominant medium of discourse,[13] this finding is to be expected since literacy in English presupposes literacy in native language in those areas. The acquisition of literacy in English in those areas implies mere extension of the literacy skills which one already has in the native language.

Therefore, in light of the above research evidence and conceptualizations, the multiplicative algorithm was found appropriate for transforming more precisely the pattern of Spanish and English literacy scores into the cardinality of a biliteracy score. In addition, this algorithm gives the flexibility of deriving a cardinality from two or more numbers whose referents are so different (as is the case with Spanish and English literacy scores) that direct addition of such numbers would not be very meaningful.

iii. Quantitative Literacy:[14] The author constructed items (see Appendix B, pp. 192-199)

with which to measure this variable along four dimensional skills in which numbers and/or number concepts are used:

1. Respondent's knowledge of the functional characteristics (ordinality and cardinality) of number,
2. Respondent's knowledge of the standard units of measures and weights which are in common use in his/her area,
3. Respondent's computation skills, and
4. Respondent's intuitive use of numbers and number concepts.

Like the SORT instrument, the quantitative literacy test (QLT) items were also translated into Spanish to facilitate administration to the Spanish-speaking respondents. A composite score was derived for each respondent from the items designed to measure the four dimensional skills stated above. It was conceived that the higher the respondent's score on the QLT items, the higher would be his/her level of quantitative literacy. The QLT items were tested for reliability as described below.

Testing the QLIT Items for Reliability

> If an instrument is valid, it is reflecting primarily the characteristic which it is supposed to measure, with a minimum of distortion by other factors, either constant or transitory; thus there would be little reason to investigate its reliability--that is the extent to which it is influenced by transitory factors (Sellitz, et al., 1959, p. 166).

The above paragraph is both informative and instructive. Firstly, the paragraph is informative in that it specifies the close connection between validity and reliability, and, in general, to the extent that a measure is unreliable, it lacks validity.[15] Secondly, the paragraph is instructive in that if the validity of a measure is not known, it is necessary to investigate the reliability of the measure.

Since no earlier studies had been concerned with the construct of quantitative literacy, it was not known if the 48 items had satisfactory validity for measuring this construct. It was therefore necessary to test for the reliability of these items in their measure of quantitative literacy.

In this study, the 48 items designed to measure the construct of quantitative literacy were tested for their reliability among the study's respondents who were divided into four groups for the purpose of this analysis: (1) Whites (N = 83) whose last grade of school completed (LGRADE) was equal to or less than 12 years of school, (2) Whites (N = 58) whose last grade of school completed was equal to or greater

than 13 years of school, (3) Chicanos or Mexican Americans (N = 61), and (4) Black and Native Americans (N = 38).

In each of these four groups, the 48 items were tested through the Split-half model of the reliability analysis routine to test for the equivalence of measures. Four reliability coefficients were computed in each group:

First, a correlation coefficient between the two halves each of which had 24 items was computed. This coefficient measures the extent to which the two halves measure the same thing, i.e., quantitative literacy.

Second, the Spearman-Brown split-half coefficient was generated to measure how reliable the scale would be if the two equally reliable halves were combined into one.

Third, the Guttman split-half coefficient was computed. This is similar in form to the Spearman-Brown coefficient except that the Guttman split-half coefficient does not necessarily presume equal reliabilities or equal variances.

Finally, coefficient alpha was computed for both halves. This is a maximum likelihood estimate of the reliability coefficient if a parallel model is assumed to be true. That is, the model in which the items or tests are assumed to have the same true score variances over a set of objects (i.e., quantitative literacy) being measured, and the same error variance over replications.

The following paragraphs report the results of these four coefficients in each of the four groups of respondents stated above.

Coefficients of Reliability Among Whites; LGRADE ≤12 Years (N = 83)

In this group, the correlation coefficient between the two halves (scale form) is .712 which is very high.[16] The Spearman-Brown split-half coefficient is .932 which is significantly high. The Guttman split-half coefficient (.831) generated is also significantly high. The coefficient alpha computed for the first and second half of scale forms is .888 and .889 respectively both of which are significantly high and stable.

Coefficients of Reliability Among Whites: LGRADE≥13 Years (N = 58)

The correlation coefficient between the scale forms in this group is .334 which is rather low. The Spearman-Brown split-half coefficient (.501), and the Guttman split-half coefficient (.472) are moderate. The coefficient alpha for the first and second scale form is .564 and .696 respectively both of which are fairly high and rather stable.

Coefficients of Reliability Among Mexican Americans (N = 61)

In this group, the correlation coefficient (.746) between the scale forms is very high. The Spearman-Brown split-half coefficient (.854) is significantly high, and the Guttman split-half coefficient (.851) is also significantly high. The coefficient alpha for the first and second scale form is .897 and .844 respectively both of which are significantly high and stable.

Coefficients of Reliability Among Black and Native Americans (N = 38)

The correlation coefficient (.814) between the scale forms in this group is significantly high. The Spearman-Brown split-half coefficient (.898), and the Guttman split-half coefficient (.894) are both significantly high. The coefficient alpha for the first and second scale form is .893 and .856 respectively both of which are significantly high and stable.

Clearly, the four reliability coefficients related to these groups generally indicate relatively high consistency in the scale items in their measure of the construct of quantitative literacy. Any variation in the scores therefore is to a greater extent to be attributed to variation among the respondents rather than to the scale.

The items on the QLT were selected to have "face validity"; i.e., the items were assumed to be relevant in measuring the selected dimensions of quantitative literacy. A factor analysis of the QLT data showed the items presumed to be measuring the same concepts and operations generally loaded together on the expected factors.[17]

b. The Dependent Variables. These included quantitative literacy, knowledge of selected technological innovations, and adoption of those innovations. While quantitative literacy is primarily considered a predictor and explanatory variable for the knowledge and adoption of technological innovations, it is used as a dependent

variable in some of the computations to determine the extent to which it can be predicted by the other independent variables. Since operationalization of QLT has already been discussed, only the operationalization of knowledge and adoption will now be presented.

i. Knowledge of selected technological innovations in health, Co-operative Extension and Social Service Agencies was derived from responses to the following items:

1. Respondent had heard of the innovation.
   Yes = 1; No = 0

2. If yes, where had he/she heard about it?
   Any correct source = 1;
   no source or wrong source = 0

3. Give a meaning of the innovation.
   Correct answer = 1; wrong or
   don't know = 0

4. Where would the respondent go for information about the innovation?
   Any correct source = 1; no source
   or wrong source = 0

5. Under which of the listed conditions would he/she consider using the innovation?
   Correct answer = 1;
   wrong or don't know = 0

In addition, a sixth item was asked for cardiopulmonary resuscitation (CPR): Do you think you know enough to do CPR if someone needed it?: Yes = 1; No = 0.

Each respondent's score of knowledge derived from the summation of his/her

responses on the items as described above.

ii. Adoption measures were derived for the innovations by asking respondents about their use of each. Four of the technological innovations offered two options for adoption --a simple version and a complex version. These were scored zero if the respondent had never used either of the two versions; 1 if the respondent used the simple version, and 2 if the respondent used the complex version. For the other innovations, respondents were scored 0 if they had never used it; 1 if they used it sometimes, and 2 if they used it most of the time.

As may be noted in the questionnaire (Appendix B), the structure of the items for the four complex innovations was somewhat different; and in the analysis pertaining to those four innovations, the propensity of adopting complex innovations is taken as the dependent measure. The data were obtained by providing the respondents with a situation in which they were to choose either the simple or the complex version of the technological innovation. These four technological innovations were: DIABKITS

(two versions of kits for testing for diabetes); DRUGFORM (two forms of administering a drug for an illness); TECHCPR (two techniques of emergency for CPR), and FOODFORM (two forms of food preparation for the same food product). One form of each of those innovations required more precise measurements and was thus considered more complex than the other form (see items 7, 8, 16, and 35 in Appendix B, pp. 187-189, 191.

These innovations offering the simple-complex choice were provided on the assumption that individuals who are less sophisticated in the use of numbers and number concepts (i.e., low in quantitative literacy) would shy away from adopting the more complex technological innovations. Hence, they would adopt the simpler versions of the innovations which did not require precise measurements on their part. The more quantitatively sophisticated individuals were expected to adopt the more complex types of technological innovations which required precise measurements and, ipso facto, in which numbers and number concepts were used.

The respondents' level of adoption derived from the summation of their scores on the adoption indicators as described above and in footnotes 18 and 19.

The complete text of the knowledge, adoption, and quantitative literacy items, and biographical information for the instrument used in the USA - Michigan sample may be seen in Appendix B.

c. Development of Data Collection Instrument for the USA - Michigan Data Set. Generally, the construction of the instrument for the USA - Michigan sample space involved the steps described below.

First, the author reviewed the literature on mathematics and statistics to supplement his basic training and personal experience in these areas. From these areas, a number of specific quantitative concepts derived from four operational concepts of intuition and logical thinking:

(1) Series in which a group of events are related by order of occurrence. The specific quantitative concepts or number properties considered included ordinality--cardinality, commutativity, and invariance or conservation of number.

(2) Sets which are concerned with intuitive categories for classifying objects or events. As Langbehn, et al., (1972) assert, "intuitively, we

think of a set as a collection of things which are separate and distinct from other things. Thus, given something, we know whether it belongs to that set or it does not" (p. 113). Set is a name which is given ". . . for an aggregate, ensemble, or collection of things that are combined under a certain criterion or according to a certain rule. The concept of a set arises by an abstraction. By considering a certain collection of objects as a set, we disregard all the connections and relations between the various objects that make up the set, but we preserve the individual features of the objects" (Aleksandrove, et al., 1969, p. 5). The specific quantitative concepts considered included inclusion/exclusion, isomorphism (one-to-one correspondence) and the axioms of equality, viz., reflexitivity, symmetry, and transitivity.

(3) Proportionality which is concerned with the relation between quantities or cardinalities such that if one quantity varies another varies as a multiple of the first. The specific quantitative concepts included fraction, ratio, and percentage.

(4) Matrices which facilitate the simultaneous classification of or operation upon the relation between elements in two ways as defined by the rows and columns of a matrix (see Weiss and Yoseloff 1975, p. 260). The specific quantitaitve concepts

considered included simultaneity in classification through the mathematical operations of addition, subtraction, and division.

Second, items were developed and compiled to measure the four dimensions of quantitative literacy stated earlier in this chapter. These dimensions were manipulated along the specific quantitative concepts which derived from the concepts of series, sets, proportionality, and matrices as stated above.

Third, after compiling the quantitative literacy items, the author checked with some mathematicians, statisticians, and similar others for the correct responses on the QLT items. Appropriate changes were made on the wording and structure of some of the items whenever this was necessary. The quantitative concepts stated above and their corresponding QLT items in the instrument are summarized in Table 8.

Fourth, a number of community agencies were contacted for information on their current innovations for the clients they serve. The agencies included health, Co-operative Extension, and Social Service Agencies, inter alia. From these contacts and documents secured from the agencies, ten innovations were selected to be included in the instrument.

In selecting the innovations, effort was made to ensure that the types of innovations to be included in the instrument represented a range of innovations from the very simple to the more complex innovations. The more complex

Table 8. Quantitative Concepts and Their Corresponding Number of QLT Items in the Instrument for the USA - Michigan Data Set

Basic Quantitative Concepts of Operation	Specific Quantitative Concepts	Item # (see Appendix B, pp. 182-199
1. Series	a. Ordinality:	1a,b; 2a,b; 13a; 14a; 16a,b;
	b. Cardinality:	3a,b; 10; 11; 12a-c; 20e; 22a-e; 23a-e
	c. Commutativity:	17
	d. Invariance or conservation of number	7; 13b; 14b
2. Sets	a. Symmetry:	9; 18
	b. Transitivity:	4;
	c. Inclusion-Exclusion:	8a-c; 19
	d. Isomorphism (one-to-one correspondence):	5; 6; 15a-c
3. Proportionality	a. Fraction:	20c; 21a-c
	b. Percent:	18;
	c. Ratio:	20d
4. Matrices	a. Simultaneous operations	20a-b

innovations were distinguished from the simple ones in that the former imposed a demand for more precise measurements on the part of the potential adopter than did the simpler innovations. It was assumed that the more numerate (i.e.,

quantitatively sophisticated) individuals would be those with higher levels of education. It was therefore expected that individuals with higher levels of education would be more likely than not to adopt or to have the propensity to adopt the more complex innovations compared to the individuals with lower levels of education; the latter category of individuals would tend to shy away from the complex types of innovations in which numbers are used.

For this purpose, items were included in the instrument to measure individual's propensity to adopt certain types of innovations which were described in the instrument. This was done by describing a situation of adoption in which the respondent was required to choose adopting only one of two types of technological innovations described, one of which was a simple innovation and the other a more complex one which required use of numbers in some way.

To these rather contrived innovations--eight of them (see items #7, 8, 16, and 35, Appendix B, pp. 187-189, 191) were added ten simpler innovations which included Consumer Reports, Dollar Watch, Tel-Med, Consumer Credit, Expanded Nutrition Program, Diabetes test, Cardiopulmonary resuscitation (CPR), Project Health, the Michigan Winter Heating Bill, and Meal Planning.

Hence, this range of technological innovations was expected to discriminate more sensitively the knowledge levels and the adoption behavior among the populations in question.

Fifth, the items designed to measure respondent's knowledge and adoption levels for the stated ten simpler innovations and adoption propensity for the eight more complex innovations were then developed. For the simpler innovations, the items included were those assumed to be more sensititve and complete in measuring the important dimensions of knowledge and adoption as discussed in the operationalization of variables in this sample space (also see Appendix B, pp. 182-200).

Sixth, the instrument was then put together using both the QLT items and the knowledge and adoption items, and items for biographical information. These were then all translated into Spanish.

Seventh, the instrument was then pretested among ten Spanish speakers from a Spanish Speaking Senior Citizens organization in Lansing, and among six students from Michigan State University.

Following this pretest, further word changes were made whenever necessary to improve the sensitivity of the instrument. In addition, the open-ended questions which asked for the respondent's reasons for his/her answers on some of the QLT items were deleted since the questions did not seem to provide useful data for analysis. This deletion also reduced the amount of time and energy of the respondent in completing the instrument. This saving in time and energy was particularly necessary for two reasons. First,

reading problems were anticipated among some of the respondents in this study. Secondly, except for the MSU students who were to be given extra credit for their participation in this study, the rest of the respondents merely volunteered to participate in the study. Consequently, it was necessary to keep the final version of the instrument as short as possible.

After the preceding preliminary precautions, the final version of the instrument was then printed in both English and Spanish.

B. SAMPLING

The theoretic hypotheses to be tested in this study were stated in the last section of the first chapter of this dissertation. The preceding section of the current chapter, (1) operationalized the variables in this study's two sample spaces of Nigeria-Ilewo and the USA - Michigan, and (2) reported the reliability test of the QLT items. The purpose of the current section is (1) to discuss the method of selecting this study's respondents, (2) to discuss the characteristics of these respondents, and (3) to point out the limitations of the samples.

1. Method of Selecting Respondents

This is an exploratory study whose main goal was to obtain valuable insights which may lead to further investigations. As mentioned earlier, some of the observation units

(respondents) in this study merely volunteered to participate in this study; others were given an incentive of extra credit in an introductory communication course for them to participate in this study.

In the Nigerian village of Ilewo, the respondents merely volunteered to participate in the study. Every male over the age of twenty was interviewed throughout this village as part of the Nigerian Diffusion Project at Michigan State University with the Economic Development Institute of the University of Nigeria at Enugu as a cooperating institution. The survey involved 364 male cases altogether. At the time of the survey, Ilewo was a re-settlement and predominantly farming village.

The respondents for the USA - Michigan sample space derived from:

1. the Spanish Re-entry (school dropouts) students of English as a second language and the Spanish Speaking Senior Citizens Organization under the auspices of Cristo Rey in Lansing;

2. the Spanish Re-entry students of English as a second language in the United Migrants for opportunity (UMOI) organization within the Adult Basic Education (ABE) program of the Lansing School District;

3. two high schools in Flint, viz., Carman High School and Mott Adult High. These samples included demographically heterogeneous ABE students, and

4. Michigan State University (MSU) students who were enrolled in an introductory communication course.

These data sources provided a total of 242 useful cases for analysis. Their distribution by race and sex is

shown in Table 9.

