The Relationship Between

Literacy Proficiency and the Digital Divide

Among Adults With Low Education Attainment

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A technical report from the

Longitudinal Study of Adult Learning

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This research was supported by the National Center for the Study of Adult Learning and Literacy funded by the Educational Research and Development Centers program, Award Number R309B60002, as administered by the Office of Educational Research and Improvement, U.S. Department of Education, through contract to Harvard University. The content of this reports do not necessarily represent the positions or policies of the Office of Educational Research and Improvement, or the U.S. Department of Education, and you should not assume endorsement by the Federal Government.

Summary of findings

Adults who didn't finish high school are the demographic group making the most gains as the digital divide closes. The Longitudinal Study of Adult Learning followed a representative sample of these adults (born between 1954 and 1980) in the Portland, Oregon metropolitan area, with repeat tests of literacy proficiency, work, and technology use.

Computer ownership increased 62%, from 45 percent of the study population owning a computer in 1998 to 73 percent in 2005. Internet connection in home rose 11%: from 47 percent in 2001 to 52 percent in 2005.

Computer use increased from 61 percent in 1998 to 98 percent in 2005. Most of the jump occurred between 1998 and 2001. People of color are as likely as whites to be computer users, when ownership is accounted for.

The rate of change of computer ownership is greater for white English speaking households and than for households of people of color. While ownership is increasing overall, it is slower for people of color so that these households are not catching up to white households. Rates of ownership and use by people of color are more subject to fluctuations in the economy than are the rates for whites.

At baseline, working, household income and owning a computer predict computer use. Controlling for these characteristics, literacy proficiency significantly predicts computer use status. With literacy proficiency held constant, African Americans are more than twice as likely to be computer users than whites.

Among people who were not computer users at baseline, only computer ownership predicts the nine percent of the population who remain non-users in 2003.

People with higher literacy proficiency scores are earlier adopters of computer use. New adopters at each time period reach into progressively lower levels of literacy proficiency.

Literacy proficiency scores and reading non-fiction predict familiarity with technology terms over and above computer use.

Most adults born before 1968 learn computer skills informally or at work, while younger users are taught in school. Participants of adult education programs were not more likely to be computer users than non-participants. All users prefer to continue to learn new computer skills through trial and error and with help from friends and family.

Among people working, computer use at work increased by 19 percent: from 47 percent in 1998 to 56 percent in 2005.

Workers with higher literacy proficiency were more likely to use computer technology at work.

Tables and Figures

Thanks to

Steve Reder, Eunice Askov, David Rosen, and John Brynner

for critical reading, comments and support.

A recurrent topic of concern among those working to address the digital divide is the parallel gap in computer use and proficiency of basic literacy skills and how these two skill sets are inter-related (Carvin, 2000; Digital Divide Network, 2005/2006). No matter how many free computers are made available, the argument goes, people can't or won't be able to access information technology if they have poor reading, writing, problem solving and technical skills. This paper informs the discussion by examining the relationships between basic literacy proficiency and use of computer technology among adults who did not finish high school.

The conceptual definitions and dimensions of basic literacy and fluency with information technology are evolving with theoretic developments and changes in technology itself. Literacy proficiency is commonly defined in large national and international studies as "the ability to use printed and written information to function in society, to achieve one's goals, and to develop one's knowledge and potential" (Organization for Economic Cooperation and Development, 1995, p 14). definition is challenged by theory from New Literacy Studies that argues for a more ideological understanding of literacy practices in the contexts of power and interpretation of meaning (Gee, 1996).

Likewise, we are beyond a simplistic measure of computer use. The phrase "fluency with information technology" (Committee on Information Technology Literacy, 1999) is meant to capture the skill of computer literacy that adapts to evolving technology. Fluency with technology involves continuous learning by applying foundational concepts to new practices. Computer use is understood as a practice that involves a range of cognitive, conceptual and basic literacy skills. As computer applications constantly change, computer literacy goes beyond the ability to use a keyboard and the functions in particular programs. Computer proficiency can also be defined as fluency with 'computer operations skills [that] interact and interchange regardless of application" (Norris & Conceicao, 2004: 71-72).

However, this definition does not incorporate the situated character of computer practices that intersect with literacy and involve meaning embedded in context. A computer application does not stand independent from the social context of its use. A data entry person can enter numbers by rote into an excel spreadsheet and an analyst can interpret financial trends from the same spreadsheet. Both are using the

same application but the meaning of the practices differs.

New literacies driven by computer technology build on the logic of information processing rather than narrative (Lankshear & Knobel, 2003). A common information processing task is to scan and select from rolling pages of links generated by a search engine, interpreting their value for the purpose at hand but not unfolding content to tell a story. Beyond the important information literacy skills of finding and evaluating information, information processing includes the ability to interpret text presented in hyper-textual media or a-synchronistic communications, outside of a linear narrative context (Alvermann, 2004).

These developments suggest a "computer-mediated communication literacy," defined by Warshauer (2003, p.117) as "the ability to create, manage, and participate in effective online communication in a variety of genres and formats." This paper builds on this definition toward the concept of "computer-mediated literacy practices." Dimensions of computer-mediated literacy practices are defined by the relationships between literacy proficiency, fluency with technology, and contexts of practices situated in power relationships. This perspective extends the notion of bridging the digital divide to broadening communities of practice to new practitioners and to new practices introduced by those new users and by developing technologies.

Table 1 shows one way to map these properties: placing access, technical skills and literacy proficiency in a matrix opposite contexts of practice such as home, school and work, where new contexts and new skills

Table 1: Matrix of computer-mediated literacy practices

	Home/personal	**School**	**Work**	**New contexts**
Access	Ownership	Technology integration into curriculum	Stratified by worker roles	Broadband & wireless infrastructure
Fluency with Technology	Informal learning	Formal training	Formal and informal	New tech practices
Literacy proficiencies	Felt need. Literacy related to income	How integrated with technology?	Access to advanced practices	New literacies*
New practices	Integration of adult roles & technical tools	Virtually supported learning	Participation in new economies	Virtual communities & distributed authorship*

* (Knoble & Lankshear, 2007)

extend in each direction.

