Cognitive Modeling for Illiteracy Eradication

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Abstract
High illiteracy rates are one of the main challenges in developing countries to overcome. Movements to eradicate this problem such as literacy campaigns often fail since they don't accommodate for cognitive styles of illiterates in their design. This study aims to highlight the cognitive differences in problem solving domain due to literacy campaigns. A field study was already conducted on 40 participants across the literacy spectrum in the domains of algorithms and reasoning problem solving. The study will further be extended to more problem domains, different cultural contexts worldwide and the field of human-computer interaction as a special domain. In addition, a software model will be developed to represent the cognitive styles of literates and illiterates. The software model will be used to adapt educational systems to illiterate cognitive styles.

Author Keywords
Literacy; cognition; ethnocomputing; cultural differences; software modeling.

ACM Classification Keywords
H.1.2 User/Machine Systems; I.6 Simulation and Modeling; H.5.2 User Interfaces

Introduction

Officially, 73.8% of Egypt's population can read or write, leaving it at the 164th position worldwide [1]. Unofficially, however, it can be assumed that the functional illiteracy rate is very high. On the other hand, Egypt is described as having the largest overall education system in the Middle East and North Africa. So, there is a huge gap between literate and illiterate individuals. Many activists now are working hard to reduce this literacy gap by offering strong literacy campaigns. Despite their strong efforts, illiterates are still dropping out of the campaigns or having very slow learning curves. According to our field research, one of the main reasons behind this problem is the cognitive gap that illiterates observe during these campaigns. They frequently report that the campaign curricula are hard for them to absorb and do not comply with the way they process information.

This research aimed to investigate into the root causes as well as solutions for this by studying the cognitive processes of literates versus illiterates and the mental model involved with problem solving in both levels of education. The findings of ethnocomputing are taken into account in order to approach the topic.

Theoretical Background

Ethnocomputing is aimed at understanding computation in different cultures [4]. The current direction of ethnocomputing is to create culturally-inspired agents that are either used for educative purposes about a certain culture or used in creating agents that can interact socially with a certain culture. These agents can either be generated to have culture-specific parameters or have parameters that can be easily tweaked to simulate a given culture. One of the main objectives behind the field is to reduce the computer-generated cultural gaps and utilize computers for the benefit of reducing existing ones.

Literacy has been documented to affect cognitive style in different domains. According to Tulviste et al. theoretic syllogistic reasoning is a skill that is first developed at schools, but then evolves to be used in everyday life on different types of problems [2].

Other cognitive domains affected by literacy include problem solving [5]. Studies show that expert users display a much higher level of formality than novice users in problem solving techniques. This includes memory utilization, mental representation, initial state elaboration and others.

Our Previous Work

A study was conducted on 40 participants to identify the literacy-generated cognitive differences as well as the diversity in mental models during problem solving [3]. The study was conducted on four groups of participants on a scale of education formality. The first group consisted of 10 illiterate individuals, the second 10 Applied Arts students with a more creative rather than formalized approach to education. The third group consisted of 10 young Computer Science students and the fourth 10 senior Computer Science students who studied logical subjects such as Constraint Programming. All groups were Egyptian adults. All participants were represented with two problems, an algorithmic problem, namely Towers of Hanoi and a reasoning problem, which was a simplified version of the Zebra puzzle. The correctness of the result, the formality of the solving technique as well as the mental

model created in the participants' brain was recorded by a structured qualitative interview.

Results of the Towers of Hanoi and Zebra puzzle test show that participants are consistent in the formality of their approach in solving both problems. This formality was also statistically related to the formality of their education. Despite the independency of the two domains in working memory usage, the development of the working memory is still correlated to the education level, which in turn reflects on its usage similarly in both problem domains.

Study Design and Software Model

The problem of illiteracy is not solely a national problem in Egypt, 26% of the entire world population are illiterates. With the advancement in technology and availability of computers, computer science can help the activists in these areas too. The field of HCI for development has opened many doors to using computers in developing regions to solve fundamental problems. Our work capitalizes on the concept of software mental models to represent cognitive models of individuals from the campaigns. However, cognition has been observed to vary across national borders and cultures. This variation will not allow generalization of findings to all literacy campaigns worldwide. Therefore, this study will further be extended to underdeveloped countries in Africa and Asia in collaboration with graduate students in these countries. Extending the problem domains to include also numerical problem solving, then developing a primary software model will complete the first phase in Egypt. Next the practices from the Egyptian field studies will be taken to countries in Asia such as India and China in collaboration with graduate students in these countries. The same studies will be replicated to obtain data about mental models of illiterate adults in these regions. Next, the studies will be extended to Africa and more countries in Asia to complete a total of ten countries, five in each continent. The objective of the research is not only to aid curricula development in these countries, but also to compare illiterate adults' cognitive processes in all these countries. HCI4D researchers can use these comparative models worldwide to assist in targeted application development. Predictive software models will be developed for all cultures investigated and presented to governments and NGOs in these regions for use in campaign content development.

Conclusion

Egypt is a country that suffers from a high percentage of illiterates. It also observes a very noticeable cognitive and cultural gap between literates and illiterates. This gap has affected the eradication process of illiteracy since individuals developing literacy campaigns are literates and do not understand the cognitive processes of illiterates. This causes a large dropout rate from the campaign classes.

This research studies the cognitive differences in problem solving strategies caused by literacy differences through field studies. One study has already been conducted on 40 participants in the domains of algorithms and reasoning. Results show that formality of education is correlated to formality of problem solving in both domains and that formality in both domains is correlated.

Future Work

The goal of this research is to reduce the rate of illiterates around the world. It is hypothesized that HCI dedicatedly designed to enhance the cognitive abilities of users has a great potential to reach this objective. Therefore, this line of research will be further extended further to include studies on more problems from these two domains as well as other domains (e.g. numeracy) to develop a deeper understanding of the cognitive processes of both educational backgrounds.

In addition, the study it is intended to replicate and adapt it to different cultural groups in Asia and Las Americas that have a low literacy rates in an attempt to compare literacy's effect on cognition in different cultural contexts.

In the end, the software model mentioned above will be created to represent the findings. I is intended to act as a predictor to the cognitive approach of an individual to a given problem based on their literacy background. This body of knowledge will help to tailor educational systems to personal cognitive styles. The adaptation, in turn, will be of benefit when trying to increase the educational backgrounds worldwide.

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