Table 9. The Distribution of Respondents in the USA - Michigan Sample Space by Race and Sex

DATA SOURCES	RACE AND SEX OF RESPONDENTS										Total
	Black American		Mexican American		Native American		White American		Other		
	F	M	F	M	F	M	F	M	F	M	
Cristo Rey: Re-entry Students			5	5							10
Senior Citizens			6	4							10
UMOI: Re-entry Students			4	6							10
Carman High School	4	1	6	8	3	3	36	21			82
Mott Adult High	7	11	2	14	3		21	5			63
MSU	4	2	1		1		42	16	1		67
Total	15	14	24	37	7	3	99	42	1		242

This investigator located the first four data sources through friendship and professional networks. After locating them, he then contacted the respective administrators for their permission and cooperation for this study to be done in their institutions.

Like in the Nigeria - Ilewo sample space, the respondents from the first four data sources named above merely volunteered to participate in the USA - Michigan part of this

study. The respondents from Michigan State University were, however, promised and given extra credit for their participation in this study. This extra credit was to be added to each respondent's potential grade in the introductory communication course in which the respondents were enrolled at the time of this study. This arrangement served as an incentive which attracted more respondents with college level education.

Thus, in both sample spaces (Nigeria - Ilewo and USA - Michigan), a non-random sampling method was applied to obtain the needed measurements (observations) from these two sample spaces. This method was conceived as the most appropriate sampling technique for obtaining a large amount of observations for valuable insights in a volunteer situation where "probability sampling either may be too expensive or lead to fewer such insights" (Blalock, 1972, p. 527).

Measurements were therefore taken from all the observation-units who volunteered in the sample spaces to participate in this study. Because of the volunteer situation, each individual ipso facto had an equal chance of being included in the study sample. Accordingly, it is also to be assumed here that there is independence of selection within the sample spaces in the sense that the choice of one individual or groups of individuals has no connection on the choice of another individual or groups of individuals to be included in the sample spaces.

Moreover, it may also be assumed that the variables being studied are random variables in these sample spaces. That is, these variables can assume any of the possible values of random variables. Hence, each variable "as a random variable, the probability of distribution of a sample observation is identical with that of the population of measurements--the random variable under consideration" (Chou, 1972, p. 270).

Given these assumptions, the findings which derive from the test of this study's hypotheses are generalizable to populations which are made up entirely of the individuals who are relatively homogeneous with respect to the variables or characteristics being studied here.

2. Characteristics of Respondents

Both the Nigeria - Ilewo and USA - Michigan sample space have observation-units (respondents) or groups of observation-units (respondents) who are representative of this study's population with respect to the variables being studied.

The Nigeria - Ilewo sample space has observation-units whose level of formal education is a continuum ranging from no years of school to thirteen and above years of school. Following the conceptualizations in the first chapter with respect to this variable, it is expected that years of school will discriminate these respondents with respect to their levels of literacy in native language

(Yoruba) and in English and, ipso facto, with respect to their levels of awareness and adoption of technological innovations in agriculture and health.

Moreover, since the observation-units in this sample space came, as it was stated above, from a re-settlement and predominantly farming village at the time of the survey, it may be assumed that these observation-units had farming experience. The agricultural innovations should therefore be assumed to be relevant to the observation-units particularly since the agricultural innovations included in the survey were those which were related to the type of agricultural systems in the village. The health innovations were also those which were related to the health practices in a rural setting. It may therefore be assumed that any discrimination on awareness and adoption levels is to be attributed to differences among the observation-units with respect to their levels of education and, ipso facto, to their differences in levels of literacy rather than to the relevancy of the innovations in the survey.

The USA - Michigan sample space has observation-units whose level of formal education is a continuum ranging from no years of school to college or university level of education. Again, following the conceptualization in the first chapter with respect to this variable, it is assumed that this variable will discriminate among the observation-units with respect to their levels of literacy in native language

(Spanish), literacy in English,[18] and literacy in quantitative symbols and concepts and, ipso facto, with respect to their knowledge and adoption of technological innovations in health, cooperative extension, and social service programs.

The college or university observation-units were included in this sample space to provide a complete array of individuals on the continuum of formal education variable. Thus, this inclusion provides useful comparative bases for the study variables such as levels of literacy (both quantitative and non-quantitative) and knowledge and adoption of technological innovations when these observation-units are arrayed along the continuum of formal education.

Moreover, those adult populations who have little or no formal education in this sample space, are rather similar to the majority of the adult populations in the Developing countries with respect to this variable. It is therefore expected that they have a pretty limited level of quantitative literacy. This, therefore, makes them appropriate, although not the preferred, populations for the tests on the relationships between quantitative and non-quantitative literacy on one hand and knowledge and adoption of technological innovations on the other. Their similarity to "Third-World" populations makes the findings of the measures in this study generalizable to those populations.

3. Limitations of the Samples

The Nigeria - Ilewo sample space, as stated earlier, involved 364 cases which were all male. Thus, this sample space has a sex bias. In areas where women traditionally make the decisions with respect to family farm operations and/or health practices, this male bias might lead to biases in the observations particularly with respect to measures of awareness or knowledge and adoption of technological innovations in agriculture and/or health.

A limitation in the USA - Michigan sample space may also be observed. The observation-units in this sample space are frequently exposed to messages of technological innovations in health, Cooperative extension, Social services, and so forth disseminated by some of the highest technological mass media developments in the world. These mass media have included television and radio which generally do not require reading nor writing skills to acquire knowledge for decision making with respect to the technological innovations. Thus, these mass media channels have potential to contribute additional explanation in the variance of knowledge of technological innovations beyond that explained by literacy among these observation-units.

C. DATA COLLECTION

1. The Nigeria - Ilewo Data Set

As stated earlier, every male over the age of twenty years was interviewed in 1966 throughout Ilewo village as part of the Nigerian Diffusion Project which was administered at Michigan State University with the Economic Development Institute of the University of Nigeria at Enugu as a co-operating institution. The interviews were carried out by a team of trained interviewers using the Project's questionnaires. The survey involved a total of 364 male cases.

The schedule had several indices together with questions regarding the awareness and the use of technological innovations in agriculture and health as well as communication behavior, farming operations, achievement motivation, empathy, fatalism, interpersonal trust, personal ratings in the village, occupational aspirations, education, literacy (in local language-Yoruba and in English), plus several sociometric and demographical questions.

From this schedule, this investigator selected the variables of interest for the current study. The variables which were selected and their respective response categories were stated earlier in this chapter under the operationalization of variables.

These data are very important in investigating the potential effects of literacy in English on the awareness or knowledge and adoption of technological innovations as a

new dimension of literacy in diffusion practices in parts of the world where English is not the native language. The data also provide a very important comparative basis on the relationship between literacy in English and awareness or knowledge and adoption of technological innovations since African languages and dialects do not have a common linguistic root with the English language compared to the Spanish language whose native speakers are included in the second part of this study.

2. The USA - Michigan Data Set

The data in the USA - Michigan sample space were collected in the Spring and Summer of 1978 using the questionnaire or instrument described earlier in this chapter (also see Appendix B).

The questionnaires were either distributed to the respondents to fill them out at their own leisure, or they were administered in group situations and on a one-to-one basis whenever either method was the necessary possibility.

This investigator supervised all the groups involved in the data collection process. In addition, he picked up the completed questionnaires from each of the study sites where the questionnaires had been left for completion at a later time.

For MSU students, this researcher made a brief appearance in each of the sections of an introductory Communication course to solicit for students to participate in his study

for extra credit. After a brief announcement and explanation, this researcher left copies of a memo with each instructor for the students who needed extra credit to pick them up from him/her for extra details such as purpose of the study and schedules for participating in the study. Participation in this study meant filling out the study's questionnaire. Each participant was given 0.05 extra credit per hour of participation following the Department's regulations.

Those students who needed extra credit reported to a room as stated in the memo and according to the schedule. The researcher introduced himself and reiterated the purpose of the study and the details concerning extra credit. The purpose of the study was stated to be in line with the message addressed to each participant on the cover page of the questionnaire (see Appendix B) with the addition that several other people (both in-school and out-of-school) were participating in this study. The researcher then invited questions related to the study from the participants, and after answering them (whenever there were some), he then passed out the questionnaires to be completed at that sitting. The Slosson Oral Reading Test (SORT) was administered to each participant before leaving the room. This segment of respondents yielded 67 completed questionnaires.

In case of the High School and ABE students in the two Flint schools, the researcher delivered the questionnaires to the Principal of each school involved. Through their

cooperation, the questionnaires were administered by the teachers who normally conducted the classes in which the volunteering students were enrolled. These students filled out the questionnaires during their leisure time. Important details in administering the questionnaires and the SORT instrument were given to the principal of each school to pass on to his teachers involved in the collection of the data.

In one school in Flint, 88 questionnaires were returned out of the 150 distributed. Of these 88 questionnaires, six questionnaires had very few items completed. Hence, these six questionnaires were not very useful; they were discarded, thus, leaving the total of 82 useful questionnaires from this particular school. From the other Flint school, of the 70 questionnaires distributed, 63 well-completed questionnaires were returned.

The data from the three Spanish groups: the Re-entry students, and Spanish Speaking Senior Citizens organization, and the United Migrants for Opportunity (UMOI) who had reading problems were gathered in group situations with the help of some of the Spanish-speaking students and their spouses in MSU, and sometimes with the assistance of the Spanish-speaking persons working among these populations. From these groups derived 20 well-completed questionnaires.

In addition, some questionnaires were distributed to those Spanish Speaking Senior Citizens who reported no reading

problems and had volunteered to participate in the study. They took the questionnaires with them to complete at their leisure. In this case, only the SORT instrument was administered at the place of the meeting. Of the 50 questionnaires distributed to this group, only 10 well-completed questionnaires were returned.

Following the above analysis, the investigator was thus able to get altogether 242 completed questionnaires (67 from MSU, 82 from one Flint school, 63 from the other Flint school, and 30 from the Spanish-speaking groups).

D. DATA PROCESSING

After collecting the data, this investigator did a content analysis of the responses to the open-ended items of knowledge of technological innovations. From this content analysis, he derived the common categories for coding the responses to the open-ended items.

Using these categories and the response categories of the non-open-ended items in the instrument, this investigator constructed the codebook for the study. A copy of this codebook may be obtained from this investigator.

After printing the codebook, this researcher then proceeded with the coding of the data. The coding was done on opscan computer sheets by groups of coders whom this researcher trained to do the coding. These groups included the students who were doing independent study with this

researcher, students who needed extra credit toward their grades in an introductory course in the Department of Communication at MSU, friends in MSU and relatives and their friends from Lansing Community College.

When the coding was over, a data deck was then punched from the opscan computer sheets using the computer facility of the Evaluation Services at Michigan State University.

Using the MSU computer interactive system, this investigator proceeded to clean the data deck for analysis. He had the assistance of two friends with computer programming experience.

E. METHODS OF ANALYSIS

This study's data were analyzed through multiple regression, and correlations which the regression routine provided, Chi square (X^2) tests, and one way analysis of variance (ANOVA).

1. Multiple Regression Models

Since functional relationships have been specified among the variables in this study, multiple regression models were formulated relating the independent and dependent variables in each of the two sample spaces. Specifically, the following regression models were tested in each sample space using the stepwise mode of this analytic routine; in each model, B_0 is the so-called constant term parameter. It expresses the value of the intercept that the dependent

variable Y_i takes on when the value of each independent variable X_i in the model is set to zero; B_i is the regression coefficient associated with the ith independent variable. That is, it is the slope of the regression line and it indicates the change in the mean of the probability distribution of the dependent variable per unit increase in an independent variable, and E_i is the residual term which is associated with the ith dependent variable. It expresses the difference between the observed value of Y_i and the corresponding fitted or predicted value $\hat{Y}_i$:

a. Multiple Regression Models in the Nigeria - Ilewo Sample Space. In this sample space, the following models were tested with the number and order of variables fianlly appearing in the equation determined by the stepwise routine:

i. $Y_1 = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + E_1$

where Y_1 = level of awareness (AWARE) of technological innovations,

X_1 = level of literacy in native language (YORUBA),

X_2 = level of literacy in English (ENGLIT), and

X_3 = last grade of school completed (LGRADE).

ii. $Y_2 = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + E_2$

where Y_2 = level of adoption (ADOP) of technological innovations,

X_1 = level of literacy in native language (YORUBA),

X_2 = level of literacy in English (ENGLIT),

X_3 = last grade of school completed (LGRADE), and

X_4 = level of awareness (AWARE) of technological innovations.

b. Multiple Regression Models in the USA - Michigan Sample Space. For purposes of analysis, this sample space was divided up into two groups which included the native English-speaking group (N = 169) and the native Spanish-speaking group (N = 61) as noted earlier.

The following models were tested in the native English-speaking group, with the number and order of variables finally appearing in the equation determined by the stepwise routine:

i. $Y_1 = B_0 + B_1X_1 + B_2X_2 + E_1$

where Y_1 = level of quantitative literacy (QLIT),

X_1 = last grade of school completed (LGRADE), and

X_2 = level of literacy in English (ENGLIT).

ii. $Y_2 = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + E_2$

where Y_2 = level of knowledge (KNOW) of technological innovations,

X_1 = last grade of school completed (LGRADE),

X_2 = level of literacy English (ENGLIT), and

X_3 = level of quantitative literacy (GLIT).

iii. $Y_3 = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + E_3$

where Y_3 = level of adoption (ADOP) of technological innovations,

X_1 = last grade of school completed (LGRADE),

X_2 = level of literacy in English (ENGLIT),

X_3 = level of quantitative literacy (QLIT), and

X_4 = level of knowledge (KNOW) of technological innovations.

The following models were tested in the native Spanish-speaking group, with the number and order of the variables finally appearing in the equation determined by the stepwise routine:

i. $Y_1 = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + E_1$

where Y_1 = level of quantitative literacy (QLIT),

X_1 = last grade of school completed (LGRADE),

X_2 = level of literacy in English (ENGLIT),

X_3 = level of literacy in native language--Spanish (SPANLIT), and

X_4 = level of literacy in both English and Spanish-biliteracy (BILIT).

ii. $Y_2 = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + E_2$

where Y_2 = level of knowledge (KNOW) of technological innovations,

X_1 = last grade of school completed (LGRADE),

X_2 = level of literacy in English ENGLIT),

X_3 = level of literacy in Spanish (SPANLIT)

X_4 = level of literacy in both English and Spanish (BILIT), and

X_5 = level of quantitative literacy (QLIT).

iii. $Y_3 = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + E_3$

where Y_3 = level of adoption (ADOP) of technological innovations,

X_1 = last grade of school completed (LGRADE),

X_2 = level of literacy in English (ENGLIT),

X_3 = level of literacy in Spanish (SPANLIT),

X_4 = level of literacy in both English and Spanish (BILIT),

X_5 = level of quantitative literacy (QLIT), and

X_6 = level of knowledge (KNOW) of technological innovations.

The multiple correlation squared obtained in computing the regressions will be used to determine the variance accounted for by all the regressors in the equation for each of the hypotheses involving regressions. The additional increment added when each regressor is added to the predictive equation will be used to determine the additional variance explained by addition of each regressor to the first one, and each

subsequent one, fitted in the predictive equation.

The t-test will be used to test for statistical significance of the individual partial regression coefficients when all regressors are included in the equation; and the F-test will be used to test for statistical significance of the joint effect of the regressors at each step in the stepwise analysis. One advantage of this method with stepwise regression is that in cases where there is high multicollinearity and the individual contributions of the regressors to the variance in the dependent variable are not significant and the joint contribution is significant, it suggests that the independent variables may be indicators of an underlying concept which produces a major portion of the variance in the dependent variable.

The data in the zero order correlation matrix will be used to determine the strength of the relationship hypothesized between LGRADE and each of the other variables used in the study (Hypotheses 1, 4, and 8).

2. Other Statistical Analyses on the USA - Michigan Data Set

Two additional statistical tests will be performed on selected variables in the USA - Michigan data set to provide additional information which the multiple regression tests cannot give.

Chi square tests will be performed on the distribution of frequencies between last grade of school completed (LGRADE)

and the propensity of adopting complex technological innovations in both the native English-speaking and Spanish-speaking groups. One way analysis of variance (ANOVA) will be performed on the significance of the means of knowledge (KNOW) and adoption (ADOP) of technological innovations among the constructed levels of literacy (LITLEV) in the native Spanish-speaking group.

CHAPTER III

RESULTS

The preceding chapter operationalized this study's variables, and described the methods and techniques for sampling, data collection, and data processing. The first chapter concluded with the list of theoretic hypotheses which this study was designed to test in the two sample spaces of Nigeria - Ilewo and the USA - Michigan.

The purpose of the current chapter is to report and discuss the results in the analyses which were performed in both of these sample spaces.

A. RESULTS IN THE NIGERIA - ILEWO SAMPLE SPACE

As stated in the preceding chapter, the data set of this sample space was analyzed through the stepwise mode of multiple regression on two regression models and the correlations which the regression routine yielded.