The matrix also points to junctures of access and power with implications for policy and equity. The relationships between literacy proficiency, computer skills, and socio-economic status must be examined critically and empirically. The systemic reproduction of inequality in schooling has been widely documented (Petrovich, 2005). The digital divide is reinforced when schools serving lower income communities are not as well resourced. Warshauer (2003, p. 131) finds that, "Low level students are more likely to use skill and drill computer exercises in schools, particularly if school serves low income population. Higher literacy and higher income schools are more likely to do project based and simulations learning."

People who have more education are more likely to have higher literacy proficiency, more skilled work and higher income (Kirsch, Jungeblut, Jenkins & Kolstad, 2002). Access to technology and demands for skill development, more frequently found in high skilled occupations, create different contexts for computer-mediated literacy practices and subsequent skill development. Warschauer (2003) makes the distinction between rote use and symbolic manipulation. From the social/functional lens of computer-mediated literacy, different roles —who are cogs in a machine, consumers of information and products, or authors of knowledge and software— engage in different kinds of practices. Many computer users do rote tasks at work, such as data entry, that require little proficiency and make few demands on their ability to solve problems or manipulate the tools. At a higher level, technology authors manipulate symbols —code, text, and graphic— to create and interpret meaning. The global and domestic labor markets sort workers skilled in both literacy and technology out from low paid service workers and manufacturers without these skills (Levy & Murnane, 2004).

Adult education and the digital divide

Learning computer skills is also "learning to be" a computer user and developing a new social identity. Some people who own the hardware don't use it because they don't have a self-concept as a computer user. For these learners, becoming acculturated to a community of computer practices is as important as acquiring skills. An environment of peer users such as is available in community technology centers provides this context that might not be available to them as isolated home users (Warschauer, 2003). To some degree the language of computer practices

has infiltrated common culture making underlying concepts of technology use accessible as a bridge to future users. An example is the concept of the "world wide web" or "internet" that non-users become familiar with before actually learning to "surf." One can enter a community of practice of computer users peripherally through the ability to use the language introduced by technology whether or not one has proficient finger skills with applications.

In addition to physical access, basic literacy proficiency is an important factor in the digital divide (Levy & Murnane, 2004; Warschauer, 2003; Mossberger, Tolbert & Stansbury, 2003). Incorporating technology into adult education programs can draw new clientele (Silva & Wallace, 2000; Porter, 2004). However, age cohorts of people who encountered technology as part of their education after 1985 (in the U.S.) are natives to this community of practice while adults who encounter technology and learn computer skills after their initial education are outsiders needing acculturation (Lankshear & Knobel, 2003). This poses problems for some educators who are technology outsiders but teach young adults who are technology insiders. Professional development is among other contextual challenges to integrating technology with adult education (Askov, Johnston, Petty & Young, 2003).

Popular culture and informal learning through computer use may offer avenues for development of new literacies not available in formal programs. Websites about popular culture can present more complex literacy demands than the texts encountered in some literacy programs (Stone, 2007, chap. 3), computer games offer an experience of expertise not always available in the classroom (Gee, 2007, chap. 5), and adolescents develop voice and identity through writing on line (Thomas, 2007, chap. 7).

These theoretical developments call for better empirical work on the relationship between computer and literacy proficiencies. To date there has not been longitudinal data available that matches computer use and literacy proficiency in the population of interest to the digital divide issues.[1] Drawing on new data from the Longitudinal Study of Adult Learning, this paper investigates the effect of literacy proficiency on computer access and use, learning modalities, computer-mediated practices, and contexts of practices. I address two main questions:

- What role does literacy proficiency have in adoption of

computer technology over time?
- In what computer mediated literacy practices do adults with low education attainment engage?

Research Method

Nationally, adults who did not finish high school showed the greatest growth rate in computer use between 1998 and 2000 of any demographic group (Department of Commerce, 2000). This group, at the edge of the digital divide, is the target population of the Longitudinal Study of Adult Learning (LSAL). Data, collected in six waves between 1998 and 2007, focus on the continued learning and literacy development of adults after leaving compulsory education. With multiple and repeated measures of basic literacy proficiency[2], literacy practices in daily life, employment and computer access, use and competencies, LSAL offers a more specific and detailed look at gains in computer use among adults with low education.

Participants were recruited in 1998 through random calling and screening and by over-sampling individuals entering adult basic education classes. The sample of 934 is weighted to generalize to adults who, when recruited, were between ages 19 and 44, lived in the Portland, Oregon metropolitan area, had not earned a high school diploma or GED, and were proficient, although not necessarily native, speakers of English.[3] Twenty-two percent of the weighted sample earned a GED during the study and were retained in the study as were people who moved away from Oregon. Eighty-five percent of the sample was retained through the end of the fifth data collection period.[4] Each wave of data included an extensive interview and standardized literacy assessments that were administered in the homes of the respondents. The LSAL is designed to investigate how adult literacy develops over time, the contexts of literacy practices and skill development and the potential outcomes. Use of technology is one of these contexts.

The first wave of data, collected between October 1998 and July 1999, incorporated computer use into a range of other literacy practices in the home and at work. In this context respondents were asked whether and how often they used email, the internet or read a computer screen or entered information into a computer at work, and whether they had a computer at home. A yes response to any of these items, or reporting computer training at work, identified cases as a computer user in the wave one baseline dataset. In subsequent waves,

respondents were asked directly whether they had used a computer since the previous interview. The workplace computer use items were repeated in subsequent data collection years as a time series indicator of computer use at work.

After discovering the prevalence of computer use in the population, additional modules were developed for subsequent interviews to capture more textured descriptions of computer use as literacy practices.

How is Portland different?

Research design grounded in a geographic location rather than nationally representative allows more attention to the effects of local conditions. This is especially important when looking at technology issues. Although the large national technology surveys, such as those conducted by the Department of Commerce and the PEW Internet and American Life Project, break down findings by geographic regions, by urbanicity and by demographic factors, it is difficult to make statements about particular sub populations from a nationally representative sample, especially statements that are interpretable in a particular urban context. For example, the Portland metropolitan area, where LSAL is located, was identified as the most wired city in the US (Nielsen-netrating, 2001). This local context has implications for how we understand the penetration of technology into low-income communities. It is possible that conditions in the Portland metropolitan area are a preview for other regions, national and international, with less connectivity.

