Research Article

Correlation Between Limited Education and Transfer of Learning

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Abstract

One of the greatest challenges in designing applications for developing communities is that potential users may have little or no education. We investigate how limited education correlates with cognitive skills for conceptual abstraction, as required for transfer of learning in video-based skills training. Through a controlled experiment we compared 56 participants from low-income communities in India, split into two groups of 28, based on scores of a textual literacy assessment tool. Group A included participants who passed the test cut-off condition; Group B included those who did not. Participants were then rated for their ability to generalize video instructions on how to use a vacuum cleaner to similar, but not necessarily identical, tasks. Results confirmed that: 1) Both groups faced challenges when a skill required generalization from instructional material; 2) Group A performed better than Group B all-around on this learning task; 3) Diversification of examples within instructions helped Group A participants in transfer of learning, but not Group B participants. We conclude with design recommendations for instructional videos for populations with limited education.

1. Introduction

One of the greatest challenges faced in developing computer and mobile phone applications in the field of information and communication technology for development (ICTD) is that potential users may have little or no education and lack basic capabilities, such as the ability to read. Conservative estimates suggest, for example, that more than 800 million people in the world are completely non-literate (UN News Centre, 2011), and that more are able to read only with great difficulty and effort.

A recent body of work focuses on designing user interfaces (UIs) for low-literate populations (Chipchase, 2005; Grisedale, Graves, & Grünsteidl, 1997; Huenerfauth, 2002; Medhi, Nagasena, & Toyama, 2009; Medhi, Sagar, & Toyama, 2007; Sherwani et al., 2007). Researchers have identified various usability challenges in interacting with traditional text-based UIs. To counter these problems, non-textual UIs that use voice, graphics, and video have been proposed.

Most of the current work in this area, however, focuses explicitly on users' inability to read, with little recognition given to other cognitive challenges (Medhi, Cutrell, & Toyama, 2010). Anecdotal evidence from our past work suggests, however, that the inability to read is only one of

1. *Note from the Managing Editor: As an editor for* Information Technologies & International Development*, Kentaro Toyama has recused himself from editorial duties related to this article.*

many challenges faced by people counted as non-literate. Cognitive science studies confirm this, showing that people with limited education in *developed* countries differ from people with good educations in their performance of a variety of cognitive skills (see section 2.2). Furthermore, researchers have identified a variety of cognitive skills whose underdevelopment poses barriers for realizing useful interaction on ICT applications (Eshet-Alkalai, 2004; Van Linden & Cremers, 2008). In addition to language processing skills, facility with 2D imagery becomes important as UIs become increasingly graphical in nature. Hypermedia environments provide an array of non-linear navigational paradigms through multiple sources of information, and the effective use of these environments requires mental spatial orientation skills (Eshet-Alkalai, 2004). Also relevant to realizing useful interaction with ICTs are attention-related skills, such as multitasking, vigilance (the ability to maintain attention), and alertness over prolonged periods of time (ibid.).

Meanwhile, in ICT, how-to videos are an increasingly popular medium for teaching people a wide range of skills and tasks. Websites such as howcast.com, e-how.com, and youtube.com contain troves of instructions for cooking, repairing, building, working with software, and all manner of other things. In the domain of development, Digital Green (Gandhi, Veeraraghavan, Toyama, & Ramprasad, 2009) has been successful in using video to teach agricultural techniques to farmers in rural India. There are other examples of videos being used in development for teaching microfinance (Video, n.d.), agro-marketing (ibid.) and watershed management (Samaj, n.d.). Indeed, video instruction seems particularly well suited for imparting information to populations with limited education (e.g., see Medhi & Toyama [2007] on full-context video for computer UIs).

However, even though video-based instruction is not dependent on reading, other cognitive skills may be required to comprehend the instructions demonstrated in the video, and to then transfer that learning to actual implementation in similar real-world tasks. For instance, the ability to abstract lessons from a specific case to the general case is important; it would enable one to both identify common attributes between video demonstrations and real-world tasks, and adapt to attributes that are different.

In this paper, we investigate how limited education correlates with cognitive skills for conceptual abstraction required in transfer of learning, in the context of instructional material delivered via video. We performed a controlled experiment that compared 56 participants from low-income communities in India, split into two groups of 28 based on a test of textual literacy that was used as a proxy for assessing overall educational level. Group A included participants who passed the cut-off condition on the literacy test, while Group B included those who did not.

Participants were then rated for their ability to generalize video instructions on how to use a vacuum cleaner to similar, but not necessarily identical tasks. Results confirm the following findings: 1) Both of the groups perform worse when a skill requires generalization from instructional material, compared with the case when instructional material is specifically and exactly tailored to the skill; 2) Group A participants do better than Group B participants all-around on this learning task; and 3) diversification of examples within instructions helps Group A participants in transfer of learning, but it does *not* measurably help Group B participants.

These findings are new evidence that, when designing content for users with limited education, there needs to be sensitivity to cognitive differences beyond the inability to read—for example, to the capacity to transfer learning among intended users.

2. Related Work

2.1 UI Design for Low-Literate Users

Most previous work in UIs for users with little or no education has focused exclusively on the inability to read, by mainly examining the mechanics of interfaces on PCs, PDAs, and mobile phones that currently use or require text. These studies typically use years of formal schooling as a proxy for education level and categorize people with limited education as "low-literate users." Researchers have both recognized the value of imagery and advocated extensive use of graphics (Grisedale, Graves, & Grünsteidl, 1997; Huenerfauth, 2002; Medhi, Sagar, & Toyama, 2007; Parikh, Ghosh, & Chavan, 2003a, 2003b) to help overcome the inability to read text. More specifically, it appears that static, hand-drawn representations are better understood than photographs or icons (Medhi, Prasad, & Toyama, 2007). Some authors note that the use of numbers is acceptable,