The statistical multiple regression models tested were stated in the previous chapter (see section E. 1. a). The two models may be re-stated by substituting the Y's and X's with the real variables, and by omitting the error term from the equation. The respective mathematical models that derived are as follows, with the number and order of the

variables in the final predictive equation determined by the stepwise routine:

a. $\text{Aware} = B_0 + B_1\text{YORUBA} + B_2\text{ENGLIT} + B_3\text{LGRADE}$

b. $\text{ADOP} = B_0 + B_1\text{YORUBA} + B_2\text{ENGLIT} + B_3\text{LGRADE} + B_4\text{AWARE}$

These models were analyzed via the current version of the SPSS Subprogram Regression (SPSS volume 7.0) at Michigan State University. Four restriction parameters associated with stepwise multiple regression routine were imposed on each model to fit each regressor into the predictive equation. The four parameters included: (1) NSTEPS; the maximum number of steps, (2) FIN; which specified the minimum F value to enter a regressor into the equation, (3) TOL: which specified the minimum tolerance level to enter a regressor into the equation, and (4) FOUT; which specified the maximum F value to remove a regressor from the equation. The basic assumption of these restriction parameters is that at each step of stepwise regression analysis, the regressor which makes the greatest increment to R^2 (the coefficient of determination) is entered into the equation provided the F ratio associated with it exceeds the critical F value (FIN) for fitting such a regressor into the equation. Equivalently, it is the regressor which has the highest partial correlation with the dependent variable, after having partialled the regressors already in the equation.

Three sets of values for each of the four restriction parameters were tried in fitting the predictors of each model

into the predictive equations. The results of these preliminary trials are reported in Appendix C.

To delve into a more complete exploration of the relative predictive power of the regressors in each model, the regressors were allowed to fit liberally into the predictive equation by using the default values for the four parameters; that is, (1) NSTEPS = number of regressors in the model, (2) FIN = .01, (3) TOL = .001, and (4) FOUT = .005.

The mean ($\bar{X}$) standard deviation (S) and standard error of the mean ($S_{\bar{X}}$) for each variable in this data set are shown in Table 10.

Table 10. The Mean ($\bar{X}$), Standard Deviation (S) and Standard Error of the Mean ($S_{\bar{X}}$) for the Variables in Nigeria - Ilewo Data Set (N=364)

VARIABLE	$\bar{X}$	S	$S_{\bar{X}}$
YORUBA	1.096	1.607	.08
ENGLIT	1.064	2.166	.11
LGRADE	.613	1.141	.06
AWARE	72.779	25.808	1.35
ADOP	30.321	21.218	1.11

The results from the correlations and regression analyses are reported in the following sections.

1. Results from Correlation Analysis (N=364)

As noted above, the regression analysis routine yielded the intercorrelations among the variables in the data set.

Table 11 presents the zero order correlations among the variables in the data set.

Table 11. Zero Order Correlation Matrix Among the Variables Used in the Nigeria - Ilewo Data Set (N=364)

	YORUBA	ENGLIT	LGRADE	AWARE	ADOP
YORUBA	1.000				
ENGLIT	.853*	1.000			
LAGRADE	.859*	.894*	1.000		
AWARE	.247*	.254*	.255*	1.000	
ADOP	.101	.096	.149*	.697	1.000

*significant; $\underline{P} < .025$ (.05, two-tailed)

The following observations are to be noted on the pattern of correlations in Table 11.

First, except for the correlation between adoption (ADOP) of technological innovations and literacy in native language (YORUBA), and between ADOP and literacy in English (ENGLIT), all the other correlations are significant ($\underline{P} < .025$).

Second, all the variables have positive intercorrelations. That is, they all vary directly with each other.

Third, there is a very strong correlation between awareness (AWARE) and adoption (ADOP) of technological innovations compared to the correlations of YORUBA, ENGLIT, and LGRADE with AWARE. The correlation of ENGLIT and of LGRADE with AWARE is moderately low and about the same. YORUBA has

the weakest correlation with AWARE compared to the correlation of ADOP, ENGLIT, and LGRADE with AWARE.

Fourth, the correlation between LGRADE and ADOP is very low in absolute terms. However, it is stronger than that of YORUBA and ENGLIT with ADOP. The correlation between YORUBA and ADOP is stronger than that between ENGLIT and ADOP but both correlations are very low.

Finally, there is a very strong correlation between YORUBA and ENGLIT, and between each of them with LGRADE.

Following the conceptualizations on the theoretic relation between formal education and literacy (see Chapter I; section B. 3), a direct relationship was hypothesized between LGRADE and: YORUBA: ENGLIT: AWARE, AND ADOP. The data supported that hypothesized prediction (Hypothesis 1). As noted above, the data show that there is a significant ($\underline{P} < .025$) direct relationship between LGRADE and each type of literacy, and between LGRADE and the awareness (AWARE) and adoption (ADOP) of technological innovations.

However, note that while these correlations are all significant, the correlation between LGRADE and AWARE (.255) is moderately low and that between LGRADE and ADOP (.149) is very low; the correlation between LGRADE and YORUBA (.859), LGRADE and ENGLIT (.853) are all very strong as noted earlier. These very strong correlations imply that in predicting and explaining variations in the awareness (AWARE) and adoption (ADOP) of technological innovations, any of these three

variables (i.e., LGRADE, YORUBA, and ENGLIT) will explain most of the variance, and adding the other two will not contribute much additional variance explained.

Hence, in anticipation of the stepwise multiple regression analysis, it is to be noted that the strength of these correlations will affect the relative predictive power of these variables when they appear together in the regression models. Each regressor would explain only minimal additional variance on the criterion variable (i.e., AWARE or ADOP). The following stepwise multiple regression analyses attempt to determine the variance for each regressor in each of the two models which were tested partialling out the variance each regressor shares with the other regressor(s) already in the predictive equation.

2. Stepwise Multiple Regression for Awareness of Innovations (N=364)

In the stepwise analysis to identify the most efficient predictors of awareness of technological innovations in this sample, it was found that nearly all of the explained variance was extracted at the first step by LGRADE. As may be noted in Table 12, LGRADE explained 6.5 percent of the variance in awareness. The other two regressors explained only about a half of one percent of the additional variance.

This result could be expected with the high level of multicollinearity among the independent variables. When all the regressors are forced into the equation under the relaxed

Table 12. Results From Stepwise Multiple Regression for Awareness of Technological Innovations in Nigeria - Ilewo Data Set

Step	Variable	Multiple R	R^2	R^2 Increase	Overall F	$\hat{B}$	S_b	t	$\underline{P}(t\ \alpha/_2)$ .025
1	LGRADE	.255	.065	.065	25.138*				
2	LGRADE								
	ENGLIT	.263	.069	.003	13.231*				
3	LGRADE					2.376	2.820	.842	NS
	ENGLIT					1.178	1.459	.808	NS
	YORUBA	.264	.070	.001	8.959*	1.161	1.721	.674	NS
	(Con-stant)					68.801	1.608	42.787	

*Significant F; $\underline{P} < .05$ & df = 1/362, 2/361, & 3/360
NS = Not Significant t for $\hat{B}$

default values noted earlier for the regression routine, the overall F value continues significant at each step; however, the variance explained has been dispersed among the regressors and none produces a significant t for the partial regression coefficients. These findings show support for Hypothesis 2, which states that LGRADE, YORUBA, and ENGLIT, or some subset of the three, will explain significant awareness variance in the awareness of the technological innovations. The order of fitting may be noted in Table 12, suggesting that LGRADE has the highest partial correlation with AWARE, followed by ENGLIT, and YORUBA in that order.

Kerlinger and Pedhazur (1973, p. 296) state that it is difficult, if not impossible to untangle the variance accounted for in a dependent variable and attribute portions of it to individual independent variables which are highly correlated with one another.

One possible explanation in the present analysis is that the variables are indicators of a single underlying concept (variable). This is consistent with the position developed in the rationale in Chapter I where the interdependence of formal education, language and literacy were discussed, as well as their relationship to other behaviors. This underlying concept might be termed "symbol proficiency."

3. Stepwise Multiple Regression for Adoption of Innovations (N=364)

As with the equation for predicting awareness, the first variable extracted accounts for nearly all of the explained variance in predicting adoption. That variable is awareness of the innovations, accounting for 48.6 percent of the 50.5 percent of the variance explained by all four variables in the equation. Thus, the remaining three variables add only about 1.9 percent to that explained by awareness of the innovations, as may be noted in Table 13.

As in the preceding regression equation, when all the regressors are forced into the equation under the relaxed default values, the overall F continues significant at each step of the analysis. In this equation, however, three of the four t-tests of partial regression coefficients are significant. It is concluded that the subset of AWARE, ENGLIT, and LGRADE explain significant variance in predicting adoption with this sample of respondents, recognizing that the additional increment of variance explained by the regressors entering second and third in the analysis was very minimal. Thus, these findings show support for Hypothesis 3.

B. RESULTS IN THE USA - MICHIGAN SAMPLE SPACE

Recall, this sample space was subdivided into two groups for the purpose of analysis. The two groups included the native English-speaking group and the native Spanish-

Table 13. Results From Stepwise Multiple Regression for Adoption of Technological Innovations in Nigeria - Ilewo Data Set

Step	Variable	Multiple R	R^2	R^2 Increase	Overall F	$\hat{B}$	S_b	t	$P(t\ \alpha/_2)$ .025
1	AWARE	.697	.486	.486	340.938*	5.730	.311	18.424	S
	(Constant)					-11.410	2.398	-4.758	
2	AWARE	.703	.494	.008	174.906*	5.920	.319	18.556	S
	ENGLIT					-.855	.381	-2.244	S
	(Constant)					-11.831	2.392	-4.946	
3	AWARE	.709	.503	.009	120.606*	.586	.318	18.428	S
	ENGLIT					-1.870	.815	-2.294	S
	LGRADE					3.971	1.549	2.564	S
	(Constant)					-11.915	2.373	5.021	
4	AWARE	.711	.505	.002	91.008*	.588	.317	18.515	S
	ENGLIT					-2.297	.877	-2.619	S
	LGRADE					4.850	1.696	2.860	S
	YORUBA					-1.310	1.035	-1.266	NS
	(Constant)					-11.558	2.388	4.839	

*Significant F; $P < .05$ & df = 1/362, 2/361, 3/360, & 4/359
S = Significant t for $\hat{B}$, & NS = Not Significant t for B

speaking group.

As in the Nigeria - Ilewo sample space, the same mode of the regression routine with the same restriction parameters was used in analyzing the data sets of the two groups in the USA - Michigan sample space. This section reports the results from the analysis of the three regression models which were tested in each of the two groups and from the correlations which the regression routine provided. In addition, this section will also report the results from the Chi square (X^2) tests in the two groups, and from the analysis of variance (ANOVA) in the native Spanish-speaking group with respect to selected variables as noted earlier (Chapter II; section E. 1. b. 2).

1. Results from the Native English-Speaking Group (N=169)

The three regression models which were tested in this group were stated in Chapter II (section E. 1. b). By substituting the Y's and X's with the real variables, and omitting the error term from the equation of each model, the respective mathematical models may be restated as follows with the number and order of the variables in the final predictive equation to be determined by the stepwise routine: a. QLIT = B_0 + B_1 ENGLIT + B_2 LGRADE; b. KNOW = B_0 + B_1 QLIT + B_2 LGRADE + B_3 ENGLIT; c. ADOP = B_0 + 1 KNOW + B_2 LGRADE + B_3 QLIT + B_4 ENGLIT.

The mean ($\bar{X}$), standard deviation (S), and standard error of the mean ($S_{\bar{X}}$) for each variable in the data set of this group are shown in Table 14.

Table 14. The Mean ($\bar{X}$), Standard Deviation (S), and Standard Error of the Mean ($S_{\bar{X}}$) for the Variables in the Native English-Speaking Group

VARIABLE	$\bar{X}$	S	$S_{\bar{X}}$
ENGLIT	123.698	59.309	4.56
QLIT	29.231	11.211	.86
LGRADE	11.917	2.120	.16
KNOW	26.308	12.380	.95
ADOP	11.195	2.671	.21

The following sections report the results from the correlation, Chi square, and regression tests.

a. Results from Correlation Analysis (N=169). The zero order correlations among the variables in the data set for this group which are presented in Table 15, support the Hypotheses 4a through 4c,(that as LGRADE increases, there will be increases in ENGLIT, QLIT, and KNOW). It will be noted that Hypothesis 4d (ADOP will increase as LGRADE increases) is not supported. Hypothesis 4e will be discussed later.

The following observations are to be noted on the correlations presented in Table 15:

Table 15. Zero Order Correlation Matrix Among the Variables Used in the Native English-Speaking Group

	ENGLIT	QLIT	LGRADE	KNOW	ADOP
ENGLIT	1.000				
QLIT	.638*	1.000			
LGRADE	.648*	.553*	1.000		
KNOW	.215*	.276	.201*	1.000	
ADOP	.064	.099	.101	.126	1.000

*Significant; $P < .025$

1. Except for the correlations between ADOP and each of the literacy types, and between ADOP and LGRADE and KNOW, the rest of the correlations are significant ($P < .025$).

2. All the variables have positive intercorrelations. That is, they all vary directly with each other.

3. The correlation between KNOW and each of the literacy types and LGRADE although significant are moderately low.

4. The correlation between LGRADE and ENGLIT (.648), LGRADE and QLIT (.553), and QLIT and ENGLIT (.638) are all very strong.

Following the above findings, the data support the direct relationship between LGRADE and each of the two literacy types (i.e., ENGLIT and QLIT); but not between LGRADE and KNOW, and LGRADE and ADOP as predicted. Note, however, that although a direct relationship was found between LGRADE

and KNOW, and LGRADE and ADOP, the strength of the relationship found between LGRADE and KNOW (.201) is moderately low and that between LGRADE and ADOP (.101) is not significant as noted above.

Finally, note that the very strong correlations between LGRADE and ENGLIT (.648), LGRADE and QLIT (.553) and QLIT and ENGLIT (.638) are large enough that any of these three variables relative to the others may not explain much additional variance. As noted in the analysis of the Nigeria - Ilewo data set, each of the strongly correlated regressors will explain only minimal additional variance on the criterion variable beyond that explained by the others. The following stepwise multiple regression analyses attempt to determine the variance for each regressor in each of the three models which were tested partialling out the variance each regressor shares with the other regressor(s) already in the predictive equation.

b. Chi Square Tests Between LGRADE and the Propensity of Adopting Complex Innovations (N=169*). Recall, it was noted in Chapter II (section A. 2. b. ii) that items were

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*Note that the grand total of cases in each of the four adoption situations is less than 169. This is because the non-use or omissions category was later omitted from the tests since the hypothesis to be tested compares propensity of using either the simple or complex innovation. The exclusion of this category necessitated computing a new Chi square value. This was done on the Hewlett Packard #67 calculator.

included in the instrument for the USA - Michigan data set to measure the respondent's propensity to adopt sets of simple and complex options on four technological innovations which were described in the instrument. The technological innovations included a simple and complex version of: (1) kit for testing the presence of sugar in urine for diabetes (DIABKITS); (2) form of using a drug for a health problem (DRUGFORM); (3) technique of cardiopulmonary resuscitation (TECHCPR), and (4) form of using a food product (FOODFORM). The Chi square test of independence was used to test for the relationship between last grade of school completed (LGRADE) and the propensity of using the complex option of the above four sets of technological innovations (Hypothesis 4e). LGRADE was collapsed into five categories of years of school (viz., 0-3, 4-6, 7-9, 10-12, and 13-16). The Chi square routine showed that for the native English-speaking sample, no cases fell in the 0-3 and 4-6 LGRADE ranges for the four adoption situations noted above. Thus, the routine did not include the two LGRADE ranges in the analysis. The same five LGRADE categories will be used in the native Spanish-speaking group to test for the same relationships as noted above. The following paragrpahs and Table 16 report the results from the Chi square tests in the native English-speaking group.

With three of the four innovations, the Chi squares were statistically significant, supporting the hypothesis

Table 16. Observed Frequencies and Chi Square Values for Tests of LGRADE with Four Simple/Complex Innovations in Native English-Speaking Group

INNOVATION		LGRADE RANGE 7-9	10-12	13-16	Row Total	Chi square Values
DIABKITS	Simple	22	53	32	107	
	Complex	3	25	32	60	12.23* df = 2
	Column Total	25	78	64	167	
DRUGFORM	Simple	24	71	57	152	
	Complex	0	6	5	11	2.04 df = 2
	Column Total	24	77	62	163	
TECHCPR	Simple	12	15	7	34	
	Complex	14	61	56	131	13.88* df = 2
	Column Total	26	76	63	165	
FOODFORM	Simple	21	44	23	88	
	Complex	5	34	40	79	15.27* df = 2
	Column Total	26	78	63	167	

*Significant; $P < .05$

that those with more formal education have a higher propensity to adopt the more complex innovations. An inspection of the data shows the inverse relationship between LGRADE and adoption of the simple version of the innovation; and the direct relationship between LGRADE and the adoption of the complex version of the innovations.

c. Stepwise Multiple Regression for Quantitative Literacy (N=169). As may be noted in Table 17, most of the explained variance (40.7 percent) was extracted in step 1 by ENGLIT; and that in step 2 of the regression, the addition of LGRADE into the equation explained an additional increment of 3.4 percent of the variance. Thus, the two regressors jointly explain 44.1 percent of the variance in quantitative literacy. The partial regression coefficients for both ENGLIT and LGRADE were found significantly different from 0 by the t-tests at the second step of the regression analysis where both regressors are in the predictive equation. These findings show support for Hypothesis 5.