There are other reasons why Portland represents specific conditions. Literacy proficiency and practices are important components to technological fluency and library use also involves public access to technology. Literacy proficiency in Oregon is, on average, higher than in most states (Reder, 2001). Oregon library circulation rates are higher than the national average for public urban libraries (Oregon Library Association, 2003) suggesting both high levels of reading and accessibility of computers.

The local economy is also an important context. During the 1990's, the Portland metropolitan economy moved from one based primarily on resource extraction (lumber) to an emergent "silicon forest." The national issues pertaining to re-skilling the workforce to the information economy are very relevant in the Pacific Northwest.

The population of workers who do not have high school or GED

credentials is particularly impacted by economic fluctuations. Through the five years represented here, the local economy moved from a very low unemployment rate, 3.7 percent in April 1998, to the highest unemployment in the nation 8.5 percent in 2003.[5] Data on technology use in this population, grounded in this economic reality, offer a particular insight into the economic value of technological skills and the types of jobs affected.

Analysis

I construct a picture of the relationship of literacy proficiency to computer use over time with three sets of analyses. As access to technology is strongly predictive of use and the digital divide is frequently experienced along racial or ethnic lines, I first present bivariate descriptive trends on type of access to information technology across the seven year period of the LSAL study by user characteristics.

Second, addressing the role of literacy proficiency[6] in adoption of computer use, I estimate a logistic regression model on early adoption of technology at baseline, controlling for age, gender, ethnicity,[7] work status, household income,[8] and computer ownership.[9] I then estimate the predictive power of literacy proficiency on becoming a later adopter of technology on the sub-sample of people who were not computer users at baseline in a series of logistic regression models run independently at each time point. I chose this analytic strategy, rather than hazard modeling, because people move in and out of the status of computer user at different time points and most of the population is a computer user by the fourth time point. I further unpack the role of literacy proficiency by comparing the literacy proficiency scores of continuing users, new users and non-users at each time point, testing the hypothesis that people with lower literacy proficiency are becoming computer users over time.

Third, I operationalize the construct of "fluency with information technology" as an index scale of familiarity with computer related vocabulary. The contribution of literacy proficiency and reading practices to fluency in information technology are tested in a multivariate model controlling for duration and intensity of computer use.

Finally, I investigate computer-mediated literacy practices as sets of activities in contexts of use: at school, at work and in the home. To investigate participation in communities of technology practices I look at how people initially learned and prefer to continue learning to use technology relative to their age.

Identifying users who were introduced to technology in the context of compulsory education as "insiders" and those who encountered it later in their lives are "outsiders," following Lankshear and Knobel's (2003) thinking about acculturation to technology, draws out implications for integrating technology into educational programs.

Findings

Access and use of technology by race and ethnicity

Nearly half the LSAL population had a computer in their household in 1998/99, which compares to about 20 percent of adults without a high school diploma or GED across the US in 2000[10] (DOC, 2000). This remarkable difference can probably be attributed to the Portland area context in which technology and connectivity have a deep market penetration and industry is technology oriented. However, it is also possible that the similar difference in average literacy proficiency of this population in the Portland area compared to the same population nationally is not wholly spurious.

Table two illustrates the changes in access points over time. In the six years between 1999 and 2005, computer ownership increased 62 percent, with nearly three-quarters of this population owning a computer and over half with internet connection in their home. The frequency of accessing a computer at work increased slightly, from 49 to 53 percent of the population by 2005. The largest jump over that period is of those who use a computer at both home and work, an increase of 71 percent. This pattern is

Table 2: Percent of population with physical access to computers1998-2005

	1998-1999	1999-2000	2000-2001	2002-2003	2004 - 2005	Percent change**
Computer in household	45	57	59	69	73	62
Internet connection at home	na	na	47	62	52	11**
Uses computer at work*	49	49	40	45	53	8
Uses computer at home only	22	20	28	32	20	-9
Uses computer at work only*	25	24	13	11	12	-52
Access at both home and work	24	32	30	34	41	71
No access at home or work	33	24	17	18	17	-48
Access elsewhere	na	47	29	29.5	32	-32**
No access anywhere	na	23	12	11.5	8	-65**

*coded 0 if not working. If used computer at work access was assumed. Distinction between access and use at work is not made.

**Change is between first available data and 2005, calculated as the last figure less the first divided by the first. ((2005-1999)/1999)

Table 3: Computer Ownership comparison of Anglos and people of color.

	1998-1999	1999-2000	2000-2001	2002-2003	2004-2005	% change 1998-2005
All households	45	57	60	69	74	64
Anglo	48	61	64	71	77	60
People of color	44	48	51	65	67	52
probability	ns	.00	.00	ns	.01	

n = 644 cases valid across all waves (using all cases available at each time point makes the trend more pronounced)

important because access and use in multiple locations suggests that technology is integrated into the lifestyle of the user. People not owning a computer or using one at work most frequently access use at the homes of friends or family. Others take advantage of the public access points at libraries or community centers made available by policy initiatives to address the digital divide. By 2005, the need for public access points seems to be decreasing in this population, as only eight percent say they did not have access to technology anywhere, down 65 percent since 2000.

This good news is tempered by breaking out the rate of computer ownership by racial and ethnic groups. While the rate of computer ownership by Anglo, non-Hispanic households has risen steadily, the rate of ownership among other groups is slower. Table 3 below shows that the trend overall is toward a widening gap with computer ownership by Anglo households

