Defining Functional Illiteracy to Empower Inclusive Technology Design

Khadijah, D, Mohammed

Information System and Operations Management Group, Aston University, 159168644@aston.ac.uk

Victoria, Uren

Information System and Operations Management Group, Aston University, v.uren@aston.ac.uk

Sian, Joel-Edgar

Northeastern University London, sian.joel-edgar@nulondon.ac.uk

Priscilla, Omonedo

Information System and Operations Management Group, Aston University, p.omonedo1@aston.ac.uk

Limited literacy presents a significant challenge in HCI research, yet the field lacks consistent definitions and measurement criteria. Researchers often interchange terms such as 'functional illiterates,' 'low literates,' and 'semi-literates,' further complicating the field. This paper conducts a systematic literature review (SLR) of 33 HCI studies, revealing concerns about the absence of a definition in 41% of the studies and the lack of measurement technique in 74%. Based on the results from our SLR and relevant research beyond HCI, we propose the following work-in-progress definition. *'Functional illiterates are **motivated adults** with **some familiarity with text** but insufficient to fully comprehend meanings and **low skills in the measured** digital skill, with enough **language proficiency** in the study language if they are literate in their native language*. This understanding, coupled with addressing the identified issues, will empower the HCI4D community to design more inclusive technology solutions for functionally illiterate users in developing countries.

CCS CONCEPTS •Social and professional topics~User characteristics •Human-centered computing~Accessibility~Accessibility theory, concepts and paradigms •Human-centered computing~Human computer interaction (HCI)~HCI theory, concepts and models.

Additional Keywords and Phrases: functional illiterates, low-literates, semi-literates, HCI4D

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1 INTRODUCTION

Literacy is a significant topic in Human-Computer Interaction (HCI) research, focusing on barriers faced by users with limitations in literacy and strategies to overcome them [1]. However, knowledge in this field is scattered across academic sources, and inconsistent terms like 'functional illiterates' (FXI), 'low literates' (LL), and 'semi-literates' (SL) for identifying users with literacy challenges contribute to this fragmentation [2]. This lack of standardized criteria obstructs the clear

conceptualization of user needs and appropriate design solutions. We adopt "functional illiterates" (FXI) for several compelling reasons within the HCI4D context including: 1) The prevalence of limited literacy in developing regions, particularly Africa [3]. 2) This term aligns seamlessly with the broader academic discourse on literacy. It stands as a recognized concept by UNESCO to characterize individuals with restricted reading and writing abilities [4]. 3) It provides a valuable tool to establish a precise boundary between users possessing minimal reading skills (FXI) and those entirely incapable of reading or writing, that is illiterates (IL), which is paramount for tailoring technology solutions effectively, and 4) The term transcends language barriers [5] and can be applied universally to describe individuals with limited reading and writing skills, regardless of their native language. This universality makes it a valuable choice for HCI4D research conducted across different regions and languages. By addressing our research problem, we aim to contribute to understanding FXI user characteristics, enabling more informed and effective design strategies tailored to their unique needs. Thus, our research aims to define and measure functional illiteracy in HCI4D studies.

2 METHOD

We conducted a systematic literature review (SLR) of studies between 2013 and April 2022 in the ACM Digital Library and Scopus databases to fulfil our aim. ACM Digital Library was selected for its extensive coverage in computing [6], while Scopus further broadened our coverage. We followed the technique applied in an SLR study in HCI [2], which followed Kitchenham and Charter's guidelines [7]. We focused on four keywords, including 'functionally illiterate' *or* 'low literate' *or* 'semi-literate', *and* 'Human-Computer Interaction.'

The initial search yielded 257 results from the ACM Digital Library and 48 from Scopus, totalling 305 studies on the Mendeley reference managing tool. We assessed each paper's abstract in the initial screening to identify those relevant to technology interaction with FXI/SL/LL groups. Exclusion criteria involved algorithms, architecture/models, and voice/speech interfaces, as these weren't our focus. We also omitted studies concerning children or individuals with disabilities. Applying these criteria led to the identification of 50 papers for further analysis.

In the second phase of our SLR, we performed an in-depth paper-based evaluation, resulting in a narrowed dataset of 33 relevant studies. We focused on papers that addressed graphical user interfaces (GUIs) for LL/SL/FXI users. To ensure consistency, we excluded studies involving gesture-based interfaces, virtual reality, and brain-computer interaction, maintaining focus on our core population. Information from the 33 chosen studies was tabulated, including publication year, research location, terminology, definitions, and measurement techniques, as detailed in the next section.