The strong intercorrelations among the regressors concerned result in the first regressor entered into the predictive equation extracting a major portion of the variance, with lesser amounts attributable to that which was entered next into the equation.

d. Stepwise Multiple Regression for Knowledge of Innovations (N=169). The data in Table 18 show that QLIT was extracted first in the stepwise analysis and explained 7.6 percent of the variance. Under the relaxed default values noted earlier, LGRADE fitted into the equation at step 2 and ENGLIT was added at step 3. Those two variables together added less than half of one percent to the variance explained at step 1. Table 18 shows that the three regressors together explain 8.0 percent of the variance in KNOW.

Table 17. Results From Stepwise Multiple Regression for Quantitative Literacy in the Native English-Speaking Group

Step	Variable	Multiple R	R^2	R^2 Increase	Overall F	$\hat{B}$	S_b	t	$\underline{P}(t\ \alpha/_2)$ .025
1	ENGLIT	.638	.407	.407	114.794*	.121	.011	11.000	S
	(Constant)					14.307	1.544	9.266	
2	ENGLIT					.912	.144	6.337	S
	LAGRADE	.664	.441	.034	65.458*	1.271	.403	3.156	S
	(Constant)					2.797	3.945	.709	

*Significant F; $\underline{P} < .05$ & df = 1/167, & 2/166
S = Significant $\underline{t}$ for $\hat{B}$

Table 18. Results From Stepwise Multiple Regression for Knowledge of Techological Innovations in the Native English-Speaking Group

Step	Variable	Multiple R	R^2	R^2 Increase	Overall F	$\hat{B}$	S_b	t	$\underline{P}(t\ \alpha/_2)$ .025
1	QLIT	.276	.076	.076	13.717*	.304	.821	.370	NS
	(Constant)					16.414	2.571	6.384	
2	QLIT					.261	.099	2.636	S
	LGRADE	.282	.079	.003	7.157*	.414	.522	.799	NS
	(Constant)					12.749	5.293	2.409	
3	QLIT					.243	.110	2.206	S
	LGRADE					.315	.589	.535	NS
	ENGLIT	.283	.080	.001	4.791*	.083	.228	.364	NS
	(Constant)					13.414	5.614	2.390	

*Significant F; $\underline{P} < .05$ & df = 1/167, 2/166, & 3/65
S = Significant $\underline{t}$ for $\hat{B}$, & NS = Not Significant t for $\hat{B}$

The high intercorrelations among the regressors continue to create difficulties in attributing the contributions to the dependent variable by the individual regressors. This is further complicated by the small amount of the total variance explained by the regressors.

From these data it appears that QLIT is a somewhat stronger predictor of knowledge of technological innovations in this situation than were the other two regressors. Thus, these findings show support for Hypothesis 6.

e. Stepwise Multiple Regression for Adoption of Innovations (N=169). In the analysis of this model, the multiple correlation data and the regressors added at each step under the default values used are shown in Table 19.

As was evident from the correlation matrix discussed earlier, the regressors explained practically none of the variation in adoption with this sample. One of the difficulties may have been the lack of relevance of the innovation to this sample of respondents nearly a half of whom were college students. The mean score for adoption was 11.195 out of a maximum possible of 30. This puts the mean at the top of the bottom third of the range.

From the data in Table 19, it is apparent that Hypothesis 7 was not supported since no one of the regressors in the model extracted a statistically significant amount of the variance in adoption.

Table 19. Results From Stepwise Multiple Regression for Adoption of Technological Innovations in the Native English-Speaking Group

Step	Variable	Multiple R	R^2	R^2 Increase	Overall F	$\hat{B}$	S_b	t	$P(t\ \alpha/_2)$ .025
1	KNOW	.126	.016	.016	2.701	.272	.166	1.639	NS
	(Constant)					10.506	.466	22.545	
2	KNOW					.238	.169	1.408	NS
	LGRADE	.148	.022	.006	1.851	.988	.988	1.000	NS
	(Constant)					9.415	1.186	7.938	
3	KNOW					.224	.173	1.295	NS
	LGRADE					.074	.117	.632	NS
	QLIT	.151	.023	.001	1.281	.090	.225	.400	NS
	(Constant)					9.481	1.201	7.894	
4	KNOW					.226	.174	1.303	NS
	LGRADE					.097	.131	.741	NS
	QLIT					.131	.249	.526	NS
	ENGLIT	.154	.024	.001	.993	-.196	.508	-.386	NS
	(Constant)					9.322	1.273	7.323	

F is not significant; $P < .05$ & df = 1/167, 2/166, 3/165, & 4/164
NS = Not Significant t for $\hat{B}$

2. Results from the Native Spanish-Speaking Group (N=61)

As in the native English-speaking group, the same three statistical models were tested in the native Spanish-speaking group with the exception that the models in the latter group included literacy in Spanish (SPANLIT) and literacy in both Spanish and English; i.e., biliteracy (BILIT) among the regressors.

Recall, the three models to be tested were stated earlier (Chapter II; section E. 1. b). When the Y's and X's are substituted with the real variables, and the error term is omitted from the equation of each model, the respective mathematical models may be restated as follows with the number and order of the variables in the predictive equation to be determined by the stepwise routine: $QLT = B_0 + B_1$ BILIT + B_2 LGRADE + B_3 ENGLIT + B_4 SPANLIT; $KNOW = B_0 + B_1$ QLIT + B_2 BILIT + B_3 LGRADE + B_4 ENGLIT + B_5 SPANLIT; $ADOP = B_0 + B_1$ KNOW + B_2 QLIT + B_3 BLIT + B_4 LGRADE + B_5 SPANLIT.

The results from the regression test of these models as well as from the correlations which the regression routine provided will be reported in this section. In addition, this section will report the results from the Chi square tests between LGRADE and the propensity of adopting complex technological innovations as in the native English-speaking group, and from the analysis of variance (ANOVA) for knowledge (KNOW) and adoption (ADOP) of technological innovations by literacy levels (LITLEV).

The mean (X), standard deviation (S), and standard error of the mean ($S_{\bar{X}}$) for each variable in the data set of this group are presented in Table 20.

Table 20. The Mean ($\bar{X}$), Standard Deviation (S), and Standard Error of the Mean ($S_{\bar{X}}$) for the Variables in the Spanish-Speaking Group

VARIABLE	$\bar{X}$	S	$S_{\bar{X}}$
SPANLIT	114.885	46.493	4.56
ENGLIT	46.131	40.206	5.15
BILIT	5665.033	6167.704	789.72
QLIT	19.492	10.540	1.35
LGRADE	7.639	4.363	.56
KNOW	18.262	5.986	.77
ADOP	11.066	2.394	.31

a. Results from Correlation Analysis (N=61). The zero order correlations among the variables in this group's data set are shown in Table 21.

The following observations are to be noted on the correlations shown in Table 21.

1. Except for the correlation between ENGLIT and SPANLIT, KNOW and SPANLIT, KNOW and QLIT, KNOW and LGRADE, and ADOP and each of the other variables, the rest of the correlations are significant ($P < .025$).

2. All the variables have positive intercorrelations. That is, they all vary directly with each other.

Table 21. Zero Order Correlation Matrix Among the Variables Used in the Native Spanish-Speaking Group

	SPANLIT	ENGLIT	BILIT	QLIT	LGRADE	KNOW	ADOP
SPANLIT	1.000						
ENGLIT	.199	1.000					
BILIT	.561*	.801*	1.000				
QLIT	.272*	.463*	.493*	1.000			
LGRADE	.282*	.650*	.461*	.371*	1.000		
KNOW	.185	.283*	.299*	.244	.004	1.000	
ADOP	.079	.091	.013	.034	.205	.178	1.000

*Significant; $P < .025$

3. Though the correlations between KNOW and ENGLIT, KNOW and BILIT, QLIT and SPANLIT, and LGRADE and SPANLIT are all significant, each of them is moderately low.

4. The correlations of QLIT and ENGLIT, QLIT and BILIT, LGRADE and BILIT, and LGRADE and QLIT are moderately high; while the correlations between BILIT and SPANLIT, BILIT and ENGLIT, and LGRADE and ENGLIT are quite strong, especially BILIT with ENGLIT at .801.

Following the above findings, the data support the hypothesized direct relation between LGRADE and each of the four literacy types--SPANLIT, ENGLIT, BILIT, and QLIT: but not between LGRADE and KNOW, and LGRADE and ADOP. Note that although the correlations between LGRADE and KNOW, and LGRADE and ADOP are in the hypothesized direction, they are not statistically significant ($P < .025$). In addition, note that

though all the relationships are in the expected direction, their strengths vary as noted above. The lowest correlation is between LGRADE and KNOW (.004), and the highest is between LGRADE and ENGLIT (.650) with respect to the hypothesized direct relationships.

Note particularly that the correlations between LGRADE and BILIT (.461), LGRADE and QLIT (.371), QLIT and ENGLIT (.463), and QLIT and BILIT (.493) are moderately high while those between LGRADE and ENGLIT (.650), BILIT and SPANLIT (.561), and BILIT and ENGLIT (.801) are all very high. These significant correlations imply that each of these variables will explain only minimal additional variance on the criterion variable when they appear together in a regression model.

b. Chi Square Tests Between LGRADE and the Propensity of Adopting Complex Innovations (N=61*). As in the native English-speaking group, the Chi square test of independence was also used in the native Spanish-speaking group to test for the relationship between last grade of school completed LGRADE) and the propensity of using the complex varsion of the four sets of technological innovations noted earlier.

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*Note that the grand total in some of the above contingencies is less than 61. This is for the same reason as noted earlier in the footnote for the Chi square tests in the native English-speaking group. A new Chi square value was also computed in the current group using the Hewlett Packard #67 calculator.

The results from the Chi square tests in this group are reported in Table 22.

Note that unlike the English-speaking group, the current group has all the categories of LGRADE except for the highest category (i.e., 13-16 years of school); none of the subjects in the Spanish-speaking group had reached this level of education. Note also the small number of respondents in the 7-9 and 10-12 LGRADE ranges.

In this group, only one of the four innovations (viz., FOODFORM) produced a significant Chi square when comparing LGRADE with the simple versus the complex versions of the innovations. It was therefore concluded that the propensity of using the complex FOODFORM increases as LGRADE increases as had been hypothesized. The data did not support the hypothesized direct relationship between LGRADE and each of the other three complex versions of innovations (Hypothesis 8g).

Note, however, that 2/3 of the Spanish-speaking group were below the seventh grade level of education, while none of the English-speaking sample were below seventh grade level. From this perspective, it seems encouraging to pursue the study of the relationship between LGRADE and complexity of innovations.

The following stepwise regression analyses attempt to determine the variance contributed by the independent variables in predicting quantitative literacy (QLIT), knowledge

Table 22. Observed Frequencies and Chi Square Values for Tests of LGRADE With Four Simple/Complex Innovations in Native Spanish-Speaking Group

INNOVATION		LGRADE RANGE 0-3	4-6	7-9	10-12	Row Total	Chi square Values
DIABKITS	Simple	12	20	10	3	45	
	Complex	8	3	2	2	15	5.20 df = 3
	Column Total	20	23	12	5	60	
DRUGFORM	Simple	18	20	12	5	55	
	Complex	1	3	0	0	4	2.73 df = 3
	Column Total	19	23	12	5	59	
TECHCPR	Simple	14	19	7	2	42	
	Complex	6	4	6	3	19	5.32 df = 3
	Column Total	20	23	13	5	61	
FOODFORM	Simple	14	18	10	0	42	
	Complex	5	5	3	5	18	12.84* df = 3
	Column Total	19	23	13	5	60	

*Significant; $P < .05$

of innovations (KNOW), and adoption of the innovations (ADOP).

c. Stepwise Multiple Regression for Quantitative Literacy (N=61). Table 23 shows that BILIT was fitted first into the predictive equation, and it accounts for most of the variance in QLIT, viz., 24.3 percent. LGRADE explains an additional 2.7 percent, with virtually nothing additionally explained by ENGLIT and SPANLIT.

As may be seen in Table 23, when the regressors are forced into the equation by the relaxed default values noted earlier, they are fitted in the order: BILIT, LGRADE, ENGLIT, and SPANLIT.

The hypothesis that some subset of the regressors will explain significant variance on quantitative literacy is supported when BILIT and LGRADE explain 27 percent of the variance as indicated by the F test. The t-test, however, shows that only BILIT yielded a significant $\hat{B}$ for literacy and that occurred in steps one and two.

d. Stepwise Multiple Regression for Knowledge of Innovations (N=61). In predicting knowledge as in predicting quantitative literacy, BILIT is fitted first into the predictive equation by the stepwise analysis routine. It does not explain as high a proportion of the variance in KNOW--about half of the variance in this case, viz., 8.9 percent of the total of 18.7 percent of the variance explained by all the regressors in the equation. As may be noted in Table 24, LGRADE, ENGLIT, and SPANLIT add approximately two

Table 23. Results From Stepwise Multiple Regression for Quantitative Literacy in Native Spanish-Speaking Group

Step	Variable	Multiple R	R^2	R^2 Increase	Overall F	$\hat{B}$	S_b	t	$\underline{P}(t\alpha/_2)$ .025
1	BILIT	.493	.243	.243	18.960*	.843	.194	4.345	S
	(Constant)					14.718	1.614	9.119	
2	BILIT					.699	.216	3.236	S
	LGRADE	.519	.270	.027	10.701*	.442	.306	1.444	NS
	(Constant)					12.159	2.385	5.098	
3	BILIT					.629	.326	1.929	NS
	LGRADE					.387	.363	1.066	NS
	ENGLIT	.520	.271	.001	7.049*	.168	.584	.288	NS
	(Constant)					12.200	2.408	5.066	
4	BILIT					.593	.485	1.222	NS
	LGRADE					.370	.401	.923	NS
	ENGLIT					.215	.749	.287	NS
	SPANLIT	.520	.271	.000	5.197*	.040	.398	.101	NS
	(Constant)					11.854	4.203	2.820	

*Significant F; $\underline{P} < .05$ & df = 1/59, 2/58, 3/57 & 4/56
NS = Not Significant t for B

Table 24. Results From Stepwise Multiple Regression for Knowledge of Technological Innovations in the Native Spanish-Speaking Group

Step	Variable	Multiple R	R^2	R^2 Increase	Overall F	$\hat{B}$	S_b	t	$\underline{P}(t\ \alpha/_2)$ .025
1	BILIT	.299	.089	.089	5.799*	.290	.121	2.397	S
	(Constant)					16.618	1.005	16.535	
2	BILIT					.367	.135	2.719	S
	LGRADE	.335	.112	.023	3.672*	-.234	.191	-1.225	NS
	(Constant)					17.973	1.493	12.038	
3	BILIT					.148	.201	.736	NS
	LGRADE					-.407	.223	-1.825	NS
	ENGLIT	.380	.145	.033	3.214*	.527	.359	1.468	NS
	(Constant)					18.102	1.481	12.223	
4	BILIT					-.159	.293	-.543	NS
	LGRADE					-.548	.243	-2.264	S
	ENGLIT					.924	.452	2.044	S
	SPANLIT	.418	.175	.030	2.961*	.342	.240	1.425	NS
	(Constant)					15.151	2.540	5.965	
5	BILIT					-.202	.297	-.679	NS
	LGRADE					-.575	.244	-2.351	S
	ENGLIT					.909	.453	2.004	S
	SPANLIT					.339	.241	1.409	NS
	QLIT	.432	.187	.012	2.523*	.728	.809	.900	NS
	(Constant)					14.288	2.718	5.256	

*Significant F; $\underline{P}$ < .05 & df = 1/59, 2/58, 3/57, 4/56 & 5/55
S = Significant $\underline{t}$ for $\hat{B}$; NS = Not Significant t for $\hat{B}$

to three percent additional variance explained, while QLIT at the last step of the analysis adds about one percent of the variance explained.