Figure 1: Computer owners by race/ethnicity – percent within group

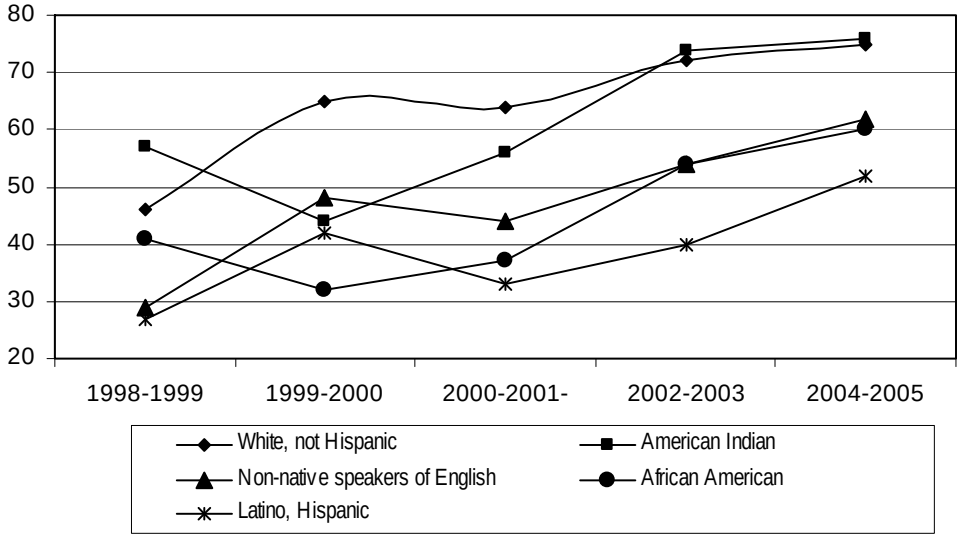


Table 4: Computer user comparison of Anglos and people of color						
	1998-1999	1999-2000	2000-2001-	2002-2003	2004-2005	% gain
All	61	66	90	91	98	42
Anglo	64	67	91	95	97	52
People of color	56	64	90	84	100	57
probability	.05	ns	ns	.00	ns	

N = 644 valid cases across all waves.

increasing faster than people of color, going from non-significant in 1999 and 2003 to significant at .01 in 2005.

Figure 1 shows that most of the significant difference in rates of computer ownership lies between Latino and Anglo households. African Americans and American Indians experienced a dip in computer ownership in 2000 and Latinos and Non-Native Speakers of English in 2001, from which each group had to recover, while Anglos only leveled out slightly in that period.

Computer use

The number of computer users increased by 42 percent, from 61 percent in 1999 to 98 percent by 2005. While there has been significant gain for all groups, the difference between white and minority households narrowed by 2000-01 and then became significant again by 2002-03 with economic recession, suggesting that gaps in use open and close with the economy. By 2005, with nearly 100 percent use, there is no difference in computer use based on racial or ethnic group.[11]

Estimations of computer use

The relationship of literacy proficiency and computer use is tested below using multivariate logistic regression. The models predicting being a computer user are shown in Tables 5 and 6. Model A is the basic model and Model B adds literacy proficiency, testing the hypothesis that literacy proficiency predicts computer use over and above the control variables and computer ownership. Wald statistics and odds ratios are reported, with a five percent probability indicating significance. Figures less than one indicate a less than even chance of computer use and figures over one indicate an increased likelihood, all else equal. The odds for gender are for women as compared to men. The odds for race/ethnicity are for each group as compared to English speaking, non-Hispanic whites. When comparing results with other studies it is important to keep in mind that the LSAL population is capped at age 44 (when first interviewed) and more people in older age groups do not use technology.

Table 5: Probability of being a computer user at wave one 1998-1999

	Model A		Model B	
	Wald	Odds Ratio	Wald	Odds Ratio
Age	11.87*	0.96*	7.34*	0.97*
Female	1.21	1.21	2.88	1.36
Anglo	**8.71**		**12.23**	
ESL	0.08	1.09	1.98	1.53
African Am	2.40	1.69	5.42*	2.25*
Other min	5.08*	0.58*	3.54	0.63
Household income	**13.90**	**1.41**	**10.20**	**1.34**
Working	**13.10**	**1.94**	**13.52**	**1.97**
Computer in household	**134.33**	**9.90**	**136.94**	**11.03**
Literacy proficiency			**15.87**	**1.44**
Constant	0.49	1.29	0.12	0.88
NR2	0.32		0.34	
% correct	75		78	
Step χ^2 (df,p)			16.4 (1, .000)	

* p< .05, bold p< .01

Table 6: Probability of non-users at wave one being computer users in subsequent years

	1999-2000				2000-01				2002-03			
	Model A		Model B		Model A		Model B		Model A		Model B	
	Wald	OR	Wald	OR	Wald	OR	Wald	OR	Wald	OR	Wald	OR
Age	**10.78**	**0.94**	4.76*	0.95*	2.23	0.97	0.20	0.99	5.68	0.93	5.66	0.93
Female	**8.19**	**0.41**	2.97	0.56	3.93*	0.47*	1.76	0.60	0.00	1.02	0.04	1.11
Anglo	**25.45**		**20.36**		0.34		1.22		11.24		6.66	
ESL	**15.64**	**0.13**	5.13*	0.28*	0.16	0.81	0.88	1.80	9.01*	0.15*	4.31*	0.23*
African Am	5.18*	3.83*	**9.29**	**7.00**	0.00	1.01	0.23	1.39	0.21	0.69	0.00	0.99
Other min	3.40	2.12	4.79*	2.57*	0.10	1.17	0.58	1.48	0.55	1.95	0.68	2.12
Household income	0.54	0.89	0.17	0.93	0.41	0.88	0.36	0.88	0.01	0.97	0.02	0.96
Working	1.69	0.65	1.82	0.62	1.07	1.53	0.17	1.19	0.32	1.38	0.18	1.27
Comp. in household	**74.29**	**31.89**	**71.49**	**35.41**	**10.45**	**3.58**	**10.23**	**3.66**	**15.89**	**21.46**	**15.82**	**22.11**
Literacy proficiency			**14.07**	**2.18**			**7.43**	**1.72**			1.42	1.42
Constant	4.55*	4.53*	0.98	2.13	**6.91**	**9.01**	3.21	4.71	**10.37**	**39.49**	10.41	39.14
NR^2	.49		.54		.13		0.17		.42		.43	
% correct	82		81		83		82		93		93	
Step χ^2 (df,p)			16.15 (1, .00)				7.96 (1,.01)				1.036 (1, .24)	

* p< .05, bold p< .01

Table 5 displays a baseline model estimated on the entire sample predicting computer use at wave one. As expected, owning a computer in the household is strongly associated with computer use.

Controlling for age, ownership, income and work status, literacy proficiency is a significant predictor of computer use, with probability increasing by 44 percent with each standard deviation in literacy proficiency score. With literacy proficiency held constant, African Americans are more than twice as likely as Anglos to be computer users.