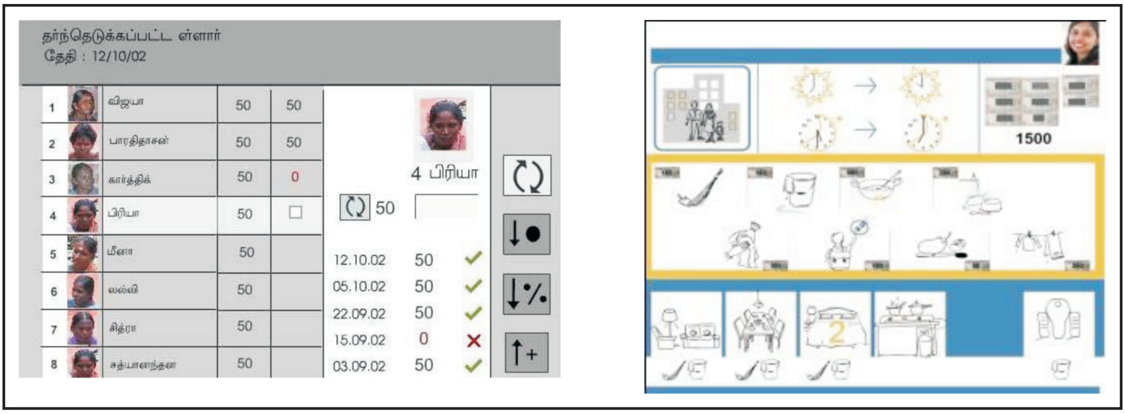

Figure 1. Examples of some UIs designed for users with little or no education (Medhi, Sagar, & Toyama, 2007; Parikh, Ghosh, & Chavan, 2003a).

as many people with limited education can read numerical digits (Parikh, Ghosh, & Chavan, 2003a, 2003b). Other work has focused on ultra-simple navigation as a design goal (Grisedale, Graves, & Grünsteidl, 1997), or on removing anxieties about technology use. For example, looping video clips that include dramatizations of the overall usage scenario have been found to be effective in reducing barriers to usage by first-time users (Medhi & Toyama, 2007).

Apart from work that focuses on PCs and PDAs, there is some research that looks at mobile UIs, also for low-literate users. Researchers have recognized the value of voice feedback (Medhi, Sagar, & Toyama, 2007; Parikh, Ghosh, & Chavan, 2003a; Plauche & Prabaker, 2006) and speech interfaces (Boyera, 2007; Plauche & Prabaker, 2006; Sherwani et al., 2007). Others have questioned the suitability of menu-based navigation for novice users (Jones, Buchanan, Thimbleby, & Marsden, 2000), and have discussed designs that advocate fewer menus and dedicated buttons for this target group (Kurvers, 2007). However, none of this work looks beyond addressing the inability to read (e.g., by removing or reducing text) to consider other problems that a user with limited education may face when interacting with ICT applications.

There are two studies that look beyond the mechanics of the UI and examine coping mechanisms employed by users with limited education when they are confronted with traditional mobile interfaces (Chipchase, 2005, 2006). However, even these studies do not look into designing UIs with the explicit goal of accounting for the cognitive challenges.

Work that takes into consideration cognitive skills other than literacy remains shallow, with little of it addressing specific skills. One study shows that such users have "less developed cognitive structures and linguistic sequential memory" when compared to educated users, and calls for attention to these "unorganized" structures when doing instructional design for rural e-learning applications (Katre, 2006). This study, however, is a small-sample qualitative analysis that does not specifically investigate cognitive skills for abstraction. Another study investigates the proficiency levels of users with limited education on a number of cognitive skills important for the successful interaction with ICT—language processing skills, visual organizational and visual memory skills, mental spatial orientation, speed of cognitive processing, vigilance, divided attention, and perceived self-efficacy. And these findings serve as guidelines for the design of UIs for a bank ATM (Van Linden & Cremers, 2008).

2.2 Limited Education and Cognitive Science

There have been studies in the cognitive sciences that support the hypothesis that education is correlated with general cognitive skill development. In the studies mentioned subsequently, years of formal schooling or reading-writing ability at the time of tests have been used as proxies for the overall education levels of study participants.

A study on the influence of formal schooling on intelligence and its cognitive components suggests that the level of formal schooling correlates with performance on IQ tests, reflecting an influence of schooling on the cognitive processes supporting task performance on these tests (Ceci, 1991). The study implies that this influence can be interpreted in two ways: 1) Students acquire general knowledge and processing strategies important for task performance, and 2) formal schooling provides students with attitudes, values, and motivation that are important in testing situations (Van Linden & Cremers, 2008). It has also been suggested that educated people acquire skills to organize and process information in less idiosyncratic and more efficient ways compared with people who have little or no education (Luria, 1974; Manly, Touradji, Tang, & Stern, 2003). Thus, in addition to the skills of reading and writing, educated people seem to acquire cognitive skills and strategies for efficient processing of information (Van Linden & Cremers, 2008). Among other things, this implies that education can influence the outcomes of specific psychological and neuropsychological tests. Consistent with this suggestion, several behavioral studies have demonstrated through empirical research that education level influences various cognitive skills—visuospatial and visual organization (Ardila, Rosselli, & Rosas, 1989; Matute, Leal, Zarabozo, Robles, & Cedillo, 2000; Reis, Petersson, Castro-Caldas, & Ingvar, 2001), language tasks (Abadzi, 2003; Castro-Caldas, 2004; Kurvers, 2002; Morais, Cary, Alegria, & Bertelson, 1979; Reis & Castro-Caldas, 1997), and self-efficacy (Bandura, 2005; Czaja et al., 2006). There are a number of relevant observations involving visuospatial skills. Participants with limited education performed significantly worse on immediate naming of two-dimensional representations of common, everyday objects compared to well-educated participants, both in terms of accuracy and reaction times (Reis, Petersson, Castro-Caldas, & Ingvar, 2001). Abstract icons have been known to be less recognized by participants with limited education—they possibly have difficulty integrating details of 2D line drawings into meaningful wholes (Castro-Caldas, 2004).

Most of the above work is undertaken in developed regions—North America and Western Europe—and therefore, it is subject to caveats of cultural bias that may differ in other geographies. Nevertheless, the strength of the evidence suggests that formal education can shape cognitive skills beyond the mere ability to read and write. If anything, in environments where standards of education are even poorer, we might expect differences in cognitive skills arising from educational quality to be even more pronounced.