While the t-test of the regression coefficients in the step 5 analysis show nonsignificance for the t-test for BILIT, this seems inappropriate since the two variables entered later into the equation and explaining a smaller percentage of the variance produced significant t's for the coefficients. Apparently, as more variables are entered in the equation, there was a partitioning of the variance away from BILIT in the relatively small pool of variance being explained by all variables.

From the data in Table 24, it is concluded that Hypothesis 10 is supported, since BILIT alone explains significant variance at the first step and all the regressors together explained significant variance in the knowledge of innovations, although the additional increments added at steps 2-5 are very small.

e. Stepwise Multiple Regression for Adoption of Innovations (N=61). As in the previous regression models, the stepwise regression routine forced into the predictive equation, under the default values noted earlier, all the regressors which were specified for the current model.

Table 25 shows that the routine fitted LGRADE first into the predictive equation followed by KNOW, BILIT, SPANLIT, QLIT, and ENGLIT in that order. All the six

Table 25. Results From Stepwise Multiple Regression for Adoption of Technological Innovations in the Spanish-Speaking Group

Step	Variable	Multiple R	R^2	R^2 Increase	Overall F	$\hat{B}$	S_b	t	$P(t\ \alpha/_2)$ .025
1	LGRADE	.205	.042	.042	2.588	.112	.070	1.600	NS
	(Constant)					10.206	.614	16.622	
2	LGRADE					.112	.069	1.623	NS
	KNOW	.271	.073	.031	2.298	.708	.505	1.402	NS
	(Constant)					8.915	1.104	8.075	
3	LGRADE					.161	.079	2.038	S
	KNOW					.937	.534	1.755	NS
	BILIT	.315	.099	.026	2.093	-.746	.584	-1.277	NS
	(Constant)					8.550	1.135	7.533	
4	LGRADE					.159	.079	2.013	S
	KNOW					.929	.537	1.740	NS
	BILIT					-.933	.668	-1.397	NS
	SPANLIT	.324	.105	.006	1.637	.461	.787	.586	NS
	(Constant)					8.154	1.326	6.149	
5	LGRADE					.164	.082	2.000	S
	KNOW					.949	.546	1.738	NS
	BILIT					-.869	.709	-1.226	NS
	SPANLIT					.457	.794	.550	NS
	QLIT	.326	.106	.001	1.306	-.100	.342	-.292	NS
	(Constant)					8.243	1.371	6.012	
6	LGRADE					.147	.108	1.359	NS
	KNOW					.914	.570	1.603	NS
	BILIT					-.111	.126	-.881	NS
	SPANLIT					.061	.104	.590	NS
	QLIT					-.101	.344	-.293	NS
	ENGLIT	.327	.107	.001	1.079	.047	.199	.234	NS
	(Constant)					8.181	1.409	5.807	

*F is not significant; $P < .05$ & df = 1/59, 2/58, 3/57, 4/56, 5/55, & 6/54
NS = Not Significant t for $\hat{B}$

regressors together explained approximately 10.7 percent of the variance in ADOP. LGRADE alone explained the largest amount of variance explained at any of the steps by any of the regressors. Thus, Hypothesis 11 was not supported.

f. Results From One Way Analysis of Variance (ANOVA) for Knowledge (NOW) and Adoption (ADOP) of Technological Innovations Among Literacy Levels (N=50*). Four levels of literacy (LITLEV) were derived to match the four theoretic levels of literacy discussed under Figure 2 (see Chapter I, section B. 4). The author wished to determine whether or not knowledge (KNOW) and adoption (ADOP) of technological innovations are related to the four levels of literacy derived.

The four levels of literacy were derived by arbitrarily imposing some constraints on the respondents' literacy scores in Spanish (SPANLIT), English (ENGLIT), and quantitative symbols and concepts (QLT). A series of constraints were tried to get a relatively meaningful distribution of this group's 61 cases along the four literacy levels.

The investigator at first tried to use the scores in the first and third quartile of SPANLIT, ENGLIT, and QLT as shown below.

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*This is not equal to the total of 61 cases in this group becuase 11 cases could not meet the criteria imposed in deriving the four levels of literacy.

Level I: SPANLIT $\leq$ 64; ENGLIT $\leq$ 64, and QLIT $\leq$ 10

Level II: SPANLIT $\geq$ 145; ENGLIT $\leq$ 64, and QLIT $\leq$ 10

Level III: SPANLIT $\geq$ 145; ENGLIT $\geq$ 145, and QLIT $\leq$ 10, and

Level IV: SPANLIT $\geq$ 145; ENGLIT $\geq$ 145, and QLT $\geq$ 30

Unfortunately, however, these constraints were too conservative; 55 cases could not be placed on any one literacy level. Level III was lost in that no case could be located on it. Level I, II, and IV had 2, 3, and 1 cases respectively. These frequencies are too low for meaningful discrimination in variance among literacy levels.

Consequently, the above set of constraints were relaxed as shown below.

Level I: SPANLIT $\leq$ 64; ENGLIT $\leq$ 64, and QLIT $\leq$ 10

Level II: SPANLIT $\geq$ 100; ENGLIT $\geq$ 64, and QLIT $\leq$ 10

Level III: SPANLIT $\geq$ 100; ENGLIT $\geq$ 100, and QLIT $\leq$ 10, and

Level IV: SPANLIT $\geq$ 100; ENGLIT $\geq$ 100, and QLIT $\geq$ 26

Under these constraints, 52 cases could not be placed on any one literacy level, and Level III was again missing. Level I, II, and IV had 2, 6, and 1 cases respectively. Once again, the investigator felt that these frequencies were too low for meaningful analysis. Hence, the constraints were further relaxed as shown below.

Level I: SPANLIT $\leq$ 80; ENGLIT $\leq$ 80, and QLIT $\leq$ 25

Level II: SPANLIT $\geq$ 81; ENGLIT $\leq$ 80, and QLIT $\leq$ 25

Level III: SPANLIT $\geq$ 81; ENGLIT $\geq$ 81, and QLIT $\leq$ 25, and

Level IV: SPANLIT $\geq$ 81; ENGLIT $\geq$ 81, and QLIT $\geq$ 26

Under these sets of constraints, 9 cases were on Level I; 33 on Level II; 2 on Level III, and 6 on Level IV. These were used in the analyses; Level III and IV were combined into one level (Level III) which thus resulted in a total of 8 cases for the new level. The following paragraphs report the results from the ANOVA for knowledge (KNOW) and adoption (ADOP) of technological innovations among the three literacy levels.

i. Results From One Way ANOVA for Knowledge (KNOW) of Innovations Among Literacy Levels (N=50)

Table 26 shows the means of knowledge of technological innovations for the number of cases in each of the three literacy levels.

Table 26. The Mean of Knowledge of Technological Innovations for Spanish-Speaking Group

	N Cases	Mean
Level I	9	16.56
Level II	33	17.94
Level III	8	21.13
Grand Mean = 18.20		

The summary statistics from the analysis of variance are presented in Table 27.

Table 27. One Way ANOVA Summary Table for Knowledge of Technological Innovations Among the Literacy Levels in the Native Spanish-Speaking Group

SOURCES OF VARIATION	SS	df	MS	F
Main Effects				
LITLEV	95.024	2	47.512	1.208
Residual	1848.976	47	39.340	
Total	1944.000	49	39.673	

Multiple R^2 = .049; Multiple R = .221; ETA = .22

The F test was not significant (F = 1.208; df = 2 & 47; $P < .05$). This implies that the means of knowledge of technological innovations presented in Table 26 do not differ significantly. In other words, individuals with the three different levels of literacy do not differ significantly in their knowledge of technological innovations. This is further indicated by the very low R^2 (.049). It was therefore concluded that there is no statistically significant relationship between level of literacy and knowledge of innovations. Thus, the data did not support Hypothesis 12a which predicted a direct relationship between level of literacy and knowledge of technological innovations.

However, although this hypothesis did not have statistical support, note that the means for knowledge of innovations were in the expected direction (see Table 26).

ii. Results From One Way ANOVA for Adoption (ADOP) of Innovations Among Literacy Levels (N=50)

Table 28 presents the means of adoption of technological innovations for the number of cases in each of the three literacy levels.

Table 28. The Mean of Adoption of Technological Innovations for Spanish-Speaking Group

	N Cases	Mean
Level I	9	10.22
Level II	33	11.06
Level III	8	11.63
Grand Mean = 11.00		

The summary statistics from the analysis of variance are shown in Table 29.

Table 29. One Way ANOVA Summary Table for Adoption of Technological Innovations Among the Literacy Levels in the Native Spanish-Speaking Group

SOURCES OF VARIATION	SS	df	MS	F
Main Effects				
LITLEV	8.691	2	4.345	.731
Residual	279.309	47	5.943	
Total	288.000	49	5.878	
Multiple R^2 = .030; Multiple R = .174; ETA = .17				

The F test was not significant (F = .731; df = 2 & 47; $P < .05$). This implies that the means of adoption of technological innovations presented in Table 28 do not differ

significantly. That is, individuals with the three different levels of literacy do not differ significantly in their adoption of technological innovations. The extremely low R^2 (.030) further indicates that there is no significant difference among the means of adoption of technological innovations among the three literacy levels. It was therefore concluded that there is no significant relationship between level of literacy and adoption of technological innovations. Thus, the data did not support the theoretic Hypothesis 12b which predicted a direct relationship between level of literacy and adoption of technological innovations.

However, although this hypothesis did not have statistical support, note that the means for adoption of technological innovations relatively tend toward the expected direction (see Table 28).

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This study's research problem, rationale, and related theoretic frameworks and hypotheses were specified in the first chapter of this dissertation. The methods of approaching the study's research problem were described in the second chapter, and the results from the statistical analyses were reported and their respective interpretations were presented in the third chapter.

The purpose of the current chapter is to summarize the results and to suggest some areas for practical and further research considerations. In this respect, the chapter is organized along three general parts, viz., (a) summary, (b) conclusions, and (c) recommendations. Summarily discussions for each of these three parts follow.

A. SUMMARY

This study's basic purpose was to explore the relative potential contributions of quantitative and non-quantitative (English) literacy in predicting and explaining knowledge and adoption of technological innovations.

The study's data derived from two sample spaces, viz., Nigeria - Ilewo, and the USA - Michigan. The latter sample space was subdivided into the native English-speaking group and native Spanish-speaking group for the purposes of analysis.

The hypotheses tested and the results of those tests are summarized in Table 30.

B. CONCLUSIONS

One major conclusion to be drawn from this study is that there are generally strong direct intercorrelations among the measures of literacy and last grade of school completed.

Theoretically, this implies that in predicting and explaining variations in knowledge and adoption of technological innovations, any of those measures could generally be sufficient. The results from the stepwise multiple regression analyses tended to support that conclusion. When sets of measures of literacy and last grade of school completed appeared together in the regression models, the measure which fitted first into the predictive equation extracted most of the variance explained such that each of the remaining measures in the set explained only minimal additional increments of variance on the criterion.

Ideally, one would expect the regressor fitted first into the predictive equation to yield a statistically

Table 30. Summary of Results Supporting and not Supporting the Theoretic Hypotheses in the Nigeria - Ilewo and the USA - Michigan Sample Spaces

HYPOTHESES	SUPPORTED/ NOT SUPPORTED	REMARKS
I. NIGERIA - ILEWO SAMPLE SPACE		
H_1: As last grade of school completed (LGRADE) increases, the level of:		
a. Literacy in native language (YORUBA) increases;	Supported	Very strong relationship (r = .859)
b. Literacy in English (ENGLIT) increases;	Supported	Very strong relationship (r = .894)
c. Awareness (AWARE) of technological innovations increases, and	Supported	Moderately low relationship (r = .255)
d. Adoption (ADOP) of technological innovations increases	Supported	Very low relationship (r = .149)
H_2: In predicting the awareness (AWARE) of technological innovations, the following three regressors or some subset of them will explain significant variance:		
a. Last grade of school completed (LGRADE),		LGRADE explains nearly all
b. Literacy in native language (YORUBA), and	Supported	of the explained variance.
c. Literacy in English (ENGLIT)		When all regressors were in the equation, they jointly explain significant variance, but individually they do not.
H_3: In predicting the adoption (ADOP) of technological innovations, the following four regressors or some subset of them will explain significant variance:		
a. Last grade of school completed (LGRADE),		AWARE explains most of the explained variance.
b. Literacy in native language (YORUBA),	Supported	AWARE, ENGLIT, & LGRADE are
c. Literacy in English (ENGLIT), and		independently significant;
d. Awareness (AWARE) of technological innovations.		all four are jointly significant.

Table 30 (cont'd.)

HYPOTHESES	SUPPORTED/ NOT SUPPORTED	REMARKS
II. USA - MICHIGAN SAMPLE SPACE		
A. Native English-speaking group		
H_4: As last grade of school completed (LGRADE) increases:		
a. Level of literacy in English (ENGLIT) increases;	Supported	Very strong relationship (r = .648)
b. Level of quantitative literacy (QLIT) increases;	Supported	Very strong relationship (r = .553)
c. Level of knowledge (KNOW) of technological innovations increases;	Supported	Moderately low relationship (r = .201)
d. Level of adoption (ADOP) of technological innovations increases, and	Not Supported	Statistically not significant (r = .101)
e. The propensity of adopting a complex form of a:		
1. DIABKIT increases;	Supported	Significant Chi square
2. DRUGFORM increases;	Not Supported	Chi square not significant
3. TECHCPR increases, and	Supported	Significant Chi square
4. FOODFORM increases	Supported	Significant Chi square
H_5: In predicting quantitative literacy (QLIT), each of the following two regressors independently or together will explain significant variance:		
a. Last grade of school completed (LGRADE), and	Supported	R^2 = .441
b. Literacy in English (ENGLIT).		

Table 30 (cont'd.)

HYPOTHESES	SUPPORTED/ NOT SUPPORTED	REMARKS
H_6: In predicting the knowledge (KNOW) of technological innovations, the following three regressors or some subset of them will explain significant variance:		
a. Last grade of school completed (LGRADE);	Supported	QLIT is independently significant; all three are jointly significant.
b. Literacy in English (ENGLIT), and		
c. Quantitative literacy (QLIT).		
H_7: In predicting the adoption (ADOP) of technological innovations, the following four regressors or some subset of them will explain significant variance:		
a. Last grade of school completed (LGRADE);		
b. Literacy in English (ENGLIT);	Not Supported	None is independently significant nor are they jointly significant.
c. Quantitative literacy (QLIT), and		
d. Knowledge (KNOW) of technological innovations.		
B. Native Spanish-speaking group		
H_8: As last grade of school completed (LGRADE) increases:		
a. Level of literacy in Spanish (SPANLIT) increases;	Supported	Moderately low relationship (r = .282)
b. Level of literacy in English (ENGLIT) increases;	Supported	Moderately strong relationship (r = .650)
c. Level of biliteracy (BILIT) increases;	Supported	Moderately high relationship (r = .461)
d. Level of quantitative literacy (QLIT) increases;	Supported	Moderately high relationship (r = .371)
e. Level of Knowledge (KNOW) of technological innovations increases;	Not Supported	Statistically not significant (r = .004)

Table 30 (cont'd.)

HYPOTHESES	SUPPORTED/ NOT SUPPORTED	REMARKS
f. Level of Adoption (ADOP) of technological innovations increases, and	Supported	Statistically not significant (r = .205)
g. The propensity of adopting a complex form of:		
1. DIABKIT increases;	Not Supported	Chi square not significant
2. DRUGFORM increases;	Not Supported	Chi square not significant
3. TECHCPR increases, and	Not Supported	Chi square not significant
4. FOODFORM increases.	Supported	Significant Chi square.
H_9: In predicting quantitative literacy (QLIT) the following four regressors or some subset of them will explain significant variance:		
a. Last grade of school completed (LGRADE),		
b. Literacy in Spanish (SPANLIT),	Supported	When all regressors were in the equation, none* was independently significant; all four combined were significant.
c. Literacy in English (ENGLIT), and		
d. Biliteracy (BILIT).		
H_{10}: In predicting the knowledge (KNOW) of technological innovations, the following five regressors or some subset of them will explain significant variance:		
a. Last grade of school completed (LGRADE),		
b. Literacy in Spanish (SPANLIT),	Supported	When all regressors were in the equation, BILIT,* LGRADE & ENGLIT were independently significant; all five are jointly significant.
c. Literacy in English (ENGLIT),		
d. Biliteracy (BILIT), and		
e. Quantitative literacy (QLIT).		

*The t-test was not significant at step 5, but the F test was significant at step 1, when BILIT was the first regressor fitted into the predictive equation.

Table 30 (cont'd.)

