# Beyond Strict Illiteracy: Abstracted Learning Among Low-Literate Users

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*Abstract*— **One of the greatest challenges in designing applications for developing communities is that potential users may have limited literacy. Past work in UI design for low-literate users has focused on illiteracy as the inability to read *per se*, with little recognition to other cognitive differences between literate and non-literate users.**

**In this paper, we investigate the correlation between literacy and cognitive skills for conceptual abstraction using video-based skills training. We performed a controlled experiment that compared 28 non-literate and 28 literate participants from low-income communities in India. Results confirm that both the groups did worse when a skill required generalization from instructional material, compared with the case when instructional material was specifically and exactly tailored to the skill. Literate participants did better than non-literate participants all-around on this learning task. In addition, we found that diversification of examples within instructions helped literate participants in transfer of learning, but did *not* help non-literate participants. We conclude that ICT UI and content for low-literate users should be sensitive to issues beyond strict illiteracy, to additional cognitive differences among these users.**

***Index Terms*—Low-literate, cognitive skill, abstraction, instructional video, transfer learning**

## I. Introduction

One of the greatest challenges faced in developing applications of computers and mobile phones in the field of Information and Communication Technology for Development (ICTD), is that potential users may lack fluent literacy. Conservative estimates of illiteracy suggest that anywhere from one to two billion people in the world are completely non-literate [37], and more are semi-literate – able to read only with great difficulty and effort. Non-literate and semi-literate people are together referred to as *low-literate*.

A recent body of work aims at designing user interfaces (UIs) for low-literate populations [21, 28, 30, 42, 45, 58]. Researchers have identified various usability challenges that low-literate users may encounter in interacting with traditional text-based UIs. To counter such problems, non-textual UIs that use voice, graphics and video have been proposed. Most of the current work in this area, however, focuses on illiteracy as the inability to read *per se*, with little recognition to other challenges that a low-literate user may face with ICT applications designed for the literate [41].

Researchers have identified a variety of cognitive skills, whose underdevelopment poses barriers for realizing useful interaction on ICT applications [24, 59]. In addition to language processing skills, facility with 2D imagery becomes important as UIs become increasingly graphical in nature. Furthermore, hypermedia environments provide an array of non-linear navigational paradigms through multiple sources of information. The effective use of these environments requires mental spatial orientation skills [24]. Other skills relevant to realizing useful interaction on ICTs are attention-related skills, such as multitasking, and vigilance [24].

Anecdotal evidence from prior work, as well as cognitive-science studies of illiteracy in *developed* countries suggest that non-literate users have different cognitive skills for abstraction, in comparison with literate populations.

How-to videos are an increasingly popular mechanism for teaching people how to perform a wide range of skills and tasks. Websites such as howcast.com, e-how.com and youtube.com contain a trove of instructions for cooking, repairing, building, working with software and all manner of other things. In the domain of development, DigitalGreen [26] has had a great deal of success using video for teaching agricultural techniques to farmers in rural India. There are other examples of videos being used in development for teaching microfinance [10], agro-marketing [10], and watershed management [8]. Indeed, video instruction seems particularly well-suited for imparting information to low-literacy populations (e.g., see Medhi, et al.'s work on full context video for computer UIs [43]). However, even though video-based instruction is not dependent on reading, other cognitive skills are still required to comprehend the instructions and translate to learning.

In this paper, we investigate the correlation between literacy and the ability for conceptual abstraction in learning skills, in the context of instructional material delivered via video. We ran a controlled trial comparing literate and non-literate

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participants drawn from low-income communities in Bangalore, India. We administered four transfer learning tasks that required varying degrees of abstraction to comprehend the video instructions and translate to skills learning for task completion. Results (1) confirm that both the groups do 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) literate participants do better than non-literate participants all-around on this learning task, (3) diversification of examples within instructions helps literate participants in transfer of learning, but does *not* help non-literate participants.

These findings are new evidence that when designing UI or content for low-literate users, there needs to be sensitivity to cognitive differences beyond the inability to read *per se*. Attention to these cognitive differences can have far-reaching influence on the design of UIs as well as organization of content for low-literate populations.