3 FINDINGS

Our findings indicate a peak interest in studying FXI between 2013 and 2017, followed by a decline in subsequent years, with only one study in 2021. Research locations were primarily Asia (23 out of 34), notably India (13 studies), while Africa had 9 studies, reflecting progress since Dell and Kumar's 2016 review [8]. This underscores the continued need for research. In line with our research aim, our analysis revealed the following insights.

1. *Terminology:* LL was the most prevalent term used exclusively in 19/33 studies [2, 9–26]. Meanwhile, SL was used solely in 4/33 studies [27–30]. In 10/33 other studies, LL and SL were often used alongside 'illiterates' (IL) [31–39]. Notably, 7/33 studies made no distinction between LL/SL and IL [2,9,28,36–39].
2. *Definition:* 14 studies lacked explicit user definition while the rest used 'educational level' (7/33) [14,20,21], [26,27,34,35], 'reading and writing skills' (6/33) [9,16,19,23,30,32], and 'experience with technology' (4/33) [23,25,35,40]. A few studies (3/33) adopted a combination of the above [23,35,40].

3. *Measurement Technique:* Most studies (26/33) did not employ specific measurement techniques. Some studies relied on 'self-identification' based on 'educational level' (2/33) [26,34] or 'assessments' (4/33), 2 of which used pre-established tests [17,32], while the other 2 did not mention the test type [23,25].
4. *Users Age:* Only 2 studies explicitly mentioned adult users [17,23], while others indicated adulthood indirectly using terms like 'women,' [31] 'parents,' [17,22] and occupational roles such as 'farmer' [11–13,20,28,36].
5. *Motivation for Technology Use:* Users' interest in the study's context is not mentioned in any studies.

Our results confirmed terminology, definition, and recruitment inconsistencies for FXI, challenging meaningful comparisons and understanding of FXI characteristics. This inconsistency raises concerns about the overall outcomes' consistency and comparability.

Some studies in our results classified individuals with limited literacy based on formal education. However, the ability to read/write does not solely depend on the level of education [41]. Factors such as institution quality, teaching methods, family support, environment, effort, genetics, and attendance play roles in literacy [4, 41]. Due to these complexities, the ability to read /write remains a more reliable descriptor for these users [42], as some studies in our review have adopted.

However, [43] challenges defining literacy solely by reading/writing abilities, citing instances where people can read/write but struggle with comprehension or using technology in different contexts and languages, e.g., reading a newspaper or using a computer. This highlights the need to consider language proficiency and technological skills, leading to definitions embracing cultural and linguistic diversity [5], classified under 'functional literacy' [43]. Thus, we adopt 'functional illiterates' to include the 'function' aspect, resonating with HCI4D's contextual nature [1].

Moreover, our findings identify a gap in recognizing the significance of motivation for technology use, despite its crucial role in influencing user performance [44]. Assessing motivation is essential in developing countries where technology might not be as integrated into daily life as in developed countries.

Additionally, our findings highlight a gap in age definition. Developmental differences between children and adults can complicate accurately identifying literacy challenges, rendering adults a more reliable measure [42]. Furthermore, the cognitive patterns linked with FXI closely resemble those observed in children rather than regular adult readers [45]. This distinction highlights that FXI primarily applies to adults, and categorizing children as FXI is inappropriate.

Regarding the need to assess users to verify their literacy levels, our results show that 74% of the studies did not employ any measurements, while 9% used self-identification. These approaches hinder diagnosing IL severity and blur the line between IL and FXI [42]. Also, the number of years of schooling is unreliable due to the factors above. Instead, a general reading assessment with cut-off values is more reliable because it is easily understood and replicable [4,42].

Several general reading assessments exist to evaluate literacy, including individuals with limited literacy. Recognized assessments in the field of literacy research include the Literacy Assessment Monitoring Programme (LAMP), the International Adult Literacy Survey (IALS), the Adult Literacy and Life Skills Survey (ALL), and the Programme for the International Assessment of Adult Competencies (PIAAC) [5].

It is important to note that while these assessments are valuable for evaluating general literacy, they do not specifically address functional illiteracy [4]. Furthermore, these assessments often take 30-45 minutes, which can be time-consuming to administer and score [46]. In research involving participants with limited literacy, researchers have sought quicker alternatives to reduce participant frustration and improve feasibility[46]. Some of these alternatives include assessments that take less than five minutes, such as the Rapid Assessment of Adult Literacy in Medicine (REALM) [17] or Slossen Oral Reading Test (SORT) [46].