HYPOTHESES	SUPPORTED/ NOT SUPPORTED	REMARKS
H_{11}: In predicting the adoption (ADOP) of technological innovations, the following six regressors or some subset of them will explain significant variance: a. Last grade of school completed (LGRADE), b. Literacy in Spanish (SPANLIT), c. Literacy in English (ENGLIT), d. Biliteracy (BILIT), e. Quantitative literacy (QLIT), and f. Knowledge (KNOW) of technological innovations.	Not Supported	None is individually significant nor do the six regressors together explain significant variance.
H_{12}: As the level of literacy (LITLEV) increases, the level of:		
a. Knowledge (KNOW) of technological innovations increases, and	Not Supported	The means are in expected direction.
b. Adoption (ADOP) of technolgoical innovations increases.	Not Supported	The means are in expected direction.

significant relation to the criterion since the regressor so fitted extracts most of the explained variance. The data indicated that this was so for some but not for all the models. In those models where there was no statistically significant relationship between the regressor fitted first into the predictive equation and the criterion, this implies that the amount of variance explained by the regressor was too small.

When there is the lack of significance on the regressors fitted first into the predictive equation, it may be due to specification errors in formulating the appropriate regression equation. Such errors may, for example, be due to the omission of a relevant regressor and/or incorrect use of the functional form of the regression equation. If the omitted regressor is correlated with the regressors specified for the model, the estimators of their partial regression coefficients will be biased and inconsistent. Thus, the t or F test of significance will not be valid, since such a test will tend to accept the null hypothesis more frequently than is justified by the given level of significance. The specification error may also have occurred in this study due to incorrect functional form of the characterizing equation. The models tested in this study assumed linear relationships among the variables in the equation. However, although this is a basic assumption in regression analysis, nonetheless it must be noted that the relationships

in the models may, following Kmenta (1971, pp. 391-405), be nonlinear with respect to the variables but linear with respect to the parameters estimated (i.e., intrinsically linear models), or may be nonlinear with respect to both the variables and the parameters (i.e., intrinsically nonlinear models). Such nonlinear or curvilinear relationships may be some form of power functions of polynomials. Thus, where the functional relationship is nonlinear, the assumption of linearity is expected to limit the real explanatory power of the regressors. This limitation results in the variance explained by the regressors being statistically not significant.

The data indicated two models in which a regressor fitted first showed significant variance explained on the criterion at the first step but not on the last step in which all the regressors were forced into the predictive equation under the default values of the restriction parameters. This involved biliteracy in the models predicting quantitative literacy and knowledge of technological innovations in the native Spanish-speaking group. Apparently, as more regressors were entered in the equation, there was a partitioning of variance away from biliteracy in the relatively small pool of variance being explained by all the regressors. This partitioning of variance is to be expected since the regressors were generally intercorrelated strongly.

This partitioning of variance may also explain why some of the regressors fitted after the first step of the stepwise regression analyses were individually not significant. When most of the explained variance is extracted by the regressor fitted first into the predictive equation, there was only minimal additional increments to the explained variance by the regressors fitted into the equation at the subsequent steps of the regression. In the Nigeria - Ilewo sample space, last grade of school completed, literacy in English and literacy in native language (Yoruba) were not individually significant although jointly they were significant in explaining variance in the awareness of technological innovations. Individually, awareness of technological innovations, last grade of school completed, and literacy in English are significant but literacy in native language (Yoruba) is not significant in explaining variance in adoption of technological innovations, while jointly, the four regressors are significant.

In the native English-speaking group, literacy in English and last grade of school completed are both individually and jointly significant in predicting quantitative literacy. Individually in the stepwise regression, quantitative literacy explains significant variance in the knowledge of technological innovations but last grade of school completed and literacy in English do not, but jointly the three do. Knowledge of innovations, last grade of school

completed, quantitative literacy, and literacy in English are neither individually nor jointly significant in explaining variance in the adoption of technological innovations.

In the native Spanish-speaking group, biliteracy, last grade of school completed, literacy in English, and literacy in native language (Spanish) are individually not significant when they are all present in the equation at the last step of the analysis in which quantitative literacy is predicted, but the four regressors are jointly significant. Individually, biliteracy, last grade of school completed, and literacy in English are significant but literacy in Spanish and quantitative literacy are not significant in predicting the knowledge of technological innovations. However, jointly, the five regressors are significant. In predicting the adoption of technological innovations, last grade of school, knowledge of innovations, biliteracy, literacy in Spanish, quantitative literacy, and literacy in English are neither individually nor jointly significant in predicting the adoption of technological innovations.

One possible explanation for the lack of individual and joint significance among the regressors predicting the adoption of technological innovations in both the native English-speaking and native Spanish-speaking groups may be due to specification errors of the types stated earlier. However, one other possible explanation may be due to lack of relevance of the innovations to some of the respondents

in the samples. The native English-speaking sample, for instance, had nearly a half (i.e., 66 of 169) of the cases who were college students who may have lived in school residential halls. Such innovations as Tel-Med, Project Health, Expanded Nutrition Program, Michigan Law for winter heating bills and Meal Planning Guides may not be appropriate for students living in school dormitories where these services are usually provided.

A closer examination of the data from stepwise regression analyses revealed the following observations. First, when literacy in English and in non-English native language (i.e., Yoruba and Spanish), are among the regressors in the models predicting the awareness/knowledge and adoption of innovations, and quantitative literacy, in 4 out of 5 models literacy in English is a better predictor than is literacy in non-English native language. It is therefore to be concluded that literacy in English is generally a stronger predictor of awareness/knowledge and adoption of technological innovations and quantitative literacy than is literacy in non-English native language. Secondly, when quantitative literacy and literacy in English are among the regressors predicting knowledge and adoption of technological innovations, in 3 out of 4 models, quantitative literacy is a better predictor than is literacy in English. It is therefore to be concluded that quantitative literacy is generally a stronger predictor of knowledge and adoption of

technological innovations than is literacy in English. Finally, a closer examination of the data from stepwise regression analyses in the native Spanish-speaking group revealed that in 2 out of 3 models in which biliteracy, literacy in Spanish, and literacy in English are among the regressors for quantitative literacy, knowledge and adoption of technological innovations, biliteracy is a stronger predictor than either literacy in Spanish or literacy in English. It is therefore to be concluded that biliteracy is generally a stronger predictor of quantitative literacy, knowledge and adoption of technological innovations than either literacy in Spanish (native language) or literacy in English.

On the tests for the relationship between last grade of school completed and the propensity of adopting complex technological innovations, the data indicated that 4 out of 8 situations involving the propensity of using a simple or complex technological innovations, there is a direct relationship between last grade of school completed and the propensity to use a complex technological innovation. Since, this is a 50-50 situation, no conclusion could be made confidently. However, it is to be noted that 3 of the 4 positive relationships stated above were observed in the native English-speaking group whose last grade of school completed ranged from 7 to 16 years, while the fourth was observed in the native Spanish-speaking group whose last grade of school completed ranged from 0 to 12 years with about 2/3 of them

171 having less than 7 grades of school completed. One may therefore conclude that last grade of school completed is generally related positively to the propensity of using complex technological innovations. Further work in this area would be helpful to see if the hypothesized relationship can be more clearly supported.

Recall that complex technological innovations were by definition those which required precise measurements in that they required use of numbers on the part of the potential adopters of these innovations. This conclusion therefore implies that the propensity of using technological innovations with precise measurements generally increases as last grade of school completed increases.

Finally, on the tests of relationship between the three constructed levels of literacy and knowledge and adoption of technological innovations, the data indicated no significant relationship by the ANOVA. That is, there is no significant direct relationship between these levels of literacy and knowledge or adoption of technological innovations. One possible explanation for these findings may be due to the small number of cases on some of the literacy levels. Such small number of cases may not have provided a strong base for adequate discrimination in variance.

Although the differences among the means of knowledge and adoption of technological innovations were not large enough for statistical significance, note that the means

were in the expected direction of the levels of literacy. That is, the knowledge and adoption of technological innovations increase slightly as the level of literacy increases.

C. RECOMMENDATIONS

This study has some considerations for change agents and for future research. The following lines of thought are particularly recommended for consideration.

1. Recommendations for Change Agents

First, since the relationship between quantitative literacy and literacy in native language (Spanish) is moderately low, and the relations of quantitative literacy to literacy in English, biliteracy, and last grade of school completed are very strong, change agents are recommended to begin (or continue) English literacy programs in their literacy education campaigns. It is expected that this would facilitate the acquisition of quantitative literacy in those areas where English is not the native language or the common medium of discourse.

Finally, since the propensity of using complex technological innovations generally increases with the level of formal education, it implies that the change agents' knowledge of the level of formal education among their clients and knowledge of the level of complexity of the technological innovations to be diffused among the clients is generally useful. Such knowledge will facilitate the packaging and

targeting of messages concerning the technological innovations. This recommendation implies judicious practice of audience and content analysis by the change agents.

2. Recommendations for Future Research

Probably the most immediate need is to investigate the status of specification errors in the models tested in the current study. Such investigation would, for instance, consider including into the models new variables as well as testing for the functional form of the characterizing equations as noted earlier.

This may provide the variables and their functional forms which account for greater amount of variance on the knowledge and adoption of technological innovations thus identifying optimal conditions for diffusion of technological innovations.

The most interesting variables for consideration in future models may include, for instance, leadership style and level of income. It is here speculated that leadership style and level of income are strongly related particularly to the adoption of technological innovations. Radical or counter culture groups and/or authoritarian clan leaders and/or village or community chiefs or opinion leaders as well as level of income may facilitate or impede the adoption of technological innovations beyond that explained by literacy or formal education. This study did not control for these variables.

As for the functional form of the characterizing equations, the current study did not test for the non-linear relationships. Hence, in the absence of information on the alternative forms of functional relationships, the linear equations tested in this study may lack parsimony for describing the study's data sets. What is still needed therefore is to investigate for the alternative non-linear relationships, and where these relationships are found, to linearize the equations before performing the appropriate regression analyses. Techniques are available for testing for non-linearity and for linearizing the equations (see, for example, Kmenta, 1971, pp. 451-472; Kelejian and Oates, 1974, pp. 92-103 and pp. 167-175; Kerlinger and Pedhazur, 1973, pp. 208-218; Namboodiri, Carter and Blalock, 1975, pp. 150-156, pp. 173-174, pp. 186-187, p. 194 and pp. 600-605; Harris, 1975, pp. 233-236, and Kim and Kohout, 1975, pp. 368-373).

The current study measured literacy in quantitative symbols and concepts only among native English-speaking and native Spanish-speaking populations. The latter population, however, speaks a language which has a common linguistic root with the English language. It is not yet known to what extent literacy in quantitative symbols and concepts is important in predicting and explaining knowledge and adoption of technological innovations in those populations whose native languages or dialects do not have a common linguistic

root with English or any one European language. A study is needed to investigate this aspect of literacy. Such a study would also consider if there are specific quantity descriptors used by these populations for communicating quantitative or number concepts, and then build these into the instrument to achieve more reliable and valid observations. A study along this line may have considerable application not only for change agents but also for international agencies, organizations and multinational corporations which frequently diffuse highly quantified technological innovations with precise formulations and rates of application.

What also seems needed is further refinement of the quantitative literacy test (QLT) instrument which the current study developed. Some of the items used to measure some of the dimensions of quantitative literacy in the current study used diagrams (see Appendix B, pp 194-199). Some alternatives could be to use objects instead of diagrams or to use both diagrams and objects as manipulations for the same dimensions of quantitative literacy. It may be the case that individuals with different levels of literacy differ in their ability to manipulate given quantitative concepts with objects rather than with diagrams. A study is needed to investigate these alternative operationalizations.

In addition, further refinement of the current QLT instrument could be achieved through validation. This could be done by administering the instrument to several samples

taken from different populations, and/or testing for its correlations with known quantitative or reasoning tests such as mathematical assessment tests, abstract reasoning, and so forth. Finally, further refinement of the current QLT instrument could be attained by testing it over-time. Four reliability coefficients on the QLT items were noted in the second chapter (sectiona A. 2. a. iii). The coefficients generally indicated relatively high consistency among the scale items in their measure of the dimensions of quantitative literacy. However, to determine more appropriately the stability of these items essentially calls for over-time studies which allow us to have a more careful estimate of the reliability of the instrument (see Heise and Bohrnstedt, 1970; Werts, Joreskog and Linn, 1973; Wiley and Wiley, 1970, 1974).

Finally, while the use of the SORT instrument in this study was a move toward uniformity of measuring non-quantitative literacy, the study did not consider the respondents' comprehension of what they read. Hence, a measure is still needed which involves more interpretation of what is read as that may influence decision making about technological innovations.

FOOTNOTES

[1]This study uses Solo and Rogers' (1972) conception of Developing Countries or Less Developed Countries (LDCs) as ". . . those with relatively lower levels of per capita income, literacy and education, production, etc." (p. 87). Solo and Rogers (1972) use the United Nations' arbitrary classification of less developed nations as including all those of Latin America, Africa, and Asia, with the exception of Japan, South Africa, Australia, and New Zealand. According to Solo and Rogers (1972, p. 87), "development refers to the type of change that produces higher per capita incomes and levels of living through more modern production methods and improved social organization" (see also Rogers with Svenning, 1969, pp. 8-9).

[2]In his extensive literature search, the author contacted, among others, Professor Everett M. Rogers at Stanford University, who has worked extensively on literacy particularly in Developing Countries. No diffusion study could be located in which quantitative and English literacy have been studied; nor could one piece of research be located which has been done on diffusion in the most recent years.

[3]Following Munroe (1963), a careful distinction is to be made between the symbols "number" and "numeral." "A number is an abstract idea. A numeral is a mark or set of marks used to denote such an idea. That is, a numeral is the name of a number" (p. 11).

[4]Reports and expressions of scholars and leaders throughout the world on the significance of literacy on modernization and development may be gleaned from several of the UNESCO literacy newsletters; see for example, Literacy: A Newsletter, December 1969; 1970, No. 1; April 1970, No. 2; October 1970, No. 4; 1971, Third and Fourth Quarter, and 1972, First Quarter; UNESCO, 1963; UNESCO, 1973.

[5]The modernization and development variables are discussed in the section on the correlates of literacy, and for their critiques, see footnote No. 6.

[6]Herzog (1967) has critiqued in his dissertation the literature on the five indices of modernization. According to Herzog (1967): Empathy is regarded as an ability to identify with and symbolically participate in a new unfamiliar role. Achievement motivations is the desire to succeed,

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apart from social pressure, in order to gratify a personal need to do so. Cosmopoliteness is defined as a positive orientation toward an urban mode of life. Mass media exposure is defined as being in the audience for messages from newspapers, radio, television and cinema. Political knowledge is defined as possession of basic information about one's region and country, so as to enable one to function as a citizen.

[7]These categories of literacy definitions are not necessarily mutually exclusive for it is conceivable that in research practices an investigator could use both the planning-census-type and empirical-type measures. Hence, these two categories are used here as general categories for purposes of explicating the problems with prior conceptualizations of literacy.

[8]According to Rogers and Shoemaker (1971, p. 137), there are five attributes of innovations:

a. Relative advantage: The degree to which an innovation is perceived as being better than the idea it supersedes.
b. Compatibility: The degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of the receivers.
c. Complexity: The degree to which an innovation is perceived as relatively difficult to understand and use.
d. Trialability: The degree to which an innovation may be experimented with on a limited basis, and
e. Observability: The degree to which the results of an innovation are visible to others.

[9]The focus here is on English, although the scientific symbols and concepts may appear in the languages of other industrialized nations.

[10]Skinner's (1957) functional units of language include: mands, tact, echoic, textual, intraverbal, and autoclitic verbal behaviors (see Skinner, 1957 for details).

[11]Details of transformation rules may be gleaned in Chomsky (1957, 1965). A detailed critique of transformation rules and generative grammar is presented in Lyons (1974).

[12]Although the Nigeria - Ilewo survey operationalized what was conceived as knowledge of technological innovations, this author found the measures rather inadequate. The measures were of awareness rather than knowledge of technological innovations. Consequently, he reconceptualized knowledge for awareness which is only one aspect of

knowledge. This author will provide a more adequate operationalization of knowledge in the next section (2. b. i) for the USA - Michigan sample space.

[13]This is based on the assumption that the native language or dialect uses the same alphabet as the English language. However, where this is not the case, it is conceivable that an individual may be literate in English without being literate in his/her native language or dialect, e.g., Arabic, Hindi, Persian, etc.

[14]Note that quantitative literacy is treated as a dependent variable in first regression model in each of the two groups in this sample space.

[15]This is only in general because an exception may be noted. Selltiz, et al., (1969), for instance, have noted that "When the estimate of reliability consists of split-half equivalence coefficient, low reliability does not necessarily detract from validity; paradoxically, it may even increase validity. In order for split-half equivalence to be high, all items of the test must be highly correlated; that is, they must all provide a measure of essentially the same characteristic or of characteristics that vary together. To use the technical term, they must be homogeneous. But for some purposes, a test that taps a number of different characteristics may be more valid than one that measures a single characteristic" (p. 178).