## II. RELATED WORK

### *A. UI Design for Low-Literate Users*

Most previous work in UIs for non-literate users has focused exclusively on illiteracy (the inability to read) *per se*, by mainly examining the mechanics of interfaces on PCs, PDAs and mobile phones. Researchers have recognized the value of imagery, and have advocated extensive use of graphics [28, 30, 45, 50, 51] to help non-literate users overcome the inability to read text. More specifically, it appears that static hand-drawn representations are better understood than photographs or icons [44]. Some authors note that the use of numbers is acceptable, as many non-literate people can read numerical digits [50, 51]. Other work has focused on ultra-simple navigation as a design goal [28], or on removing anxieties about technology use. For example, looping video clips which include dramatizations of the overall usage scenario have been found to be effective in reducing barriers to usage by first-time users [43].

Apart from work that focuses on PCs and PDAs, there is some research that looks at mobile UIs for low-literacy users. Researchers have recognized the value of voice feedback [45, 50, 53] and speech interfaces [15, 53, 58]. Others have questioned suitability of menu-based navigation for novice users [31] and have discussed designs that advocate fewer menus and dedicated buttons for this target group [36]. However, none of the above work looks beyond strict inability to read, into other problems that a low-literate user may face when interacting with ICT applications. There are two studies that look beyond the mechanics of the UI, and examine coping mechanisms of low-literate users when confronted with traditional mobile interfaces [20, 21]. However, even these studies do not look into designing of UIs with the explicit goal of accounting for the cognitive skills of non-literate users.

Figure 1. Examples of some UIs designed for low-literate users[50, 45]

Work in this area that takes into consideration cognitive skills of non-literate users, remains very shallow. One study shows that non-literate users have ‘less developed cognitive structures and linguistic sequential memory’ when compared to literate users, and calls for attention to these ‘unorganized’ structures when doing instructional design specifically for rural e-learning applications [32]. This study however is a small sample qualitative analysis that does not specifically investigate cognitive skill for abstraction. The other study investigates the proficiency level of functionally non-literate users on a number of cognitive skills important for the successful interaction with ICT, and these findings serve as guidelines for the design of UIs for an ATM [59]. However, even this study does not specifically investigate cognitive skill for conceptual abstraction.

### *B. Illiteracy and Cognitive Science*

There have been studies in the cognitive sciences that support the hypothesis that literacy is correlated with general cognitive skill development. It is important to note here that literacy in the context of these studies has a narrow definition which is limited to *textual* literacy, and illiteracy would mean the lack of textual literacy.

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 education on the cognitive processes supporting task performance on these tests [17]. The study implied that this influence can be conceptualized in two ways: students acquire general knowledge and processing strategies important for task performance, and formal education provides students with attitudes, values, and motivation that are important in testing situations [59]. It has also been suggested that literate people acquire skills to organize and process information in less idiosyncratic and more efficient ways compared with non-literate people [38, 39]. Thus, in addition to basic literacy (the skills of reading and writing), educated literate people seem to acquire cognitive skills and strategies for efficient processing of information [59]. Among other things, this implies that literacy can influence the outcome on specific psychological and neuropsychological tests. Consistent with this suggestion, several behavioral studies have demonstrated through empirical research that literacy level influences various cognitive skills – visuospatial and visual organization [12, 40, 54], language tasks [11, 18, 35, 47, 55], and self-efficacy [13, 22]. There are a number of observations involving visuospatial skills that are relevant. Non-literate participants performed significantly worse on immediate naming of two-dimensional representations of common everyday objects compared to literate participants, both in terms of accuracy and reaction times. [54]. Abstract icons have been known to be less recognized by non-literate participants—they possibly have difficulty integrating details of 2D line drawings into meaningful wholes [18].

Most of the above work is undertaken in developed regions-North America and Western Europe, and therefore is subject to caveats of cultural bias that may differ in other geographies. Taken together, however, this evidence shows that literacy and formal education can shape cognitive skills beyond the mere ability to read and write. Although we would like to believe that less privileged people have the same cognitive skills as literate people, this evidence confirms that lack of formal education can lead to low-literate people being differently-abled than literate people in the context of certain cognitive skills.