3. Motivation from Previous Work

Recent research in ICTD has suggested that a host of issues beyond low literacy mediate how users with limited education interact with ICT applications: availability of collaborative user experiences, social etiquette acceptable in a specific cultural context, experience and exposure to technology in general, intimidation caused by technology, mediation available through proximate users, motivation to use a given application, pricing of a service, power relations within a social group, a user's social standing, and others (Medhi, Cutrell, & Toyama, 2010).

In addition to these, a significant issue mediating how users interact with ICTs is a broad range of cognitive difficulties in skills associated with UI interaction. Our experience working with users of limited education anecdotally suggests potential challenges with abstract thinking in two ways: hierarchical and conceptual. Each of these is discussed below, based both on existing literature and our informal, incidental interactions with approximately 450 people, over six years and across rural and urban low-income communities in India, the Philippines, and South Africa, many of whom participated in literacy-related studies that we had conducted for other purposes.

3.1 Hierarchical Abstraction

We saw repeatedly that users with little or no education seemed quicker to understand a linear navigation structure than a branched, hierarchical structure. While users understood the former by analogy to the pages of a book (strangely enough, for a group not used to reading), they had trouble understanding how the navigation model in hierarchical structures narrowed from general to specific, from a home page to main sections to subsections.

In other work, hierarchical classification tree structures have been called a culture-specific visual form that codifies the representational resources available to the Western tradition, and can operate to exclude people on both graphical and ideological levels (Kress & Van Leeuwen, 1996). One study looked at the extent to which novice users in Africa were able to reproduce classificational taxonomies or tree structures; it found that there are clear cultural dimensions to the interpretation of these structures (Walton, Vukovic, & Marsden, 2002).

3.2 Conceptual Abstraction

During interviews, we also discovered that limited-education participants tended to tell long stories to convey relevant information. The stories were concrete in nature, containing information about specific objects or actual instances of events. To convey a general idea, interview participants would tell many stories that were instances of the idea. They rarely discussed general points in the abstract. One explanation for this behavior is that people with limited education have challenges with abstracting concepts—that is, pulling out inferred traits from a series of events as a common or general characteristic.

One study reports that participants with limited education had difficulty with articulate self-analysis, normally deferring to the community for an evaluation of their own characters (Bhogal, 1996). The study claims that this is because the ability to think abstractly (i.e., non-situationally) is what allows introspection and self-analysis.

In other studies, people with limited education have been shown to learn poorly from neutral, stand-alone objects (such as a book or an automated system) that contain a set of instructions to be applied across situations (Ong, 2002; Sherwani, Ali, Rose, & Rosenfeld, 2009). Rather, they tend to learn better in situ, embedded in concrete situations and practical experience.

The ability to conduct abstraction seems to be an important cognitive skill for achieving meaningful ICT usage, ranging from successful interactions with software UIs to learning from video-based instructional content. For content such as video-based instruction, abstraction skills may be required to comprehend the instructions in the video, as well as to translate that information to learning for actual practice. Traditional computing software is structured in information architectures (IAs) designed to enable navigation of enormous information systems by concentrating on a few issues at a time. Given that IAs in computing rely heavily on abstractions, related skills appear likely to be critical for the successful manipulation of many software systems.

4. The Study

Our specific interest was in investigating how limited education correlates with performance of a task, the completion of which required a kind of conceptual abstraction in the context of instructional material delivered via video. We examined this relation by conducting an experiment to answer the following questions:

- Is there a difference in conceptual abstraction required for transfer of learning between users with little or no education and those with some basic education?
- Do users with little or no education benefit from generalized examples as a way to learn abstract concepts?

Two things are worth noting: First, we highlight that the goal of our study was to examine whether there is a correlation between limited education and the ability to conduct conceptual abstraction on a transfer of learning task. Our study design does not allow us to deduce causal relations between these factors. In fact, though we specifically hypothesize that education leads to a third factor that is the cause of differences in users' abilities to transfer learning, our study is unable to prove this, and can merely provide converging evidence.

Second, we recognize that portions of our hypothesis will be controversial to some readers: We follow an extensive cognitive science literature that demonstrates that limited education stunts aspects of cognitive development (see section 2.2). While we understand alternative interpretations, such as that people with different degrees of formal education are merely "differently abled," in the context of ICT use and ICT-based learning, it is nevertheless the case that different abilities lead to disparities in users' abilities to take advantage of these tools.[2] Our position is not meant to indicate a fundamental deficiency in the potential of any given group, as much as to highlight the differences in abilities that result from differences in environmental factors, such as education. Indeed, to deny the effect of education on cognitive ability is to deny much of the value of a formal education.

2. It might also be that those without formal educations have other advantages that our study does not go into.

4.1 Working Definition of Abstraction

For the purposes of our study, we define *abstraction* as the ability to reflect on attributes and relationships separate from the specific items that display those attributes or share those relationships. Further, we focus on a narrow aspect of broader notions of conceptual abstraction, namely, the ability to *transfer learning* from specific examples of a task demonstrated in instructional video to actual implementation in circumstances similar (in attribute or relationship), but not necessarily identical, to the scenario shown in the video.

According to the transfer of learning theory (Haskell, 2001), transfer can happen in six ways, two of which are relevant in such situations: "near transfer," which refers to transfer of learning when the task or context change slightly, but still remain largely similar; and "far transfer," which refers to the application of learning experiences to related, but largely dissimilar, problems. Our experiment is done in the context of a "near transfer" learning task.

5. Methodology

5.1 Working Definition of Limited Education

Many studies in UI design and cognitive science that deal with people having limited education use years of formal schooling as a proxy for measuring the overall education level of a test participant. However, the education level of an individual may not necessarily be correlated with the quantity of education that person has received, as measured in terms of number of years of schooling. In our study, we observed that 17 (out of 56 participants) who reported having attained formal schooling (between grades 3–8) could not read or write *at all* during the time of the experiment.

The overall education status of an individual depends on a number of factors, including school the individual attended, quality of teaching, role of parents and home environment, amount of effort invested, school attendance, nutrition conditions, genetics, etc. However, the complex interaction among these traits is not fully understood, and in any case, measuring all of them accurately is impractical. Thus, we use degree of textual literacy—the ability to read and write at the time of the study—as a proxy for the overall quality of education of our subjects. This is consistent with some cognitive science studies that use the textual literacy of individuals at the time of experiments as the proxy for education level (see, for example, Manly, 2003; Reis & Castro-Caldas, 1997; Van Linden & Cremers, 2008).