Model A in Table 6 predicts the change in status from non-user to user at each time point to 2003 and is estimated on the sub-group of non- computer users in 1998-99 (n=353). Model B shows that literacy proficiency predicts being a computer user over and above demographic controls and owning a computer in 1999-00 and 2000-01. One standard deviation increase in the literacy score improves the likelihood of being a computer user by 118 percent in 2000 and 72 percent in 2001. However by 2003, when 91 percent of the population had used a computer, literacy proficiency along with all other characteristics other than computer ownership, is not significant.

In 1999-00, African Americans are seven times more likely as Anglos to be new computer users when computer ownership and literacy proficiency are held constant, but are equally likely to be computer users after that.

The relationship between fluency in technology and basic literacy proficiency

The multivariate models above suggest that as computer use reaches over 90 percent, literacy proficiency loses power as a predictor. People at lower levels of literacy proficiency are joining the group of computer users over time. An analysis of variance test comparing mean literacy proficiency scores between experienced computer users, new users and non-users shows that over the course of five years, new adopters reach into the ranks of people with progressively lower literacy proficiency scores. At the third and fourth time points the

Table 7: Mean literacy proficiencies by computer use status

	1998-1999	1999-2000	2000-2001	2002-2003	2004-2005
Continuing user	289	296	292	290	290
New users	na	280	281	276	255
Non-users	269	271	264	240	251
F (df)	31.97 (1)	16.23 (2)	10.31(2)	14.53 (2)	9.07 (3)

p<.00 in all years, n=644 valid across all waves

group of continuing users includes the previous time's new users, bringing the overall mean literacy score for continuing users down. Through 2003 the mean literacy proficiency of computer users is higher than the mean of the small group of non users.

This mean score of literacy proficiency does *not* mean that there are not computer and internet users at the lower levels of literacy proficiency. Table 8 shows that over half of people with below basic and basic literacy proficiency[12] had used a computer in 1999, and over half are on the internet as of 2003.

While the higher mean literacy proficiency and deeper penetration of technology in the Portland metropolitan area create a context in which computer users in the LSAL population are, on average, more proficient than the low literacy users of concern in national studies, a substantial percentage of people at every literacy level are becoming computer users over time. However, there is a much lower rate of internet use among those with lower literacy. Two possible explanations may be the affordability of internet connection and the greater literacy demands of internet use.

Fluency with technology and literacy proficiency

The increase over time of users with lower basic proficiency poses the question of whether there are differences in fluency with technology attributable to literacy proficiency over and above experience as a user. One component of fluency in technology is knowledge of foundational concepts, measured here as familiarity with computer specific vocabulary. People may be able to do something on the computer, but may not know the language used or have the background information to explain what they are doing. Knowing the vocabulary indicates understanding beyond rote finger skills. At wave three a simple vocabulary test was administered in which respondents gave an open ended response to questions asking the function of a word processing program, a spreadsheet program, a browser or a search engine, and a

Table 8: Computer and internet users as percent within literacy proficiency group

	1998-1999	1999-2000		2000-2001		2002-2003		2004-2005	
Literacy level	computer	comp	net	comp	net	comp	net	comp	net
Below Basic & Basic	52	48	40	77	48	79	52	99	47
Intermediate	62	72	51	94	81	95	82	98	68
Proficient	79	82	72	97	88	97	92	98	87

Table 9: Literacy practices and proficiency and explain fluency in technology				
		Estimate	Std. Error	Wald
Threshold	[vocabscore = 0]	3.860	0.475	66.118
	[vocabscore = 1]	4.829	0.485	99.342
	[vocabscore = 2]	5.771	0.496	135.194
	[vocabscore = 3]	6.772	0.510	176.453
Location	Hours per week computer use	0.014	0.004	14.988
	Months of computer experience	0.005	0.001	32.016
	Reading non-fiction	0.133	0.038	12.607
	Literacy proficiency	0.016	0.002	78.767
Nagelkerke R^2		0.29		
Goodness of fit	Deviance χ^2 (df,p)	2222.68 (3040, 1.00)		
All significant at .000				

keyword. Correct answers were added to yield an index score on a scale of 0 to 4. To test the hypothesis that literacy proficiency and literacy practices are important contributors to fluency in technology, I estimate this index with an ordinal regression model represented in Table 9. In addition to literacy proficiency, literacy practices such as reading manuals should also predict fluency in technology. Reading non-fiction, measured on a five point scale from never to everyday, indicates literacy practices as a predictor along with the literacy proficiency score. Literacy practices and proficiency explain most of the variance in computer vocabulary scores accounted for in this equation.

These findings suggest that, even among experienced computer users, literacy proficiency continues to play a role in being fluent with technology. Higher literacy proficiency and reading practices facilitate initial entry into the status of computer user and a deeper understanding of the practices engaged in beyond what users learn through experience.

Situated contexts of computer-mediated literacy practices

Communities for learning and practicing computer skills are situated in educational institutions and work places as well as in personal interests and informal social support. Where and how people learn to compute is the first instance of joining such a community, whether it is on-line, informal, or highly formal as in a classroom or workplace. Since the early days of micro-computing, computer literacy has emerged from a culture of peer guidance (popular user groups in the 1980's) and learning by trial and error. A whole generation of adults developed computer-mediated literacy after leaving formal education, making the novice status less stigmatized even among adults who didn't

Table 10: Initial learning modality by percent within age group (1998)

	18-24	25-30	31-39	40 +	All ages
Part of K-12 curriculum	57	38	3	0	34
Teach yourself by trial and error	11	15	28	29	18
Have a friend or family member teach you	17	18	15	24	17
Take a class	7	4	12	15	9
Learn on the job	0	8	14	24	8
Combination of the above	5	16	8	5	8
Other	1	1	16	3	5
Teach yourself by reading screen/help or a manual	1	1	3	0	1
Hire an expert to teach you	0	0	0	0	0

finish high school. One of the draws of community based technology centers is that learners can develop literacy skills under the guise of learning computer skills. Learning in an environment of peers also helps people acquire the identity of "computer user" (Russell & Ginsberg, 1999; Silva & Wallace, 2000).

School contexts for learning computer-mediated practices

Almost half of the LSAL population was, in 1998-99, between the ages of 18 and 24 and over half of computer users in this age group learned while enrolled in compulsory education. This group would have been between ages five and twelve in 1985 when computers started becoming more common in U.S. schools. Fewer computer users (38 percent) in the 25-30 age groups learned at school and almost no one older than 30 learned in the K-12 environment. Older users are most likely to learn on the job or to teach themselves through trial and error. Table 10 shows the patterns of learning modality by age cohort.