## III. BEYOND STRICT ILLITERACY

Recent research in ICTD has shown that it is not just the inability to read text that prevents useful interaction of existing ICTs for low-literate users. In fact low-literate users may have the ability to realize basic interaction on existing text-based UIs through rote memorization [41]. But, there seem to be a host of other issues that mediate how a low-literate user interacts 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; one's social standing; and others [41].

In addition to these, a significant issue mediating how low-literate users interact with ICTs is a broad range of cognitive difficulties associated with UI interaction. Our experience working with low-literate users (previously unpublished), suggests potential problems with abstract thinking at two levels—hierarchical and conceptual—as explained in more detail below.

### *Hierarchical Abstraction*

We have repeatedly seen that low-literate users seemed quicker to understand a linear navigation structure rather than a branched, hierarchical structure (users understood the former by analogy to the pages of a book). Users had trouble understanding how the navigation model in the hierarchical structure went from general to specific, from a home page to main sections to subsections.

Hierarchical classification tree structures have been called a culture-specific visual form which codifies the representational resources available to the Western tradition, and can operate to exclude people on both graphical and ideological levels [34]. One study looked at the extent to which novice users in Africa were able to reproduce classificational taxonomies or tree structures and found that there are clear cultural dimensions to the interpretation of these structures [61].

### *Conceptual Abstraction*

During interviews with low-literate users, when responses were elicited on particular ideas and concepts, participants would tell long stories only remotely related to the main point, to convey relevant information. The stories included concrete stories, specific objects, or actual instances of events. To convey a general idea, interview participants told many stories that were instances of the idea. They did not discuss general points or characteristics of the story or did not move down into more specific stories and details about each of those points.

This poses the question of whether non-literate participants had challenges with abstracting concepts – that is, pulling out main points from a series of events as a general quality or characteristic. One study reports that non-literate participants had difficulty with articulate self-analysis, normally deferring to the community for an evaluation of their own characters. The study claims that this is because the ability to think abstractly, i.e. non-situationally is what allows introspection. Literate people can and do have an abstract, contextless image of themselves, whereas the non-literate person does not, as his or her identity is defined largely by context, action and communication [14].

Non-literate people have been shown to learn poorly from neutral, stand-alone objects (such as a book, or automated system) which contain a set of instructions to be applied across situations [49]. Rather, they tend to learn better *in situ*, embedded in concrete situations and practical experience. Given these unique traits of non-literate people one study argues for design principles and research methodologies (in Human-Computer Interaction for Development) to be specifically tailored to suit the needs of non-literate users [57].

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

## IV. THE STUDY

Our specific interest was in investigating the relationship between literacy (which we define for our context in the next section) and performance on a task, the completion of which required a kind of conceptual abstraction in the context of instructional material delivered via video. We examined this correlation by conducting an experiment, the goal of which was to understand the following:

- Is there a difference in cognitive skill for abstraction between literate and non-literate users?
- Do non-literate users benefit from generalized examples as a way to learn abstract concepts?

For the purposes of our study, 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 to, but not necessarily identical with, that shown in the video. According to the 'Transfer of Learning Theory' [29], transfer can happen in six ways, two of which are relevant in such situations: 'near transfer', which refers to transfer of learning when task and/or context change slightly but remain largely similar; and 'far transfer' to the application of learning experiences to related but largely dissimilar problems. Our experiment is done in the context of such a transfer learning task.

## V. METHODOLOGY

### A. Working definition of 'literacy'

Literacy can be examined from the perspective of the theory of orality [49], alternate literacies [48], and theories of multiple intelligence [27], but for the purpose of this study we restrict the notion of literacy to textual literacy – the ability to read. As mentioned earlier, the specific interest of this study was to investigate textual literacy and its correlation with performance on task which does not require reading at all.