A review of existing worldwide assessment tools (Western [ALSA, n.d.; CASAS, n.d.; FAN, n.d.; NALD, n.d.; NAAL , n.d.; TABE, n.d.] and Indian [NLM, n.d.; NSSO, n.d] adult literacy) did not reveal a suitable instrument to do this. As such, we devised our own in consultation with an education researcher working in the area of primary education. The sections of the textual literacy assessment tool were designed based on literature review. The tool consisted of three sections:

1. Reading—single words, simple full sentences, 3–4 sentence paragraphs (all in the local language);
2. Writing—single words, simple full sentences, correcting mistakes in paragraphs supplied (all in the local language); and
3. Numeracy—reading up to 3-digit Indo-Arabic numerals.

We did not assign numeric scores, but there was a pre-determined cut-off condition for passing the test. In other words, the participants did not receive any numeric scores, but they were categorized based on their performance with respect to the cut-off condition.

- Reading cut-off: ability to read single words and simple sentences (maintained at functional reading required for real-world print, e.g., road signs, bus schedules, etc.)
- Writing cut-off: ability to write single words (maintained at functional writing for basic form-filling activities)
- Numeracy cut-off: reading up to three-digit numbers written in Indo-Arabic numerals (maintained at functional numeracy for reading real-world print, e.g., bus numbers, price tags, etc.)

All participants were able to read up to three-digit numbers written in Indo-Arabic numerals. But the tool yielded two distinct groups in terms of the reading and writing sections; participants all either passed both the reading and writing tests, or failed both. We did not observe any borderline cases along the cut-off conditions for reading and writing. Participants who passed the test were categorized as Group A, while those who did not were categorized as Group B.

5.2 Task

We chose a vacuum-cleaning task for two reasons. First, participants recruited from our partner organization were interested in learning to use vacuum cleaners to enhance their skillset for domestic labor. Thus, vacuum cleaning was relevant and motivating for our participants. Second, vacuum cleaners are available in different models, with minor variations for each function. This was appropriate for testing *abstraction* as it would enable the transfer of learning from a specific vacuum cleaner to another model with analogous, but differing features. Any other task that met the two above criteria could have been chosen, as well.

Specific tasks included the following: unwind power cord, plug into power, turn on vacuum cleaner, replace attachments, switch off, unplug, wind cord, and empty dust receptacle.

5.3 Experimental Design and General Procedure

Participants in all conditions were first shown two instructional videos demonstrating the use of a vacuum cleaner back-to-back, including all the basic functions that participants would later be tested on. In some cases, the two videos were the same, and in others, they were different (*Specific* and *Diversified,* respectively). After viewing the instructional videos, all participants were tested on each of the tasks with two different vacuum cleaner models (*Familiar* and *Unfamiliar*) to test how much they had learned from the videos. This yielded a 2 (Education Level) x 2 (Instructional Video) x 2 (Device Familiarity) mixed design.

5.4 Participants

The participants for the experiments were drawn from five urban slum communities in Bangalore, India. They were recruited through an organization that is a facilitating body between clients (contractors, end clients, construction firms, home owners, builders, etc.) and informal sector workers in such domains as construction, domestic labor, etc. The construction workers were mostly male, and the domestic workers were mostly female. Because of the relevance of the task to their work, and as a way to control for differences in performance due to gender, only female participants were recruited in this experiment. Moreover, education levels are typically much lower for women in India (Velkoff, 2008), which makes them a particularly good population to study for this work.

Most of the women in these slum communities work as domestic helpers and have less than 12th-grade schooling. Household income is between US$30–100 per month. The male members of the house are usually daily wage laborers—plumbers, carpenters, construction workers, mechanics, bar benders, or fruit and vegetable vendors. Their primary language of communication is Kannada. Apart from this, a few people also spoke Tamil, Telugu, and Hindi. Nearly all the households in these communities had television sets, and over half of them had some video playback device (typically VCDs). Compared to men, relatively fewer women owned mobile phones. None of them had any previous experience using computers.

We worked with a total of 74 female participants, divided into groups representing each of the four between-subjects conditions (Education Level x Instructional Video). Because there were uneven numbers of participants in each cell, we randomly selected 14 participants from each condition to keep our experimental design balanced. This left us with a total of 56 participants: 28 in education Group A, and 28 in Group B (as per our literacy assessment tool). In each Group (A and B), 14 of the 28 participants watched the *Specific* instructional video, while the other 14 watched the *Diversified* video.

All participants were between the ages of 18 and 55 years (Group A median age 28 years, mean age 30 years; Group B median age 30 years, mean age 32 years). The average household income per month of Group A was US$78, while the average for Group B was US$63. Out of the 28 participants in Group A, all 28 spoke Kannada, 21 spoke Tamil, 10 spoke Hindi, and five understood very basic English. Out of the 28 participants in Group B, all 28 spoke Kannada, 22 spoke Tamil, 11 spoke Hindi, and one person understood very basic English.[3]

None of our participants had previous experience using vacuum cleaners, nor had they seen vacuum

3. These language skills were self-reported by participants; we did not conduct formal language tests.

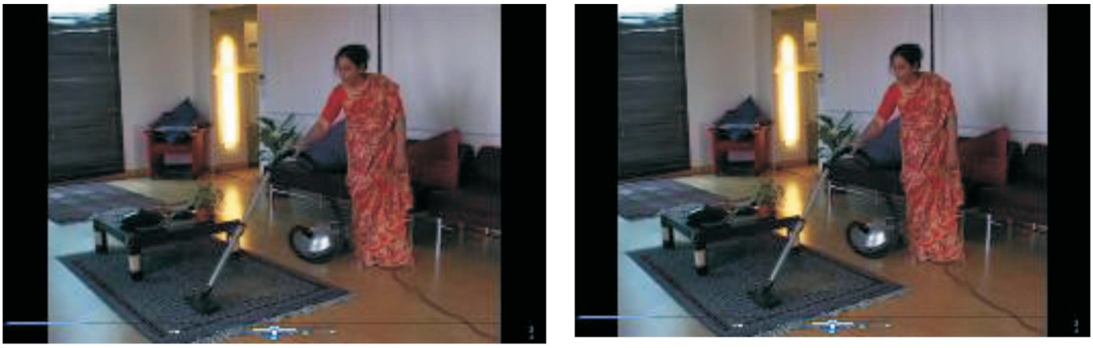

Figure 2a. Figure 2b.