Like the general population, non-formal modes of learning computer skills are preferred by the LSAL population. After leaving school, non-formal learning modalities are more common than classroom-based learning, with the exception of people in the 30's. Learning from friends and family is the most preferred way to continue developing computer skills, as shown in Table 11.

About 65 percent of the study population knows someone with whom they can discuss technology, and for most, this is their first line of support for troubleshooting. Even within self-directed learning, people are more comfortable learning experientially by trial and error than by referring to a manual or help system. Once introduced to the world of computer use, age does not make a difference in preference of learning style.

Table 11: Preferred continuing learning modality by age group *					
	18-24	25-30	31-39	40 +	All ages
Learn from family or friends	63	76	60	67	65
Learn by trial and error	56	74	49	57	58
Learn by reading help screen	46	67	55	48	52
Learn by going to class	40	48	61	50	48
Learn using a manual	46	43	47	52	46
Learn from an expert	12	10	19	19	14
Don't know	6	1	11	1	6

* multiple choices possible

The adult education context

As of 2005, over sixty percent of the LSAL population had participated in an adult basic education program to improve their basic skills or work toward a GED for at least one class session. However, participation in adult basic education programs has no statistical relationship to whether a person owns a computer or is a computer user. This suggests that not being a computer user is not creating an obstacle to attending programs, but also that adult education programs are not facilitating computer literacy development. Portland area adult education programs are offered by community colleges with computer labs available to adult education students. Therefore, I interpret this finding as positive; broad computer use and access is independent from educational institutions. Nationally, 73 percent of programs report that learners use the internet for learning (Tamassia, et.al., 2007). Nevertheless, only six percent of program participants in the LSAL population reported using the internet for school related activities, suggesting computer technology is not as integrated into the curriculum as it might be.

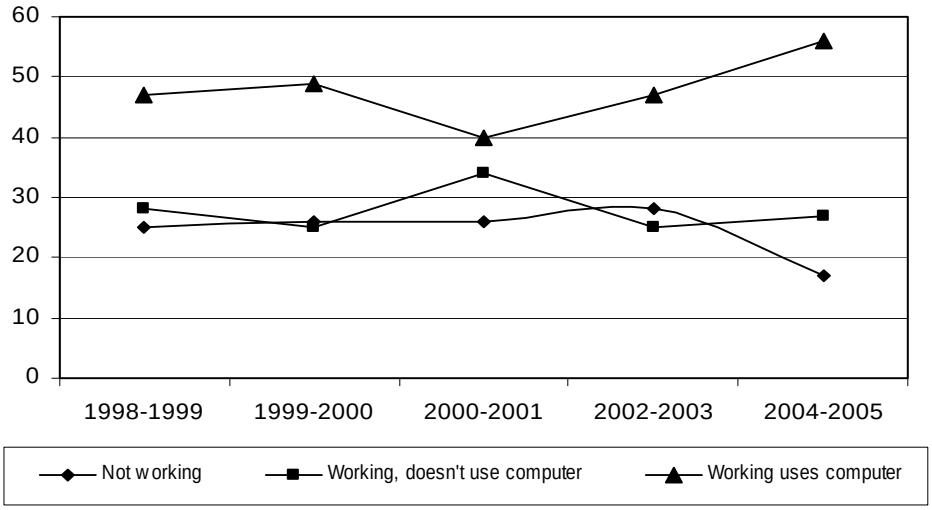
Computer-mediated literacy practices at work

At each time point in the LSAL study, people who were working or had worked since the previous interview were asked about computer use on the job. Cases were identified as work based computer users if there was a positive response to whether they entered information into the computer, read or wrote email, found information on the internet or received computer related training at work. Both basic literacy proficiency and fluency with computer technology are important to employability. Figure 2 shows employment status by computer use on the job at each time point. More workers than not use computers on the job throughout the seven year period, increasing to 56 percent by 2005. Employment not using computers was fairly consistent, between 25 and 24 percent. About a quarter of the population

did not work through the first five years of the study, but that figure dropped to 20 percent in 2005. Also by 2005 the proportion of jobs using computers jumped by 19 percent. Overall the trend is toward fewer jobs not using computers with an increase in jobs using computers corresponding to an increase in employment overall for this population of mostly low-skilled workers.

The LSAL findings confirm the important relationship between literacy proficiency and computer skills in the workplace. Literacy proficiency is highly correlated with employment using computer skills. The mean literacy proficiency score of workers using technology is between 14 and 20 points higher than workers not using technology. Figure 3 shows a clear division between skilled and unskilled labor as defined by literacy proficiency and technical skills in the LSAL population. Mean literacy proficiency scores for each group – people who work using computers, people who work but don't use computers at work and people – are shown at each time period. People not working and those who don't use computers at work have similar literacy proficiencies, the mean of which is statistically different from the proficiency of people

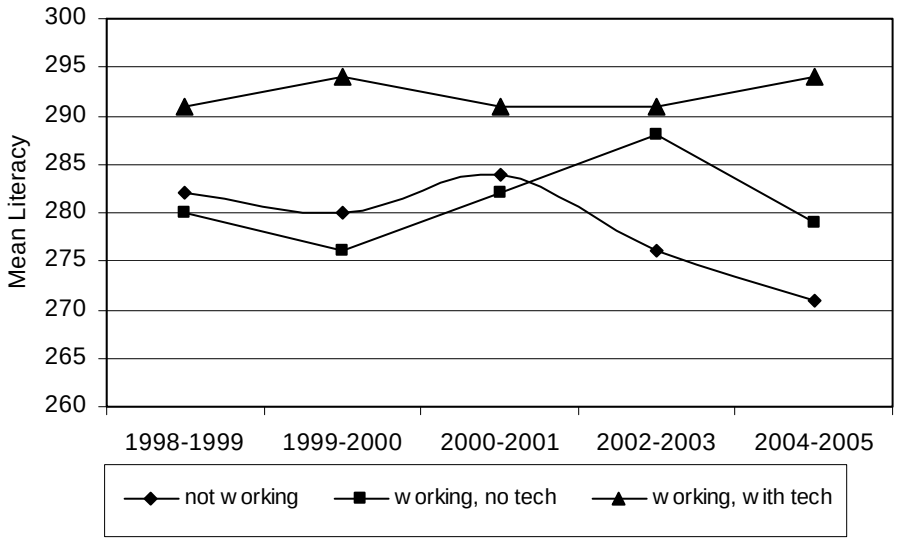
Figure 2: Labor status and computer use at work 1999-2005