Although many studies use years of formal education as a proxy for literacy, textual literacy is not necessarily correlated with the level of education, as the "The Vai Project" [56] conducted on a small Liberian population that home-schools its children, suggests that some cognitive skills are linked with textual literacy, but not necessarily with formal education.

For this experiment, the textual literacy status of test participants was defined not in terms of formal education, but in terms of their ability to read, write, and understand numbers at the time of the experiment. A review of existing worldwide assessment tools (Western [1, 2, 3, 4, 5, 9] and Indian [6, 7] adult literacy) did not reveal a suitable instrument to do this, however, and we thus devised our own in consultation with an education researcher working in the area of primary education. The sections of the literacy assessment tool were designed based on literature review. The tool consisted of three sections:

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

Participants received scores for correct answers. There was a pre-decided cut-off condition (*i.e.*, ability to read simple sentences and up to 3-digit Indo-Arabic numerals, and write single words were enough to pass). Participants who passed were considered 'literate' and those that did not were considered 'non-literate' for the purpose of the experiment.

### B. Task

We chose a vacuum-cleaning task for two reasons. First, participants recruited from the partner organization were interested in learning to use vacuum cleaners to enhance their skill set for domestic labor. Vacuum cleaning was relevant and motivating for our subjects. Second, vacuum cleaners are available in different models, with minor variations for each function. This was appropriate for testing *abstraction*, 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.

### C. Experimental Design and General Procedure

Participants in all conditions were first shown two instructional videos (back-to-back) demonstrating the use of a vacuum cleaner, 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 learned from the videos. This yielded a 2 (Literacy Level) x 2 (Instructional Video) x 2 (Device Familiarity) mixed design.

### D. Participants

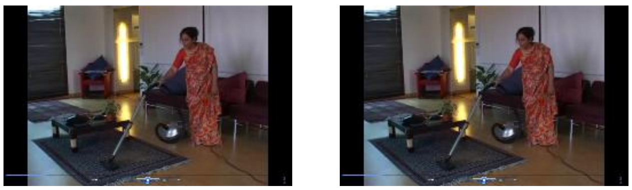
The participants for the experiments were drawn from 5 urban slum communities in Bangalore, India. They were recruited through an organization which is a facilitating body between clients (contractors, end clients, construction firms, home owners, builders, etc.) and informal sector workers in domains such as construction, domestic labor, etc. The construction workers were mostly male and domestic workers female. Due to relevance of task and to control for differences in performance due to gender, only female participants were used in this experiment. Moreover, education levels are typically much lower for women in India [60], 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 $12^{th}$ grade education. Household income is between USD 30-100 per month. The male members of the house are usually daily wage laborers—plumbers, carpenters, construction workers, mechanics, bar benders, fruits and vegetable vendors. Their primary language of communication is Kannada. Apart from this, a few people also spoke Tamil, Telugu, and Hindi. Nearly all of 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 recruited a total of 56 female participants, 28 literate and 28 non-literate. All were between the ages of 18 and 55 years and none had any previous experience using vacuum cleaners. For each type of instructional video (*Specific* and *Diversified*) there were 28 participants, randomized for literacy levels and age. Each subject performed tasks on both vacuum cleaners (*Familiar* and *Unfamiliar*).

### E. Instructional Videos

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

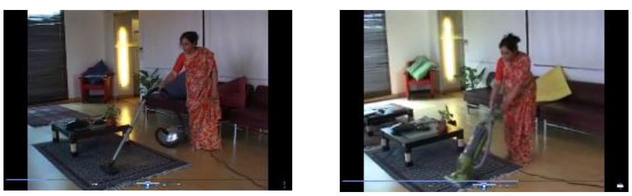
*Specific* video: This video showed the use of one vacuum cleaner (Model 1) for all of the tasks mentioned in the “Task” subsection, followed by a simple repetition of the same video. The length for the use of each part was 00:03:34 and the total length of the video was 00:07:08. Figure 2 (a) and (b) have screenshots of the video.



(a) (b)

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

*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. Figure 3 (a) and (b) have screenshots of the video.



(a) (b)

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

### F. 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 the ability for 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 of the participants were first tested on the *Familiar* device and the other half were first tested on the *Unfamiliar* device.

| **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 |

Table 1. Physical and functional differences in vacuum cleaner models used in experiment.