Figure 2. (a) Specific *video showing use of vacuum cleaner Model 1 in first half; (b)* Specific *video showing repeat use of vacuum cleaner Model 1 in second half.*

cleaners being used. For each type of instructional video (*Specific* and *Diversified*), there were 28 participants, randomized for formal schooling levels (*Specific* video formal schooling mean = 4.4, median = 4.0; *Diversified* video formal schooling mean = 4.9, median = 5.0) and for age (*Specific* video age mean = 29, median = 28; *Diversified* video age mean = 32.7, median = 29.5). Each participant performed tasks on both vacuum cleaners (*Familiar* and *Unfamiliar*).

5.5 Instructional Videos

Participants in the experiment were randomly assigned to one of two types of instructional video, *specific* or *diversified.* Each video comprised a set of instructions (either identical or using a different appliance), so all participants were exposed to two instances of instructions prior to being tested.

5.5.1 Specific Video

This video showed the use of one vacuum cleaner (model 1) for all of the tasks mentioned in the "Task" subsection, followed by an identical repetition of the same video. The length for the use of each part was 00:03:34, and the total length of the video was 00:07:08. Figures 2a and 2b present screenshots of the video.

5.5.2 Diversified Video

This video showed the use of one vacuum cleaner (model 1) for all the tasks mentioned in the "Task" subsection (the same as the first video above), followed by the use of a different vacuum cleaner (model 2) for the same tasks. To maintain consistency with the *Specific* video, both halves of this video were 00:03:34, and the total length was 00:07:08. Figures 3a and 3b present screenshots of the video.

5.6 Device Familiarity

After viewing the videos, participants were tested on the various tasks using two different models of vacuum cleaner. Model 1 was the same appliance demonstrated in the video and was therefore *Familiar* to participants. In contrast, model 3 was a new device, different than either model 1 or model 2 used in the videos. Model 3 was used to test abstracted learning on an *Unfamiliar* device. All models were selected such that the basic functions (tasks) were the same for the purpose of a fair comparative experiment. However, the physical looks and the means to accomplish various functions were different. A description of each of the models is in Table 1. The order in which the different vacuum cleaners were tested was randomized to balance out learning effects across the two models: Half the participants were first tested on the *Familiar* device, and the other half were first tested on the *Unfamiliar* device.

5.7 Data Collection and Documentation

Basic demographic information was collected for every test participant—name, age, level of schooling (if any), occupation, languages spoken, etc.

The primary metric of success in testing was the amount and extent of assistance provided by the experimenter for each task; very little assistance is equated with more and better learning. Assistance was categorized by degree of intervention: simple encouragement, a spoken reminder, and finally, hands-on help provided by the experimenter. The

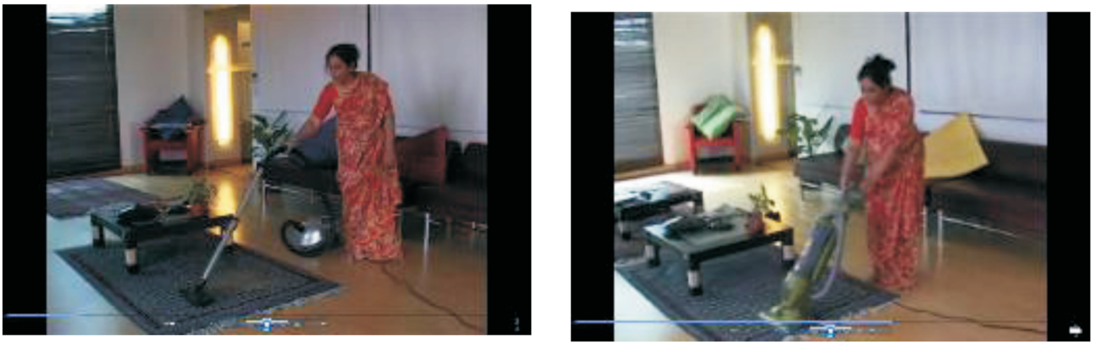

Figure 3a. Figure 3b.

Figure 3. (a) Diversified *video showing use of vacuum cleaner Model 1 in first half; (b)* Diversified *video showing use of vacuum cleaner Model 2 in second half.*

Table 1. Physical and Functional Differences in Vacuum Cleaner Models Used in Experiment.

Model	1 ***(Familiar)***	2	3 ***(Unfamiliar)***
Picture			
Type	Stick/Broom	Upright	Stick/Broom
Receptacle	Changeable bag	Canister	Canister
Cord	Retractable	Manually wound	Retractable
Attachment	In main body	Prefixed	Under main body
On/Off	Position 1	Position 2	Position 3

assistance provided was consistent across all participants, with words repeated verbatim for every participant to control for motivational differences.

In addition, all participants were video recorded by a videographer (different from the experimenter) as they performed each task and the experimenter made qualitative observations.

5.8 Hypotheses

Based on earlier observations of participants with limited education from previous and related work, we expected to see Group B participants (who did not pass the literacy test) perform significantly worse compared to Group A participants on all experimental tasks. Second, we expected to see that, of all combinations, *Specific* → *Unfamiliar* would be the most challenging, as completing that task requires participants to generalize learning from a specific example (videos of model 1 alone) to an unfamiliar test device (model 3). Furthermore, we expected that giving additional instructional examples (the *Diversified* video) would assist participants in abstracting functionality beyond the specific example devices. As a result, we expected that performance in *Diversified* → *Unfamiliar* would be better than it would in *Specific* → *Unfamiliar.*[4]

4. Despite the similarity in functions, model 1 (Familiar) was a relatively difficult model to operate compared with the unfamiliar model 3. Since this arrangement of models seems likely to work against the hypotheses (with less abstracted learning being required to operate model 3), if the hypotheses are borne out, we can be confident in the results. By

6. Results

6.1 Quantitative

For the overall analysis of performance on the vacuum cleaner tests, we performed a 2 (Education Level) x 2 (Instructional Video) x 2 (Familiarity of Device) mixed model ANOVA. Education level and video type were between-subjects factors and *Familiarity* was a within-subjects factor. The dependent measure of performance was the number of prompts by the experimenter that were required for participants to successfully complete the different tasks demonstrated in the instructional videos.