	1998-1999	1999-2000	2000-2001	2002-2003
Uses a computer at work	47	49	40	47
Does not use computer at work	28	25	34	25
Not working	25	26	26	28

*December seasonally adjusted Oregon Employment Department figures www.ohmis.emp.state.or.us/laborforce
**n = 644 valid cross all waves

Figure 3: Mean literacy proficiency of workers using computers



	1998-1999	1999-2000	2000-2001	2002-2003	2004-2005
not working	282	280	284	276	271
working, no tech	280	276	282	288	279
working, with tech	291	294	291	291	294
F,df=2 (p)	3.84 (.02)	11.06 (.00)	2.48 (ns)	6.53 (.00)	14.56 (.00)

n= 630 cases valid across all waves.

using computers at work.

With the exception of the anomaly in 2003, when fewer people were employed using computers, employment is divided by literacy proficiency and computer use. People with lower literacy proficiency are more likely to not be working after 2001 when regional unemployment rates increased. People with intermediate literacy who were not working got jobs that don't use computers . These findings are consistent with other research indicating that literacy proficiency at an approximate score of 275 is necessary to understand most workplace training materials and for success in the labor market (Tamassia, Lennon, Yamamoto & Kirsch, 2007; Mikulecky & Kirkley, 1998). This population is cognizant of the importance of computer skills for their future employability. Only eleven percent said computer skills were not needed for the type of work they do. Of the remainder, half felt that their computer skills limit their job opportunities while the other half felt they have the skills they need.

Computer-mediated literacy practices at home

Like basic literacy, computer-mediated literacy practices bridge the life contexts of home, work and school. As shown above in the discussion of physical access, about a third of the LSAL population has computer access at both home and work. Using a computer in both places indicates that technology is more integrated into one's life than if it is isolated to a specific context.

Preliminary analysis showed that having a child in the home is not a significant predictor of owning or using a computer. However, computer use and ownership, especially in multiple locations, does correspond with engaging in computer-mediated literacy practices with children. Table 14 shows the percent of parents by type of computer access who computes with their child. Sixty percent of parents with a computer in the home use it with their children. But 82 percent of parents who use technology at their jobs in addition to home engage in computer practices with their children.[13] While having a computer in the home definitely facilitates computing with their child, some parents find other locations such as libraries to engage these practices with their children.

Like reading to children, computer-mediated practices are tools to help them succeed in school. Today schools rely on teacher contact with parents by email and school web sites. Fairlie's (2003) analysis of the 2001 Current Population Survey data shows that access to a home computer and active parental computing practices positively influences children's retention in school. Knowledge of the cyber-world is also important for parents to protect their children's experiences there. However, being a computer user does not significantly correlate with whether or not parents read to children or help them with their homework.

Computer-mediated literacy practices situated at school, home, and work are very important for this population. In a culture permeated by technology, being computer literate is part of an identity of social belonging. Young people who learned technology before

Table 12: Percent within type of group with computer access who compute with their child	
No computer at home or work	25
No computer at home	29
Computer at work only	43
Computer in house only	63
Computer at home and work	82

leaving school have the advantage of being an insider to this culture. Older people have the advantage of transferable experiential knowledge, ability to teach themselves, and the motivation of employment demands to support their learning. The culture of computer literacy embraces the learning styles most comfortable for this population – learning by trial and error and with help from friends and family. Contextualized practices provide the "so what" of computer literacy.

Discussion

So, is the digital divide closing for adults with low education attainment? This paper demonstrates the multiple dimensions along which a digital divide might be considered. Given that access to and use of technology are aspects of structural inequality in the United States (and the world), a close look at the computer mediated practices of the sub-population of adults with low-education attainment offers insight into barriers and advances being made at the edges of the divide. I propose a model of computer-mediated literacy practices that links both technical skills and literacy proficiency with physical access and domains of practice as a frame for this examination (see Table 1).

In the broadest sense of increasing access to and use of technology across this population, the answer is yes -- the digital divide is closing. Ownership of computers is increasing as well as computer use at work, coupled with less reliance on public access to technology. However, reports claiming that the digital divide is closed over-simplify the situation. For the majority of adults in the LSAL population, access and use has increased consistently between 1999 and 2005. However, these trajectories appear to fluctuate with the economy. Internet use especially drops when people have less discretionary income to pay for services and less time to use them.

The relationship between literacy proficiency and technological fluency has been theorized on many levels. Higher literacy proficiency gives one access to higher paying jobs that usually demand more technical skills and offer more opportunities for skill development. Literacy proficiency also indirectly supports ownership of technology through higher skilled and better paying jobs, increasing access at both home and work. However, people with higher literacy proficiency are earlier adopters of technology over and above the indirect effect of literacy on occupation and income. People with better literacy skills are more likely to engage in diverse

computer-mediated literacy practices and have a deeper understanding of what they are doing.

Literacy proficiency is an important component of fluency with technology. Even accounting for duration and intensity of computer experience, literacy proficiency explains most of the variance in functional computer knowledge. Literacy proficiency facilitates understanding of the conceptual background of technology and makes more learning and trouble-shooting resources available through technical manuals and help tools. More data on the experiences of late adopters and more interpretive studies of how people with low literacy proficiency actually perform technology skills are needed. Questions about how sophisticated and sustained computer practices are over time and whether computer practices improve basic literacy in this population need to be investigated.

Technology increasingly compensates for low literacy. Simple literacy tasks such as correct spelling needed for search engines and passwords are being mediated by artificial intelligence and fuzzy logic algorithms in recent software releases. Text readers and graphic user interfaces make computer use more accessible to people with low basic literacy skills as they learn to read the "world" of computer-mediated practices. It is important to realize the diversity of ability within the population of adults with low education attainment. Some in the LSAL population are computer programmers and web developers; successful authors of content as well as consumers.