Notably, literacy assessments may measure one or a combination of various components of reading [5], including word decoding, language comprehension, background knowledge, inferences, fluency, vocabulary, working memory, et cetera

[47,48]. This means that the selection of an assessment method should align with the research's focus and the aspects of literacy that are most relevant to the study.

4 PROPOSED DEFINITION AND MEASUREMENT FOR FUNCTIONAL ILLITERACY IN HCI4D

The results from our SLR and the discussion of relevant research beyond HCI underscore the importance of considering various factors when defining functional illiteracy. These factors are summarised as themes in Table 1.

Table 1: Themes contributing to the proposed definition of functional illiteracy for HCI4D research.

Themes	Explanation
Reading/writing	*Difficulty understanding complex texts, leading to incomplete or wrong conclusions* [45].
Context	*Low skills in the digital area studied [function], e.g., sharing a photo on a mobile app* [43], *enough language proficiency in the study's [language]* [4]. *The latter criterion distinguishes FXI from individuals who might be literate in their mother tongue but face challenges with the study's language.*
Age	*Adults* [4]
Motivation	*High interest in interacting with technology* [43]

Taking the above themes into account, we define a functionally illiterate person as:

> "Any **motivated adult** with **some familiarity with text** but insufficient to fully comprehend meanings and **low skills in the measured** digital skill, with enough **language proficiency** in the study language if they are literate in their native language."

We clarify that FXI is distinct from "illiteracy," as the latter specifically refers to individuals who cannot read or write at all [45]. Moreover, FXI differs from digital illiteracy, which includes users finding technology challenging, spanning illiterates, functional illiterates, and literate users [2].

Regarding measurement, in our research, we considered the component of reading comprehension as a key aspect. Our definition of FXI emphasizes the "inability to fully comprehend meanings" from text. To assess this component, we chose the reading comprehension subset 'Maze' from the Dynamics Indicators of Basic Early Literacy Skills 8th edition (DIBELS8) [49]. Maze measures are valid assessment methods for low-level comprehension.

The DIBELS8 Maze has several advantages. It was originally developed to assess literacy skills, particularly reading skills, and has been validated for use with adults [50]. This assessment is also designed to be generic and not tied to any specific curriculum [49], making it adaptable to various cultural contexts. Additionally, the DIBELS8 Maze takes only 3 minutes to administer and provides comprehensive guidelines for administering test and scoring the results [51]. It includes benchmark values that categorize participants into different literacy groups based on their performance [52], facilitating the classification of individuals as FXI. We suggest that this assessment is used with an appropriate cut-off value for the research context. Additionally, users must be asked screening questions to ensure they meet the criteria in Table 1.

5 CONCLUSION

This research fills an HCI gap by emphasizing the need for clear definitions and measurement techniques for literacy-related terms. Its implication is to highlight the importance of using robust methodologies to ensure replicable findings and foster a rigorous research culture within the field. Also, it aims to advance inclusive technology design in developing regions, ensuring the correct areas for improvement are addressed by understanding FXI characteristics. For instance, consider the following scenario. An HCI4D researcher is conducting a study in English to improve the usability of M-Pesa, a mobile phone-based money transfer service in users with limited literacy. With the current trend in approaching such

users, several implications can arise: 1) If the participants are in roles that require daily use of M-Pesa, they might excel in using it, even if they have limited reading abilities. This proficiency could result from rote memorization rather than traditional literacy skills. Without considering the 'function' aspect, the researcher might assume that users with limited reading abilities are inherently skilled in using the service. 2) If the researcher builds on assumptions from previous studies that do not differentiate between IL and LL/SL users, they risk creating their designs on the wrong assumption of user capabilities. As IL users necessitate text-free interfaces while FXI allow for a more integration of text elements alongside other design elements. Our study aims to consider these hinderances to accessible design.

A limitation of our study is the inconsistent terminology, which complicates finding relevant research. To address this in future work, researchers can use similarity-based tools to identify related papers based on a reference paper and document their process for replicability. Additionally, our study's findings open new avenues for future research in HCI4D and FXI, including: (1) Investigating FXI differences between HCI4D and traditional HCI, considering educational opportunities and exposure to technology. (2) Exploring varying FXI terminologies in developing countries and their impact on perceived needs, drawing parallels with dyslexics in more developed regions to reveal nuanced differences [42].

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