Figure 4 illustrates the mean number of prompts for each of the eight cells. Overall, there are three main findings of particular interest (statistics are reported below). First, Group A participants required less assistance than Group B participants across the board. Second, participants had the most difficulty when they needed to abstract learning to an unfamiliar device. And third, Group A participants appeared to benefit from diversified examples more than Group B participants did.

Confirming our first hypothesis, Group A participants required significantly less assistance than Group B participants did, $F(1,52) = 28.5$, $p<0.001$. In Figure 4, compare the left set of four bars to the right set. Across all conditions, Group A participants required less than half of the assistance required by Group B participants (average of 11.6 vs. 26.1 prompts); Group A participants seemed to be much better at translating what they saw in the videos into actual practice.

Similarly, there was a significant effect for *Familiarity,* $F(1,52) = 14.4$, $p<0.001$. Not surprisingly, when participants were tested on the device they had seen in the video, they required less assistance than when they needed to generalize the instructions to a new device (see the alternating dark and light bars in Figure 4). The main effect of *Video* was not significant.

While no interactions were significant, two were borderline, trending toward significance. First, there was a trend for *Education* x *Familiarity,* $F(1,52) = 3.24$, $p<0.078$. Figure 4 suggests that the effect of *Familiarity* was stronger for Group A than it was for Group B participants. For Group B participants, performance was about the same, whether the device they used was in the video or not.

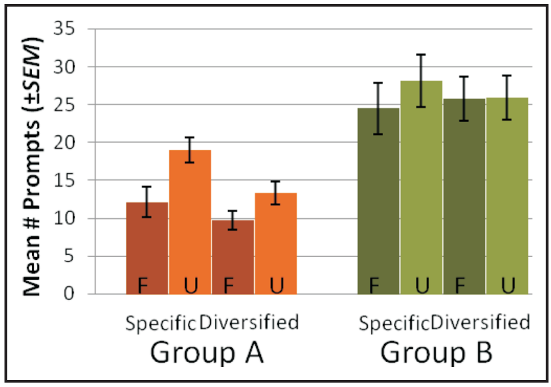

Figure 4. Assistance required by participants to complete all tasks. Familiar and unfamiliar devices are denoted as U and F.

Second, there was a strong trend for the interaction of *Video* x *Familiarity,* $F(1,52) = 3.38$, $p<0.072$. While this was not quite significant, it does lend some support to our second hypothesis: Giving additional instructional examples did seem to help participants perform better with the unfamiliar device. In Figure 4, comparing the first two bars to the second two bars in each group suggests a larger effect of *Familiarity* when participants saw *Specific* videos than *Diversified* videos, though this is much more obvious for Group A than it is for Group B participants.

In fact, Figure 4 suggests that our manipulations in abstractions had no statistically significant effect on the assistance required by our Group B participants (ranging between 24.5 and 28.0 average prompts); they appeared to have difficulty moving from the instructional video to physically reproducing what they had seen, irrespective of the amount of abstraction or generalization required. In contrast, the manipulations of *Instructional Video* and *Familiarity* influenced our Group A participants much more. These participants were good at directly matching what they saw on the screen to physical activity (*Familiar* devices for either video type), but,

assigning the relatively more difficult model as the familiar example and the easier model as the unfamiliar example, we were able to rigorously test for our expected result (the Specific → Unfamiliar combination as most challenging) without letting the complexity of the product itself impact results in a way that would have biased the experiment in favor of what we expected to observe.

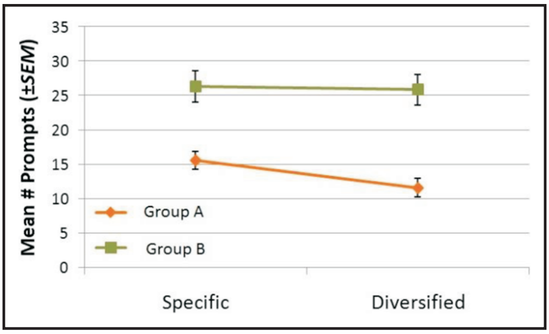

Figure 5. The help provided by diversified content is more effective for Group A than it is for Group B participants.

for both devices they used, they particularly benefited from the additional generalization provided by the *Diversified* video (see Figure 5). For both *Familiar* and *Unfamiliar* tests, the *Diversified* video appeared to reduce the amount of assistance needed by our Group A participants. As we might expect, this is largest for the *Unfamiliar* device ($M = 19.0$ and 13.4, respectively, for the *Specific* and *Diversified* videos, $t(14) = 2.56$, $p<0.017$).

Group B also registered a small improvement when using *Familiar* devices as well, but this was statistically non-significant.

Thus, our second hypothesis appears to be confirmed, at least for our Group A participants.

6.2 Qualitative

Throughout our formal subject study, we made a number of informal qualitative observations. We discuss them here, because they provide additional context and point toward future work.

Overall, we observed that for both Group A and Group B participants, within every task, people who were younger (<30 years old) were more attentive while watching the videos, displaying such behaviors as leaning toward the monitor, etc. They seemed more confident, and they went about doing the tasks briskly. Older participants (>45 years old) usually needed more encouragement for both getting started on the task and completing it. If they were unable to do a task the first time, they would look in the direction of the experimenter and pause, expecting prompting before trying the task another time. We suspect this might have happened for one of two reasons—first, this could be due to low confidence levels, especially on a piece of technology new to them. More interestingly, this may be related in some way to our older participants' having grown up in caste-entrenched times in India. Because of an implicit class hierarchy between them and the experimenter, our older participants might have feared that they would be taken to task if something happened to the vacuum cleaner—if they broke or spoiled it. It may be that they looked in the direction of the experimenter expecting reassurance that everything was, in fact, going okay.