[16]The criteria for describing the magnitude of the reliability and correlation coefficients was arbitrarily set at .70 or greater for very high or very strong; .50-.69 as high or strong; .35-.49 as moderately high; .25-.34 as moderately low; and .24 or less as very weak or very low.

[17]The results form factor analysis of the QLT items can be obtained from the author on request.

[18]Note that with the exception of the Nigeria - Ilewo sample space and the Spanish-speaking group, English is to be conceived as native language in the USA - Michigan sample space.

APPENDIX A

Literacy Test

Adapted from SLOSSON ORAL READING TEST (SORT)

APPENDIX A

Literacy Test

READING LEVEL_____

Placement

NAME_____ DATE_____ _____
Last First Middle

DATE OF BIRTH_____ EXAMINER_____

List A (20)	List B (40)	List C (60)	List D (80)	List E (100)
1. see	1. with	1. game	1. safe	1. harness
2. look	2. friends	2. hide	2. against	2. price
3. mother	3. came	3. grass	3. smash	3. flakes
4. little	4. horse	4. across	4. reward	4. silence
5. here	5. ride	5. around	5. evening	5. develop
6. can	6. under	6. breakfast	6. stream	6. promptly
7. want	7. was	7. field	7. empty	7. serious
8. come	8. what	8. large	8. stone	8. courage
9. one	9. bump	9. better	9. grove	9. forehead
10. baby	10. live	10. suddenly	10. desire	10. distant
11. three	11. very	11. happen	11. ocean	11. anger
12. run	12. puppy	12. farmer	12. bench	12. vacant
13. jump	13. dark	13. river	13. damp	13. appearance
14. down	14. first	14. lunch	14. timid	14. speechless
15. is	15. wish	15. sheep	15. perform	15. region
16. up	16. basket	16. hope	16. destroy	16. slumber
17. make	17. food	17. forest	17. delicious	17. future
18. ball	18. road	18. start	18. hunger	18. claimed
19. help	19. hill	19. heavy	19. excuse	19. common
20. play	20. along	20. station	20. complete	20. dainty

List F (120)	List G (140)	List H (160)	List I (180)
1. cushion	1. installed	1. administer	1. prairies
2. generally	2. importance	2. tremor	2. evident
3. extended	3. medicine	3. environment	3. nucleus
4. custom	4. rebellion	4. counterfeit	4. antique
5. tailor	5. infected	5. crisis	5. twilight
6. haze	6. responsible	6. industrious	6. memorandum
7. gracious	7. liquid	7. approximate	7. whimsical
8. dignity	8. tremendous	8. society	8. proportional
9. terrace	9. customary	9. architecture	9. intangible
10. applause	10. malicious	10. malignant	10. formulated
11. jungle	11. spectacular	11. pensive	11. articulare
12. fragrant	12. inventory	12. standardize	12. deprecate
13. interfere	13. yearning	13. exhausted	13. remarkably
14. marriage	14. imaginary	14. reminiscence	14. contrasting
15. profitable	15. consequently	15. intricate	15. irrelevance
16. define	16. excellence	16. contemporary	16. supplement
17. obedient	17. dungeon	17. attentively	17. inducement
18. ambition	18. detained	18. compassionate	18. nonchalant
19. presence	19. abundant	19. complexion	19. exuberant
20. merchant	20. compliments	20. continuously	20. grotesque

List J (200)

1. traverse
2. affable
3. compressible
4. excruciating
5. pandemonium
6. scrupulous
7. primordial
8. chastisement
9. sojourn
10. panorama
11. facsimile
12. auspicious
13. contraband
14. envisage
15. futility
16. enarmoured
17. gustatory
18. decipher
19. inadequacy
20. simultaneous

APPENDIX B

Test for Knowledge, Adoption, and Propensity of Adoption of Technological Innovations and for Quantitative Literacy in the USA - Michigan Sample Space

APPENDIX B

Test for Knowledge, Adoption, and Propensity of Adoption of Technological Innovations and for Quantitative Literacy in the USA - Michigan Sample Space

MICHIGAN STATE UNIVERSITY

Department of Communication, and
Department of Resource Development
East Lansing, Michigan 48824

DEAR PARTICIPANT:

We are currently engaged in a research project to determine the use of resources in various communities. It is our opinion that adult persons are in a good position to provide accurate information on the extent to which resources are being used in a community.

Therefore, we are asking you to provide answers to the questions asked in this booklet. This information is needed for planning effective communication programs for community development and for improving teaching methods. Your co-operation therefore will greatly contribute to the success of this project. We need answers which you yourself can provide. For this reason, you are requested to provide your own ideas on the basic questions on the use of resources as described in this booklet.

Your answers to these questions are confidential, and will be used for planning and teaching purposes only. Please answer all the questions.

Your cooperation is most appreciated. Thank you.

PLEASE RESPOND TO THE FOLLOWING QUESTIONS AS FAST AS POSSIBLE. BE ASSURED THAT THE ANSWERS TO THESE QUESTIONS MAY DIFFER FROM PERSON TO PERSON. HOWEVER, WE ARE INTERESTED IN ALL OF THESE ANSWERS. SO PLEASE ANSWER ALL THE QUESTIONS. CHECK OR STATE AN ANSWER WHICH YOU THINK BEST EXPRESSES YOUR FEELINGS.

1. Have you ever heard of Consumer Reports? a. Yes___
   b. No___

2. If so, where did you hear about them, or who told you about consumer reports?_____

   _____

3. What does a Consumer Report mean to you?_____

   _____

4. If you needed information about Consumer Reports, where would you go for such information?_____

   _____

5. Under which of the following conditions would you consider using a Consumer Report?:
   a. When I need information about a recipe.
   b. When I want to buy a new car.
   c. When I need information on a health problem.

6. How often do you use Consumer Reports?:
   a. Most of the time.
   b. Sometimes.
   c. Never.

7. Have you ever heard of a Dollar Watch program?
   a. Yes___
   b. No___

8. If so, where did you hear about it, or who told you about a Dollar Watch program?_____

   _____

9. What does Dollar Watch mean to you?_____

   _____

10. If you needed some information about Dollar Watch, where would you go for such information?_____

_____

11. Which of the following statements is true in budgeting money?:
    a. A budget is concerned with income only.
    b. A budget is concerned with expenditure only.
    c. A budget is concerned with both income and expenditure.

12. How often do you budget your money? (check one only):
    a. Most of the time.
    b. Sometimes.
    c. Never.

13. Have you ever heard of a Tel-Med program?: a. Yes___
    b. No___

14. If so, where did you hear about it, or who told you about Tel-Med?_____

_____

15. What does Tel-Med mean to you?_____

_____

16. If you needed some information about Tel-Med, where would you go for such information?_____

_____

17. Under which of the following conditions would you consider using Tel-Med services? (check one only):
    a. If I need to find out someone's telephone number.
    b. If I need some information on a health problem.
    c. If I need some information on income tax returns.

18. How often do you use Tel-Med services? (check one only):
    a. Most of the time.
    b. Sometimes.
    c. Never

19. Have you ever heard of Consumer Credit in your community?: a. Yes___
    b. No___

20. If so, where did you hear about it, or who told you about Consumer Credit?_____

_____

21. What does Consumer Credit mean to you?_____

_____

22. If you needed some information on Consumer Credit, where would you go for such information?_____

_____

23. Which of the following credit sources provides more reliable information for comparing Consumer Credit costs? (check one only):
    a. A credit supplier who states finance charges as an Annual Percentage Rate on the balance of the loan.
    b. A credit supplier who states finance charges based on your having the use of the loan for the full year though the balance of the loan gets smaller each month.

24. How often do you use Consumer Credit? (check one only):
    a. Most of the time.
    b. Sometimes
    c. Never.

25. Have you ever heard of Expanded Nutrition Program?
    a. Yes___
    b. No___

26. If so, where did you hear about it, or who told you about Expanded Nutrition Program?_____

_____

27. What does Expanded Nutrition Program mean to you?_____

_____

28. If you needed some information about Expanded Nutrition Program, where would you go for such information?_____

_____

29. Under which of the following conditions would you consider using Expanded Nutrition Program? (check one only):
    a. When I need information on meal planning.
    b. When I am over twenty years of age.
    c. When I need information on Consumer Credit.

30. How often do you use the services of Expanded Nutrition Program? (check one only):
    a. Most of the time.
    b. Sometimes.
    c. Never.

--PLEASE CONTINUE--

PLEASE RESPOND TO THE FOLLOWING QUESTIONS AS FAST AS POSSIBLE. BE ASSURED THAT THE ANSWERS TO THESE QUESTIONS MAY DIFFER FROM PERSON TO PERSON. HOWEVER, WE ARE INTERESTED IN ALL OF THESE ANSWERS. SO PLEASE ANSWER ALL THE QUESTIONS. CHECK OR STATE AN ANSWER WHICH YOU THINK BEST EXPRESSES YOUR FEELINGS.

1. Have you ever heard of a condition called diabetes?
   a. Yes___
   b. No___

2. If so, where did you hear about it, or who told you about diabetes?_____

   _____

3. What does diabetes mean to you?_____

   _____

4. If you needed some information about diabetes, where would you go for such information?_____

   _____

5. Under which of the following conditions would you have your blood tested for diabetes? (check one only):
   a. If you are getting overweight.
   b. If you take too much sugar.
   c. None of the above.

6. Have you ever had a blood test for diabetes? a. Yes___
   b. No___

7. Suppose you were considering to buy one of the two kits described below for testing the presence of sugar in your urine. And suppose the price of these kits is the same; which of these two kits would you buy if you needed one of them? (check one only):
   a. One kit contains strips of cellulose and a color chart. To test for sugar in urine, you moisten a strip of cellulose with urine and then compare the dipped end of the cellulose with the color chart. The greater the amount of sugar in urine, the deeper will be the color of the cellulose strip.
   b. Another kit contains small glass tubes, a color chart, and tablets of a chemical reagent. You mix 3 drops of urine with 10 drops of water in a small tube. Then, you

add one tablet of the reagent to this mixture. Wait 15 minutes. Then, compare the color of the mixture with the color chart. The greater the amount of the sugar in urine, the deeper will be the color of the mixture in the tube, and you can estimate the exact quantity of sugar in urine.

8. Suppose you wanted to buy one of the two drugs described below, and suppose the two drugs cost the same amount of money. Which of these two drugs would you buy if you needed one of them? (check one only):
   a. One type of drug comes in pills which you can take by mouth with some water. You are required to take two pills three times a day.
   b. The same drug may also be taken with a new type of injection which does not cause any pain. This drug comes in a small kit which contains a syringe, different drugs to be mixed together, and instructions on how to use the drug. You must mix the right amount of each drug in the kit and then inject the mixture into a particular part of your body by yourself.

9. Have you ever heard about CPR (Cardiopulmonary Resuscitation)? a. Yes___
   b. No___

10. If so, where did you hear about it, or who told you about CPR?_____

_____

11. What does CPR mean to you?_____

_____

12. If you needed some information about CPR, where would you go for such information?_____

_____

13. Under which of the following conditions would CPR be necessary? (check one only):
   a. When a person has too much sugar in his/her urine.
   b. When there is unconscious victim of a heart arrest.
   c. When a pregnant woman loses her appetitie for food.

14. Have you ever done CPR? a. Yes___ b. No___

15. Do you think you know enough to do CPR if someone needed it? a. Yes___ b. No___

16. There are many techniques of emergency life support for resuscitation of the unconscious victims who have only stopped breathing though the heart continues to beat. Which of the following two basic life support emergency techniques would you use if you were to attempt rescuing an unconscious victim? (check one):
    a. The unconscious victim is made to lie flat on his abdomen on a hard surface. The rescuer then presses the victim's back thus forcing the victim's abdomen against his diphragm, compressing the lungs and causing expiration.
    b. The unconscious victim is made to lie flat on his back on a hard surface. The rescuer then tilts the victim's head backward to open the victim's airway. Breathing may be restored by blowing hard into the victim's mouth. This is repeated every five seconds. The rescuer blows four quick lung inflations into the victim.

17. Have you ever heard of Project Health? a. Yes___
    b. No___

18. If so, where did you hear about it, or who told you about Project Health?_____

    _____

19. If you needed some information about Project Health, where would you go for such information?_____

    _____

20. What does Project Health mean to you?_____

    _____

21. Who is eligible for Project Health services? (check one only):
    a. Every one over twenty-one years of age who is on a Medicaid Card.
    b. Every one under twenty-one years of age who is on a Medicaid Card.
    c. Every one who is on a Medicaid Card without regard for age.

22. How often do you use the services of Project Health? (check one only):
    a. Most of the time.
    b. Sometimes.
    C. Never.

23. Suppose your doctor prescribed for you a drug which needs to be kept out of direct sunlight or places where it could be very warm (above 80°F). Which of these places would be ideal for storing such a drug? (check one only):
    a. A small storage space in a cabinet above the stove.
    b. A small wide-mouth thermos.
    c. A car baggage compartment.

24. Have you ever heard of a Michigan Law providing $38 million to help low income and elderly citizens pay their Winter heating bills? a. Yes___ b. No___

25. If so, where did you hear about it, or who told you about this law?_____

_____

26. If you needed some information about this law, where would you go for such information?_____

_____

27. What is the maximum amount of money which would be paid to persons eligible under this law? (check one only):

    a. $100.
    b. $200.
    c. $300.
    d. $400.

28. How often have you made use of this law? (check one only):
    a. Most of the time.
    b. Sometimes.
    c. Never.

29. Have you ever heard of the Meal Planning Guides?
    a. Yes___
    b. No___

30. If so, where did you hear, or who told you about Meal Planning Guides?_____

_____

31. If you needed some information about Meal Planning Guides, where would you go for such information?_____

_____

32. What does a Meal Planning Guide mean to you?_____

_____

33. Which of the following lists have a complete list of the basic food groups? (ckeck one only):
    a. Milk and milk products, meat, vegetables and fruits, breads and cereals.
    b. Milk and milk products, meat, beans, leafy vegetables, apples, oranges.
    c. Meat, vegetables and fruits, breads and cereals, beans, lemons, cabbage.
    d. Vegetables and fruits, breads and cereals, milk and milk products, oranges.

34. How often do you plan your meals to include the basic foods in the list which you checked in #33? (check one only):
    a. Most of the time.
    b. Sometimes.
    c. Never.

35. Suppose you were to buy one of two forms of the same food product whose price is the same. Which one of the following two forms of a similar food product would you buy if you needed one of them? (check one only):
    a. One food product is pre-mixed and pre-cooked and canned. This food requires only warming before it is served.
    b. The same food product as above may be prepared from different ingredients which are mixed according to a recipe. For this purpose, you will need:
    -one cup of all-purpose flour,
    -two teaspoons of baking powder,
    -half teaspoon of salt,
    -half cup of milk,
    -two tablespoons of egg,
    -two tablespoons of liquid shortening, and
    -two tablespoons of sugar.

--PLEASE CONTINUE--

THE FOLLOWING QUESTIONS DEAL WITH SPECIFIC SITUATIONS TO BE COMPARED. PLEASE ANSWER ALL THE QUESTIONS TO THE BEST OF YOUR UNDERSTANDING BY CHECKING ONE CHOICE IN EACH QUESTION WHICH YOU FEEL BEST EXPRESSES YOUR ANSWER.

1.a. If John is taller than Pete, and Pete is taller than Jane, who is the tallest of the three? (check one only):
   a. John
   b. Pete
   c. Jane
   d. Not sure

b. Who is the shortest of the three? (check one only):
   a. John
   b. Pete
   c. Jane
   d. Not sure

2.a. If Jimmy prefers basketball to football, and he prefers football to swimming, which sport does Jimmy like most? (check one only):
   a. Basketball
   b. Football
   c. Swimming
   d. Not sure

b. Which sport does Jimmy like least? (ckeck one only):
   a. Basketball
   b. Football
   c. Swimming
   d. Not sure

3.a. If swimming requires three times more effort than football, and football requires five times more effort than basketball, which sport requires the most effort in this situation? (check one only):
   a. Swimming
   b. Football
   c. Basketball
   d. Not sure

b. Which sport requires the least effort in this situation? (check one only):
   a. Swimming
   b. Football
   c. Basketball
   d. Not sure

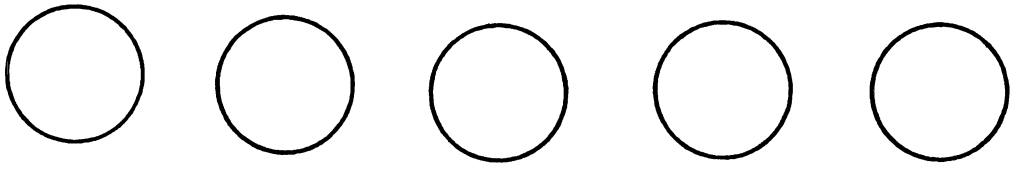
4. On visiting a foreign country, you find that for the price of a twelve-pack of any beer, you can get a "fifth" of a bottle of any type of whiskey. But you could get three bottles of any type of wine for the price of two-twelve packs. In this situation, which of the following statements is correct? (check one only):

a. A "fifth" of whiskey costs more than three bottles of wine.
b. A "fifth" of whiskey costs the same price as three bottles of wine.
c. A "fifth" of whiskey costs less than three bottles of wine.
d. Not sure.