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

In addition, all participants were video recorded as they performed each task and qualitative observations were made by the experimenter.

### H. Hypothesis

Based on earlier observations on non-literate participants from previous and related work, we expected to see non-literate participants performing significantly worse compared to literate participants on all experimental tasks. Second, we expected to see that of all combinations, *Specific* → *Unfamiliar*, would be the most challenging as participants have 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 *Specific* → *Unfamiliar*.

***Note*:** In spite of 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 (less abstracted learning seen), if the hypotheses are borne out, we can be confident in the results. By 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. The experiment would be biased in favor of the expected result, had we used Model 3 as the Familiar model.

## VI. RESULTS

### A. *Quantitative*

For the overall analysis of performance on the vacuum cleaner tests, we performed a 2 (*Literacy*) x 2 (*Instructional Video*) x 2 (*Familiarity of Device*) mixed model ANOVA. *Literacy* and Video type were between subjects factors and *Familiarity* was within subjects. The dependent measure of performance was the number of prompts by the experimenter that was 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 8 cells. Overall, there are 3 main findings of particular interest (statistics are reported below). First, literate participants required much less assistance than non-literate participants across the board. Second, participants had the most difficulty when they needed to abstract learning to an unfamiliar device. And third, literate participants appeared to benefit from diversified examples much more than non-literate participants.

Confirming our first hypothesis, literate participants required significantly less assistance than did non-literate participants, F(1,52)=28.5, p<<0.001. In Fig. 4, compare the left set of 4 bars to the right set. Across all conditions, literate participants required less than half as much assistance as non-literate participants (average of 11.6 vs. 26.1 prompts); they 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 vs. light bars in Fig. 4). The main effect of *Video* was not significant.

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

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 Fig. 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 literate than non-literate participants.

In fact, Figure 4 suggests that our various manipulations in abstractions had only a small effect on the assistance required by our non-literate participants (ranging between 24.5 and 28 average prompts); they had 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* seemed to influence our literate participants much more. These participants were very good at directly matching what they saw on the screen to physical activity (familiar devices for either video type), but they particularly benefitted from the additional generalization provided by the diversified video for both devices they used (see Figure 5). For both familiar and unfamiliar tests, the diversified video appeared to reduce the amount of assistance needed by our literate participants. As we might expect, this is largest for the unfamiliar device (M=19.0 and 13.4

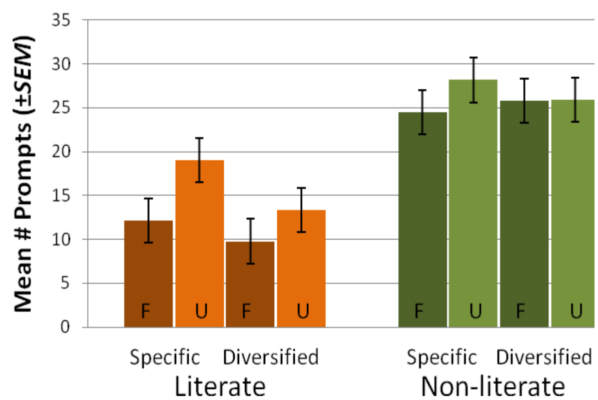



Figure 4. Assistance required by participants to complete all tasks. *Familiar* and *Unfamiliar* devices are denoted as U and F.

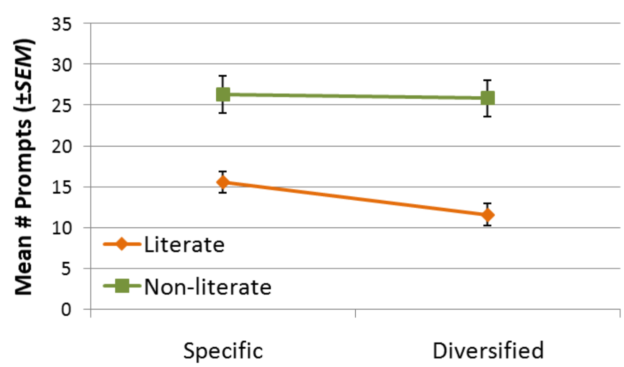



Figure 5. The help provided by diversified content is more effective for literate than non-literate participants.

respectively for specific and diversified video, t(14)=2.56, p<0.017). It is interesting to see a small, though statistically non-significant improvement when using familiar devices as well. Thus, our second hypothesis appears to be confirmed, but only for our literate participants.