There were a number of vacuum cleaning functions that we tested participants for. Some of these functions had fewer similarities between the examples in the videos and the test device. Overall, we expected to see functions with more similarities transferred relatively easily compared to functions with fewer similarities. During the experiment, we observed that both Group A and Group B participants seemed to require less assistance for accomplishing functions with more similarities (e.g., plugging the vacuum cleaner to the switchboard, turning on/off) compared to functions with fewer similarities (e.g., changing the bag in one vacuum, as opposed to cleaning the canister in another vacuum).

Overall, our participants seemed excited about watching videos on the PC to learn vacuum cleaning skills. During informal discussion with the participants after the formal study time, a number of participants were engaged enough to say that, if they watched such instructional videos a few more times, they would become "experts" in using vacuum cleaners. A few participants went on to say that, by learning this skill, they would get better-paying jobs, such as housekeeping jobs in companies.

Finally, one of the most encouraging kinds of comments came from several participants who asked if there could be instructional videos for them to learn other tasks, such as using a washing machine.

7. Discussion

The primary result of our study is concrete confirmation that limited education, as assessed by a test of textual literacy, correlates with transfer of learning in video-based skills training.

We suspect that overall quality of education leads to differences in the degree in which certain cognitive capacities are developed, and that some of those capacities directly affect how well a person can transfer learning to generalized tasks. But it remains unknown what specific cognitive capacity or capacities explain the difference in ability to transfer learning, and whether factors other than quality of education might also influence it.

These findings suggest that, when designing ICT-based learning material for users with limited education, there needs to be sensitivity to cognitive capacities beyond the inability to read, particularly to transfer of learning skills that require conceptual abstraction. We recommend that instructional video should demonstrate examples that are as close as possible to actual instances of the task for users with limited education, and that, for groups with some minimal basic education, video instructions should include variations of a task to allow better generalization to similar tasks.

8. Conclusion and Future Work

In this article, we show there are cognitive capacities other than the ability to read that are relevant for potential ICT users with limited education. A level of ability to conduct abstraction seems to be an important cognitive skill for meaningful ICT usage. Particularly in video-based instructional content, for effective transfer of learning, the ability to conduct abstraction seems important in helping to identify common attributes that the video demonstration and the real-world task share, and to adapt to different attributes in the real-world task.

We investigated how limited education correlates with a person's performance on transfer of learning tasks that require conceptual abstraction in learning a domestic skill, using video-based instructional content. We did this through a controlled experiment that compared 56 participants from low-income communities in India, split into two groups of 28, based on a test of textual literacy that was used as a proxy for assessing overall educational level. Group A included participants who passed the cut-off conditions on the literacy test, while Group B included those who did not. Participants were then rated for their ability to generalize video instructions on how to use a vacuum cleaner to similar, but not necessarily identical, tasks.

Results confirmed that both groups did worse on abstracted transfer learning tasks than they did on more specific learning tasks, and that, all-around, Group A participants did better than Group B participants on all tasks. In addition, we found that diversification/generalization within instructions helped Group A participants in transfer of learning, but did *not* measurably help Group B participants.

For future work, there are a number of potential areas of investigation. One such area is an examination of what other design principles would hold for ICTs for users with limited ability to abstract and transfer learning. If such design principles exist, how might they vary across domain or medium of expression? For example, would the principles for video instruction found here similarly apply to voice-based UIs and touch screen interfaces?

It also seems worthwhile to further investigate different cognitive skills, as well as means for measuring them accurately. In many cases, instruments for measuring certain skills may require adaptation to a subject group that is unable to read and write. ■

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References

Abadzi, H. (2003). *Improving adult literacy outcomes: Lessons from cognitive research for developing countries.* Washington, DC: World Bank.

Adult Literacy Supplemental Assessment (ALSA). (n.d.). Retrieved from http://nces.ed.gov/naal/alsa.asp

Ardila, A., Rosselli, M., & Rosas, P. (1989). Neuropsychological assessment in non-literates: Visuospatial and memory abilities. *Brain Cognition, 11*(2), 147–166.

Bandura, A. (2005). Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behaviour* (pp. 71–81). New York: Academic Press.

Bhogal, B. S. (1996, December). Discussion about orality and literacy based on Murray Jardine's sight, sound, and epistemology: The experiential sources of ethical concepts, JAAR LXIV/1. *Presented at the School of Oriental and African Studies Post-Graduate Seminar.*

Boyera, S. (2007). The mobile web to bridge the digital divide? *Paper presented at the IST-Africa Conference 2007,* Maputo, Mozambique.

Castro-Caldas, A. (2004). Targeting regions of interest for the study of the non-literate brain. *International Journal of Psychology, 39,* 5–17.

Ceci, S. J. (1991). How much does schooling influence general intelligence and its cognitive components? A reassessment of the evidence. *Development Psychology, 27*(5), 703–722.

Chipchase, J. (2005). Understanding non-literacy as a barrier to mobile phone communication. Retrieved from http://research.nokia.com/bluesky/non-literacy-001-2005/index.html

Comprehensive Adult Student Assessment Systems (CASAS). (n.d.). Retrieved from https://www.casas.org/home/index.cfm?fuseaction=home.showContent&MapID=198

Czaja, S. J., Charness, N., Fisk, A. D., Hertzog, C., Nair, S. N., & Rogers, W. A. (2006). Factors predicting the use of technology: Findings from the Center for Research and Education on Aging and Technology Enhancement (CREATE). *Psychology and Aging, 21,* 333–353.

Eshet-Alkalai, Y. (2004). Digital literacy: A conceptual framework for survival skills in the digital era. *Journal of Educational Multimedia and Hypermedia, 13*(1), 93–106.

Fluency Addition to NAAL (FAN). (n.d.). Retrieved from http://nces.ed.gov/naal/fluency.asp

Gandhi, R., Veeraraghavan, R., Toyama, K., & Ramprasad, V. (2009). Digital green: Participatory video for agricultural extension. *Information Technologies & International Development, 5*(1), 1–15.

Grisedale, S., Graves, M., & Grünsteidl, A. (1997). Designing a graphical user interface for healthcare workers in rural India. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 471–478). Atlanta, GA: ACM.

Haskell, R. E. (2001). *Transfer of learning: Cognition, instruction, and reasoning.* San Diego, CA: Academic Press.

Huenerfauth, M. (2002). *Developing design recommendations for computer interfaces accessible to non-literate users.* (Master's thesis, University College Dublin).