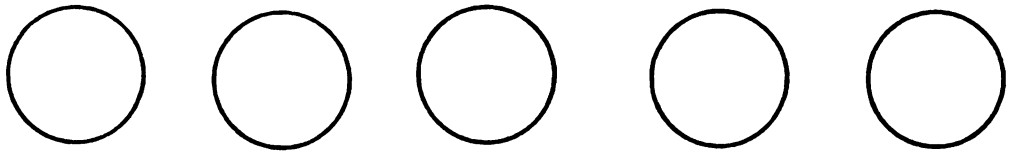
5. Suppose you are a member of a tennis club in which there are both men and women. Which of the following is true? (check one only):
   a. There are more men than members in this club.
   b. There are more members than the total number of men, or the total number of women.
   c. The total number of all men and all women together is less than the number of all members in this club.

6. Suppose a customer gave you a set of dimes for a tip, and another customer gave you another set of dimes. If, for some reason, you displayed both these sets of dimes on some flat surface as shown here:

First set:



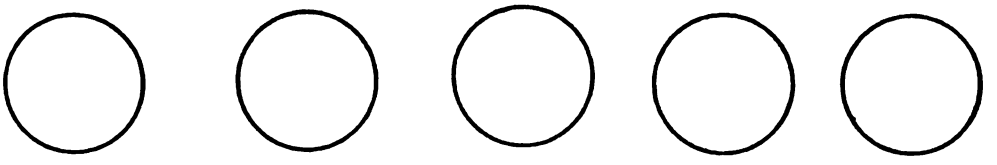
Second set:



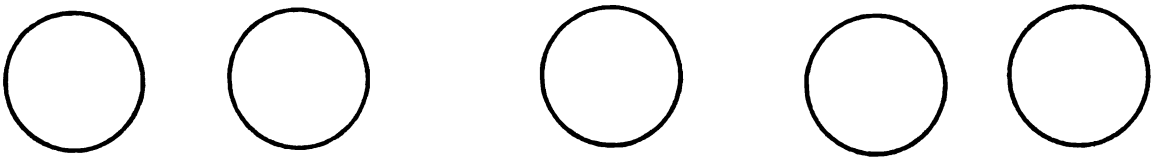
Are these two sets the same? a. Yes___ b. No___

7. If the dimes in #6 are re-arranged as shown here:

First set:



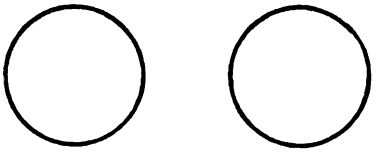
Second set:

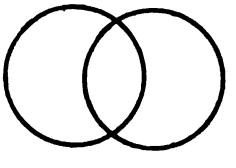


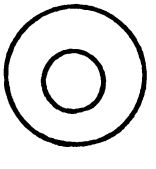
Do you still have the same two sets of dimes as in #6?

a. Yes___
b. No___

8. We always classify the things we see or feel into categories which are similar or different from each other on certain features. We give labels to those categories so that we may be able to talk about them. For instance, you understand what I mean when I say "Mike has a farm on which he keeps different types of animals such as cows, horses, pigs, and chickens. Use the following diagrams to answer the questions which follows:

i. 

ii. 

iii. 

a. Which diagram is correct when I say, "All cows are animals?"___
b. Which diagram is correct when I say, "Horses are not cows?"___
c. Which diagram is correct when I say, "Some horses are male and some are female?"___

9. Suppose you are considering making a choice between two alternatives:
   a. To take-up a job offer which pays $500 a month, or
   b. To go to school where you will pay from your savings about $500 a year for two years for tuition and fees.

   Which choice would you make?___

10. Which of the following messages contains the most information? (check one only):
   a. A tossed coin turns up heads.
   b. The railroad crossing is closed.
   c. My wife gave birth to a baby girl.
   d. The number of my bus ticket ends in digit 7.
   e. Not sure.

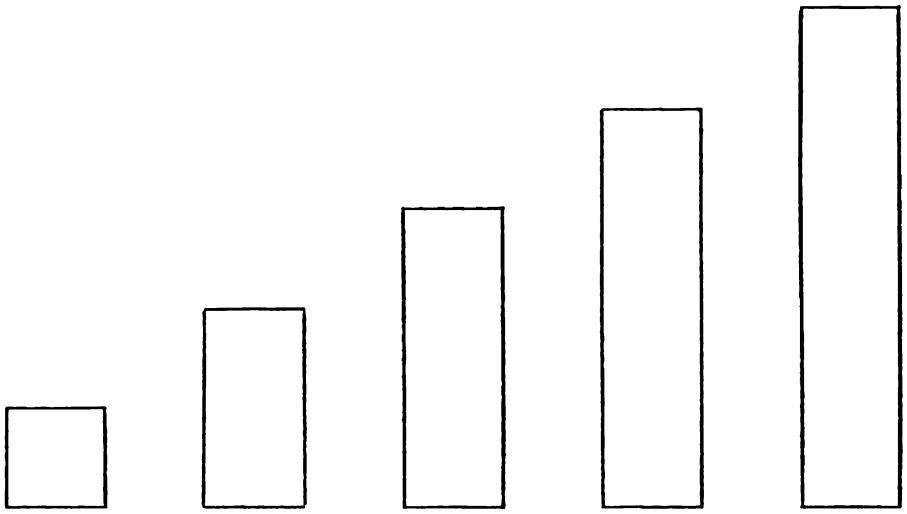
11. Imagine a stadium with several people attending, say, a football game. How many people must there be in such a stadium so that there will definitely be at least two persons with a common birthday? (check one only):
   a. 365 people.
   b. 366 people.
   c. 367 people.
   d. Not sure.

12. Suppose you have a square card "A" (remember: all sides of a square are equal). You have a series of nine other cards all of which are of the same width as card "A" but they differ in length such that:
   Card "B" is two times longer than card "A,"
   Card "C" is three times longer than card "A,"
   Card "D" is four times longer than card "A,"
   Card "E" is five times long than card "A,"
   Card "F" is six times longer than card "A,"
   Card "G" is seven times longer than card "A,"
   Card "H" is eight times long than card "A,"
   Card "I" is nine times longer than card "A."

   a. How many cards do you have altogether?
      a._____ b. Not sure_____
   b. How many cards like card "A" can you make with card "C"? a._____ b. Not sure_____

c. If a card like card "A" is cut out from card "H," which card in the series will be similar to the remaining portion of card "H"? a._____ b. Not sure_____

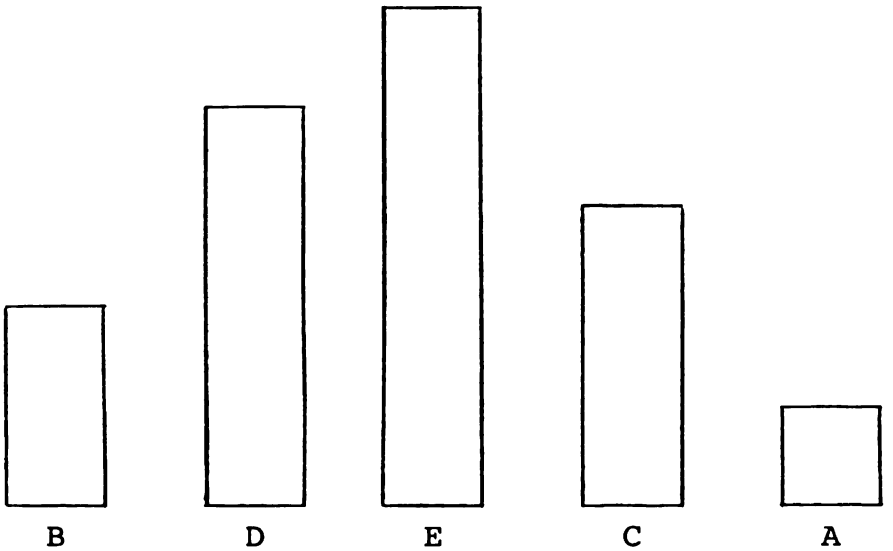
13. If you took cards A,B,C,D,E from the set described in #12, and then formed a new series shown here:



a. Reading from left to right, how do you describe the location of card "D" in this new series? a._____ b. Not sure_____

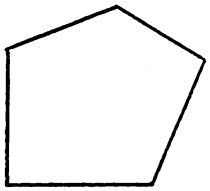
b. Is this location different from the location which this card occupied in #12? a. Yes___ No___

14. If you re-arranged the series of cards in #13 to form a new series as shown here:



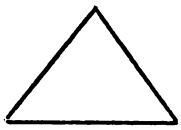
a. What location does card "D" occupy in this new series? a._____ b. Not sure_____
b. Is card "D" still of the same length as before? a. Yes_____ b. No_____

15. Given the following diagrams:

i. 

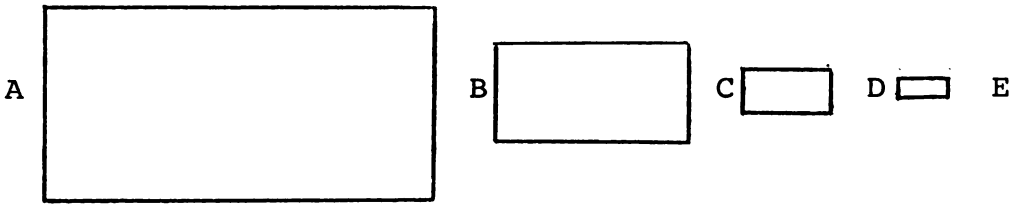
ii. 

iii. 

iv. 

Which diagram implies: a. One_____
b. Three___
c. Four____

16. The size of the following diagram is shown in a series of decreasing order:



a. Draw in the space marked "E" the next diagram which this series can take on.
b. Draw or state the last diagram which this series must be reduced to if you continued reducing the size of the series of these diagrams.

Draw or state here:_____

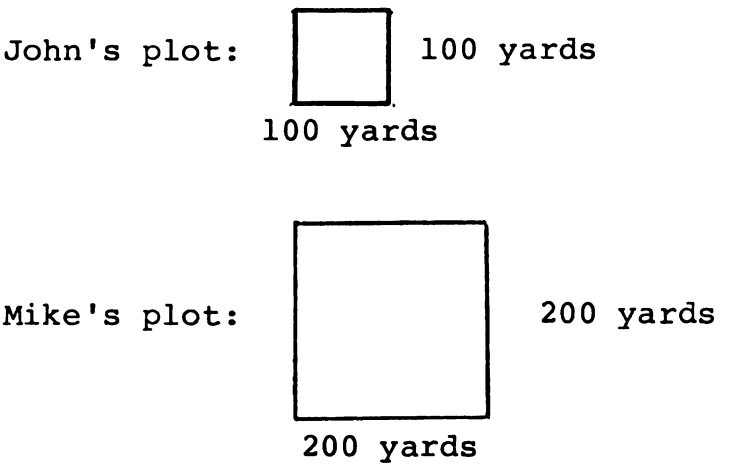
17. Suppose you gave your son four apples and two oranges. To be fair, you give the same type of fruit to your daughter. But she prefers organges to apples. So, you decide to give her four oranges and two apples. If an apple weighs the same as an orange, does your daughter have the same amount of fruit as your son?

    a. Yes_____ b. No_____

18. On listening to a radio ad, you hear that a certain brand of coffee is 97% caffein-free. But moments later, an ad for another named brand of coffee says that the second brand of coffee is 3% caffein. Do these two brands of coffee have different amounts of caffein?

    a. Yes_____ b. No_____

19. John and Mike are farmers who are neighbors. John's plot of land is 100 yards long and 100 yards wide. Mike's plot is 200 yards long and 200 yards wide (see the diagrams below):



    Which of the following statements is true? (check one only):

    a. Mike's plot is two times bigger than John's.
    b. Mike's plot is four times bigger than John's.
    c. Mike's plot is six times bigger than John's.

20. A 4-H member has three speckled rabbits and four gray rabbits for his project. At any time, all of these rabbits are either seated or running in the yard enclosed by wire-netting which this 4-H member built for his animals. Use the following box to answer the questions which follow:

	Seated rabbits	Running rabbits
Speckled rabbits	A	B
Gray rabbits	C	D

a. Which letter or letters represents running speckled rabbits? a._____ b. Not sure_____
b. Which letter or letters represents total gray rabbits? a._____ b. Not sure_____
c. What fraction are speckled rabbits? a._____ b. Not sure_____
d. What is the ratio of speckled rabbits to gray rabbits? a._____ b. Not sure_____
e. If five rabbits are running, how many are seated? a._____ b. Not sure_____

21. For the following pairs of fractions, which of the two is greater:

a. 5/8 or 7/8? a._____ b. Not sure_____
b. 3/4 or 3/5? a._____ b. Not sure_____
c. 3/4 or 4/5? a._____ b. Not sure_____

22. How many:

a. Ounces in one pound? a._____ b. Not sure_____
b. Pounds in one ton? a._____ b. Not sure_____
c. Yards in one mile? a._____ b. Not sure_____
d. Quarts in one gallon? a._____ b. Not sure_____
e. Pints in one gallon? a._____ b. Not sure_____

23. How many:

a. Millimeters in one centimeter? a._____ b. Not sure_____
b. Millimeters in one meter? a._____ b. Not sure_____
c. Milligrams in one gram? a._____ b. Not sure_____
d. Grams in one kilogram? a._____ b. Not sure_____
e. Cubic centimeters in one liter? a._____ b. Not sure_____

--PLEASE CONTINUE--

To complete this questionnaire, please fill out the blanks below. This information is needed for the analyses.

1. Today's date_____ 2. Time: AM___ PM___

3. Name_____ Address_____

_____

Telephone #_____

4. Age:____ 5. Sex: Male___ Female___

6. Marital status: Married___ Single___ Divorced___

Separated___

7. Employment: Employed___ Unemployed___

8. Race: Asian American _____
Black American _____
Mexican American ___
Native American ____
White American _____
Other (please specify)_____

9. Are you (or have you been) an Adult Basic Education (ABE) student? a. Yes___ b. No___

10. If so, what is (was) your highest student classification in ABE?_____

11. If you are going to school now, what is your present school classification? (check one only):

a. Freshman____
b. Sophomore___
c. Junior_____
d. Senior_____
e. Graduate_____
f. Other (specify)_____

Where do you go to school?_____

12. If you are not going to school now, what is the last grade of school you completed?_____

APPENDIX C

Results From Preliminary Trials with Different Values of Restriction Parameters for Fitting the Regressors into the Predictive Equations in the Nigeria - Ilewo Sample Space

APPENDIX C

Results From Preliminary Trials with Different Values of Restriction Parameters for Fitting the Regressors into the Predictive Equations in the Nigeria - Ilewo Sample Space

The first set of parameter values included 6 NSTEPS, 6.63 FIN, .01 TOL, and 6.00 FOUT. These values were too conservative. Only one step of stepwise multiple regression analysis was possible in both the first and second model in which the awareness and adoption of technological innovations were respectively predicted. For the first model, literacy in English was the only regressor in the equation. Literacy in Yoruba and last grade of school completed were both not in the equation. For the second model, the awareness of technological innovations was the only one in the equation. Literacy in Yoruba, literacy in English, and last grade of school completed were all not in the equation.

The above values were then relaxed to 6 NSTEPS, 3.00 FIN, .001 TOL, and 2.00 FOUT. However, these new values did not change the results for the first model noted above. As for the second model, three steps were possible in which the awareness of technological innovations, literacy in English, and last grade of school completed were fitted into the equation at the first, second, and third step respectively. Once again, literacy in Yoruba did not enter the equation for the second model under the new restrictions.

Finally, the following values were tried: 6 NSTEPS, 2.0 FIN, .001 TOL and 1.50 FOUT. However, this set of restrictions produced the same results as the second set of restrictions noted above. In preference for the default values of the four parameters, no further trials were made. The default values permitted a complete exploration for the relative explanatory power of the regressors in each model.

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