### B. *Qualitative*

Throughout our formal subject study, we also made a number of informal qualitative observations. These were not established with countable metrics, but we discuss them here, because they provide additional context and point towards future work.

For each learning task, we had randomized participants for age, as has been stated earlier. Overall, we observed that for both literate and non-literate participants, within every task, people who were younger (<30 years old) were more attentive while watching the videos e.g. body leaning into the monitor, etc. They seemed more confident and went about doing the tasks in a brisk manner. Older participants (>45 years old), usually needed more encouragement for both getting started on the task and for task completion. If they were unable to do a task the first time around, 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 because of either 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 growing 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 in fact was going on 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, our hunch was in fact verified when we observed that both literate and non-literate participants required lesser 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 bag in one vacuum and cleaning the canister in another vacuum).

Overall, our participants seemed excited about watching videos on the PC to learn vacuum cleaning tasks. During informal discussion with the subjects after the formal study, a number of subjects were engaged enough to say that if they watched such instructional videos a couple of 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 comments came from several participants who asked if there could be instructional videos for them to learn other tasks such as using the washing machine.

## VII. Conclusions and Suggestions for ICT Material for Low-Literate Users

Most current work in the area of UIs for low-literate users focuses on illiteracy as the inability to read *per se*, without the explicit goal of accounting for other cognitive skills of non-literate users. Anecdotal evidence from prior work, as well as cognitive-science studies of illiteracy in developed countries suggest that non-literate users have a different cognitive capacity for abstraction. A refined ability for abstraction seems to be an important cognitive skill for meaningful ICT usage, whether software UIs or video-based instructional content.

In this paper, we investigated the correlation between literacy and performance on transfer learning tasks that require conceptual abstraction (in learning a domestic skill, using video-based instructional content). We did this through a controlled experiment comparing literate and non-literate participants drawn from low-income communities in Bangalore, India. To classify our participants we developed a literacy assessment tool for low-literate, low-income populations. We then administered four transfer learning tasks that required varying degrees of abstraction.

Results confirmed that both groups do worse on abstracted transfer learning tasks compared to more specific learning tasks, and that literate participants do better than non-literate participants all-around on all tasks. In addition, we found that diversification/generalization within instructions helps literate participants in transfer of learning, but does *not* help non-literate participants.

We conclude by suggesting that when designing ICT material for low-literate users, there needs to be sensitivity beyond the inability to read *per se*, to the cognitive differences among these users, particularly skills of conceptual abstraction. In our opinion, attention to these cognitive differences can have far-reaching influence on the design of UIs as well as organization of content for low-literate populations.

## VIII. Future Work

For future work there are a number of potential areas of investigation. One area we hope to pursue is to examine what specific design principles would hold for ICTs for low-literate users, given their unique cognitive capacity for abstraction. If such design principles exist, how might they vary across domain or medium of expression? For example what principles would generalize across video instruction, voice-based UIs and a touch screen interface?

Beyond this, we are interested in examining the definition of "literacy" beyond 'scribal,' or text literacy. The theories of 'Alternate Literacies' [48], 'Orality' [49] and 'Theories of Multiple Intelligence' [27], have talked about how literacy as it is traditionally defined fails to encompass the various abilities performed by humans. These studies further discuss how 'non-scribal'-literate people may have cognitive skills comparable to traditionally 'literate' people. If so, tests of scribal literacy may not be optimal for gauging user abilities as relevant to UIs.

We are also continuing with ethnographic and formal cognitive-skills studies for testing abstract thinking—devising instruments to measure the ability to think abstractly without privileging 'scribal' literacy.

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