Jones, M., Buchanan, G., Thimbleby, H., & Marsden, G. (2000). User interfaces for mobile web devices. [www9 mobile workshop position paper]. *Proceedings of the 9th International World Wide Web Conference.* Amsterdam.

Katre, D. S. (2006). Unorganized cognitive structures of non-literate as the key factor in rural e-learning design. *I-Manager's Journal of Education Technology, 2*(4), 67–72.

Kress, G., & Van Leeuwen, T. (1996). *Reading images: The grammar of visual design.* London: Routledge.

Kurvers, J. (2002). *Met ongeletterde ogen. Kennis van taal en schrift van analfabeten.* [With non-literate eyes. Knowledge of language and writing of non-literates]. (Thesis, Tilburg University).

Lehrman, S. (2007). Dialing in: Mobile phones target the world's non-reading poor. *Scientific American, 296*(5), 30–31.

Luria, A. R. (1974). *Cognitive development: Its cultural and social foundations.* Cambridge, MA: Harvard University Press.

Manly, J. J., Touradji, P., Tang, M. X., & Stern, Y. (2003). Literacy and memory decline among ethnically diverse elders. *Journal of Clinical and Experimental Neuropsychology, 25,* 680–690.

Matute, E., Leal, F., Zarabozo, D., Robles, A., & Cedillo, C. (2000). Does literacy have an effect on stick construction tasks? *Journal of the International Neuropsychological Society, 6,* 668–672.

Medhi, I., & Toyama, K. (2007). Full-context videos for first-time, non-literate PC users. *IEEE/ACM International Conference on Information and*

Communication Technologies and Development, Bangalore, India.

Medhi, I., Cutrell, E., & Toyama, K. (2010, March 20–24). It's not *just* illiteracy. India HCI / Interaction Design & International Development, Mumbai.

Medhi, I., Nagasena, G. S. N., & Toyama, K. (2009, April 4–9). A comparison of mobile money-transfer UIs for non-literate and semi-literate users. *ACM Conference on Computer Human Interaction,* Boston (pp. 1741–1750).

Medhi, I., Prasad, A., & Toyama, K. (2007, May 8–12). Optimal audio-visual representations for illiterate users. *International World Wide Web Conference,* Banff, Canada (pp. 873–882).

Medhi, I., Sagar, A., & Toyama, K. (2007). Text-free user interfaces for illiterate and semiliterate users. *Information Technologies & International Development, 4*(1), 37–50.

Mitra, S. (2005). Self organizing systems for mass computer literacy: Findings from the Hole in the Wall experiments. *International Journal of Development Issues, 4*(1), 71–81.

Morais, J., Cary, L., Alegria, J., & Bertelson, P. (1979). Does awareness of speech as a sequence of phones arise spontaneously? *Cognition, 7,* 323–331.

National Adult Literacy Database (NALD). (n.d.). *Literacy and basic skills assessment tool from the National Adult Literacy Database Canada.* Retrieved from http://www.nald.ca/library/learning/learncha/learncha.pdf

National Assessment of Adult Literacy (NAAL). (n.d.). Retrieved from http://nces.ed.gov/naal/index.asp

National Literacy Mission (NLM). (n.d.). Retrieved from http://www.nlm.nic.in/unesco_nlm.htm

National Sample Survey Organization (NSSO). (n.d.). Retrieved from http://www.literacy.org/products/ili/pdf/LAPIndiaApp_all.pdf

Ong, W. (2002). *Orality and literacy: The technologizing of the word* (2nd ed.). London: Routledge.

Parikh, T., Ghosh, K., & Chavan, A. (2003a, April 5–10). Design considerations for a financial management system for rural, semi-literate users. *ACM Conference on Computer-Human Interaction,* Fort Lauderdale, Florida, USA (pp. 824–825).

Parikh, T., Ghosh, K., & Chavan, A. (2003b, November 10–11). Design studies for a financial management system for micro-credit groups in rural India. *ACM Conference on Universal Usability,* Vancouver, B.C., Canada (pp. 15–22).

Plauche, M., & Prabaker, M. (2006). Tamil market: A spoken dialog system for rural India. *Working papers in ACM Conference on Computer Human Interaction,* Montreal.

Reis, A., & Castro-Caldas, A. (1997). Illiteracy: A bias for cognitive development. *Journal of International Neuropsychological Society, 3,* 444–450.

Reis, A., Petersson, K. M., Castro-Caldas, A., & Ingvar, M. (2001). Formal schooling influences two- but not three-dimensional naming skills. *Brain and Cognition, 47*(3), 397–411.

Samaj Pragati Sahayog. (n.d.). Retrieved from http://samprag.org

Sherwani, J., Ali, N., Mirza, S., Fatma, A., Memon, Y., Karim, M., et al. (2007, December 15–16). HealthLine: Speech-based access to health information by low-literate users. *IEEE/ACM International Conference on Information and Communication Technologies and Development,* Bangalore, India.

Sherwani, J., Ali. N., Rose, C. P., & Rosenfeld, R. (2009). Orality-grounded HCID: Understanding the oral user. *Information Technologies & International Development, 5*(4), 35–48.

Study Guide Zone. (n.d.). *Test of Adult Basic Education (TABE).* Retrieved from http://www.studyguidezone.com/tabetest.htm

UN News Centre. (2011, September 8). Literacy vital for beating poverty and disease and reinforcing stability. Retrieved from http://www.un.org/apps/news/story.asp?NewsID=39485&Cr=literacy&Cr1=

Van Linden, S., & Cremers, A. H. M. (2008, July 9–11). Cognitive abilities of functionally non-literate persons relevant to ICT use. International Conference on Computers Helping People with Special Needs. Linz, Austria (pp. 705–712).

Velkoff, V. A. (2008). *Women's education in India.* Retrieved from http://www.census.gov/ipc/prod/wid-9801.pdf

Video. (n.d.). Retrieved from http://video.cta.int

Walton, M., Marsden, G., & Vukovic, V. (2002, April 20–25). Visual literacy as challenge to the internationalisation of interfaces: A study of South African student web users. *CHI '02 extended abstracts on human factors in computing systems,* Minneapolis, MN (pp. 530–531).