Contexts for practices

Work, school, and home are some of the contexts in which people engage in computer-mediated literacy practices. One way policy can influence the digital divide is to facilitate ownership of technology and equitable connectivity in people's homes. Home computing is a paradox of the private/public domains. As a private context for computing, the home can be personalized to the interests, needs and abilities of individuals and offer un-stigmatized avenues for learning. Home computing also opens a world of engagement in virtual community, civic and social participation and consumerism. Conversely, home computing does not provide a social environment for learning to compute. Most people have addressed this need through informal learning, drawing on their existing communities of friends and family to introduce them to the virtual community.

Parenting is an important adult role for which the demand for fluency in information technology is increasing. LSAL findings show that using a computer at work increases the likelihood of using the home computer with one's children. Encouraging adults in this population to become computer users is one possible intervention to reduce the next generation of school leavers, as shown by Fairley (2003). Beyond that, computer use at home and work is correlated with family literacy practices, Computer-mediated literacy practices may also be an important component in the inter-generational transmission of literacy proficiency.

There is room for improvement in making adult education programs gateways for entering the world of technology. There is no evidence in the LSAL comparison of program participants with non-participants that adult basic education programs facilitate fluency in technology. Many programs available to the LSAL population have computer labs available to students and adult education programs integrate technology into vocational education and situated skill development.

However, the lack of evidence for these practices in the LSAL data suggests that, as in elementary and secondary education, the integration of technology into adult education may face other contextual challenges (Cuban, 2001). The teaching and learning challenges of gaps in fluency with information technology pose opportunities for creative implementation of a "community of practice" design within programs. Integrating technology into adult learning involves development of content, research into best practices, policy alignment, and infrastructure investment in addition to educator development (Askov, et. al., 2003).

When reaching out for literacy development opportunities adults with literacy challenges need flexibility in time and place for study, anonymity, absence of judgment, and patience, all of which are potentially addressed through information technology (Osei, 2001; Norris & Conceicao, 2004). The propensity of the LSAL population to study on their own to improve basic skills (Reder, 2003) combined with the high rate of computer use suggest possibilities for innovative new practices using technology for literacy development. The Learner Web (www.learnerweb.org), currently being developed as a result of this research, is an example.

The changing importance of technology skills in the work place is well known. The globalization of the labor market, faster pace of job changes,

demands for more flexibility across work functions, and tooling up for new applications all increase the stakes for both literacy proficiency and technical fluency. The data show a clear demarcation between workplace computer uses by literacy proficiency even with nearly universal general computer use by the population. While earnings and employment have been shown to increase several years after receipt of the GED (Tyler, 2003), engagement with technology may show more immediate benefit and a stepping stone to later employability (Technology Opportunities Programs, 2005).

Findings from the Longitudinal Study of Adult Learning on technology use, situated in the Pacific Northwest, may not be broadly generalized to other parts of the country. Although technology and online market penetration has reached comparable levels in other parts of the country since 2003, average literacy proficiencies and labor market conditions set different environments for the narrowing of the digital divide. While substantial evidence points to the closing of the digital divide, we cannot assume that structural inequities will also close or that the trajectory is positive and linear. The bottom line is that most people in the LSAL population are not allowing themselves to be left behind.

Developments in technology demand new literacy skills among which are fluency with computer functions, the cognitive ability to process information and communicate in non-linear and a-synchronistic ways, to evaluate quantities of information presented simultaneously, and to author text in electronic media.

These new skills drive new technical potentialities, which in turn, stimulate new literacies. Lifelong literacy learning is the social norm in an era when emergent technology continuously transforms the text.

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[1] The National Assessment of Adult Literacy (NAAL) (Kutner, Greenberg, Jin, Boyle, Hsu, Dunleavy, 2007) conducted in the US in 2003 and the International Adult Literacy and Lifeskills Survey (ALL), also conducted in 2003, include both tests of adult literacy and computer use items in the background questionnaires. These are cross sectional, not longitudinal, studies.

[2] The LSAL uses the document measure from the Test of Applied Literacy Skills as a standardized test of literacy proficiency that can be compared to other national and international studies (Kunter, et. al., 2007). Literacy proficiency is generally reported on a scale of 0 to 500 or in five skill levels that correspond to tasks ranked by complexity. Analysis of the relationship between literacy proficiency and computer-mediate practices in this paper uses the continuous score derived from the Document standardized test.

[3] This means that the age distribution is skewed toward younger people because older people would have had a longer period of time in which to get a GED, therefore being excluded from the sample. The sample is not representative of the ESOL population as only proficient non-native speakers of English were included.

[4] Analysis of the retain sample compared to the original sample shows no attrition bias; the retained sample still accurately generalizes to the LSAL population. Analyses involving change over time are conducted on the 76% of the original sample for which there is data at every time point. There is evidence of some attrition bias toward computer users among this sub-sample

[5] Oregon Employment Department Labor Force www.ohmis.emp.state.or.us/laborforce

[6] While literacy proficiency was measured at each wave using the Test of Applied Literacy Skills, there is not enough change over time to influence these models, so this score is held constant at the baseline measure. This covariate is standardized in the model to aid interpretation.

[7] Ethnic groups are broken into four categories due to small group sizes. White English speaking is the reference categories (63.5%, n=596). African American (9%, n=85), non-native speakers of English (9.5%, n=89) Latino (11%, n=103) and native English speakers of other race/ethnicity (7%, n= 66) . More detailed group reports are shown in the bivariate comparisons.

[8] A standardized score is used in these multivariate models to aid interpretation.

[9] I also tested the probability of owning a computer as computer ownership is highly predictive of computer use. However, the base model has little predictive power (NR2 = .05) and only gender (male) and white, native speaker of English (compared to non-native speakers) were significant.

[10] That demographic group includes older adults, excluded from the LSAL study, who would be less likely to be computer users.

[11] This interpretation is made cautiously because of small cell sizes and a slight attrition bias against non-users.

[12] Literacy groups are assigned by literacy proficiency score in categories consistent with NAAL. A score under 205 is Below Basic, 205 to 249 is “Basic”, between 250 and 334 is “intermediate”, and over 334 is “proficient” (Kutner, et.al., 2007).

[13] This might also be explained by the higher average literacy proficiency of people who use computers at work.