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Problem-based Learning Approach to Human Computer Interaction

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***Abstract*—**Human Computer Interaction (HCI) has been an emerging field that draws in the experts from various fields to enhance the application of computer programs and the ease of computer users. HCI has much to do with learning and cognition and an emerging approach to learning and problem-solving is problem-based learning (PBL). The processes of PBL involve important cognitive functions in the various stages. This paper will illustrate how closely related fields to HCI, PBL and cognitive psychology can benefit from informing each other through analysing various cognitive functions. Several cognitive functions from cognitive function disc (CFD) would be presented and discussed in relation to human-computer interface. This paper concludes with the implications of bridging the gaps amongst these disciplines.

***Keywords*—**problem-based learning, human computer interaction, cognitive psychology, Cognitive Function Disc (CFD)

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I. Introduction

HUMAN computer interaction (HCI) is the study of the interaction between people and computers. It deals with how people and computers can effectively interact to carry out tasks, and how such interactive system is designed [1]. In doing these, the field of HCI draws on multidisciplinary areas of science, engineering, and art such as psychology, computer science, and anthropology. HCI makes use of relevant theories and concepts from various disciplines to understand and improve the interactions between users and computers.

Several important contributions to HCI came from psychology discipline. The psychology of human computer interaction, sometimes referred as cyberpsychology, is concerned with the thinking, behaviors, and attitudes of the person or groups using the computer system [2]. It also involves users' personality, motivation, emotions, and moods.

II. Cognitive Psychology

An important concern of HCI is on the demands made by the computer on people's knowledge and understanding, and on the amount of problem solving and thinking required by the users to complete a task using the computer [1]. Cognitive psychology is the branch of psychology that looks into the above-mentioned concern of HCI. Cognitive psychology deals with perception, memory, attention, problem solving, and decision making of the users [3].

III. Problem-based Learning Approach

Problem-based learning (PBL) approach is a cognitive-centred approach to problem solving, learning, and thinking. This paper advocates a problem-based learning approach to HCI and the importance of understanding cognitive functioning. This serves as a basis from which applicable guidelines, structures, and processes can be developed.

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IV. Nature and Characteristics of PBL

PBL is a learner-centeredness approach that puts learners in the central of each stage of learning. Reference [4] in his book *Problem-based Learning Innovation* listed out common characteristics of PBL approach as followed:

- The problem is *the starting point* of learning.
- The problem is usually a *real-world problem* that appears unstructured. If it is a simulated problem, it is meant to be as authentic as possible. Topics or issues on HCI are good illustrations of the real-world problem.
- The problem calls for *multiple perspectives*. The use of multi-disciplinary knowledge is a key feature in many PBL curricula. PBL encourages solutions that take into consideration knowledge from various subjects and topics. Similarly, the field of HCI requires multiple perspectives from the researchers across disciplines. Each discipline brings in diverse inputs to solve the problem of HCI which in turn stretches the possibility of getting the best solution.
- *Self-directed learning* is primary. Thus, learners assume the major responsibility for acquisition of information and knowledge. Tutor's role is as facilitator.
- *Harnessing of a variety of knowledge sources* are essential PBL processes.
- Learning is *collaborative, communicative, and cooperative*. Learners work in small groups with a high level of interaction.
- Development of *inquiry and problem-solving skills* is as important as content knowledge acquisition for the solution of the problem.
- Closure in the PBL process includes *synthesis and integration of learning.*
- PBL also concludes with an *evaluation and review* of learner's experience and learning process.

Besides the characteristics mentioned above, PBL approach also highlights the importance of the transfer of skills. Learners are expected to transfer concepts learned previously to new problems although spontaneous transfer can be hard without practice or expertise [5]. Transfer often fails because problem solvers fail to retrieve relevant information that they need to or relevant analog from their knowledge [6]. Since in PBL the knowledge is encoded in problem-solving context (real-life situation), problem solvers are more likely to retrieve the knowledge when faced with future problems [7]. Consider

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a person who previously learned how to use MS Windows XP in a problem-based context, and subsequently switched to MS Windows Vista. When faced with MS Windows Vista (problem), the person could retrieve his/ her prior knowledge and skills and then apply them to the new problem (MS Window XP). We anticipate a positive transfer across the two systems.

Moreover, PBL approach emphasizes on the development of problem-solving skills of learners as learners work on the real-world problem, which is multi-faceted, and find the solutions through variety of sources. Effective problem-solving skills include employing various information searching means and cognitive strategies and processes in arriving at the solutions. For information searching, reference [8] observed that we are bombarded by reports of rapid and constant changes in internet communication technologies (ICT) these days. This breakthrough of ICT facilitates much of today's information searching process. Online e-journal and Google search engine are some of the examples of online tools that can be used to collect information. In addition, collaboration between the field of HCI and PBL can be observed through the usage of e-learning in PBL teaching (see also reference [9]). For cognitive strategies and processes, reference [10] identified a range of key cognitive functions in problem solving as shown in Fig. 1.

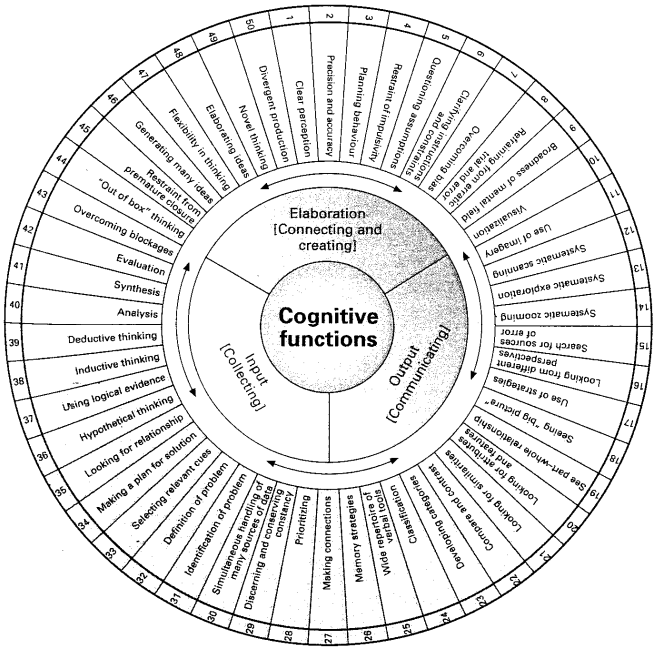


Fig. 1 Cognitive Function Disc

V. Cognitive Function Disc (CFD)

Cognitive functions refer to what is going on in the mind of the learner and the domains of thinking we seek to improve. CFD provides a map for identifying and focusing on a variety of key cognitive functions in the phases of collecting, connecting, and communicating information represented as a rotating annulus of a range of cognitive functions which may relate to each of these phases [11]. Below, several cognitive functions from CFD are discussed in terms of its relation to the field of HCI.

The very first stage of problem solving is *the identification of problem* and *definition of problem*. This is the stage when people often jump into hypothesizing causes and suggesting solutions, or 'pseudo-diagnostic' [12], without stating the facts or seeking additional information or more accurate data. Because human reasoning is often illogical (logical fallacies), we tend to defer such reasoning to computational procedures. We assume that computers use rules of logic effectively and without subjective bias. Although this works well with math and accounting, the results are not always agreeable with human preferences [2].

On the other hand, several cognitive functions from CFD can be employed to tackle the biases. They are *to restraint from premature closure, to refrain from erratic trial and error* such as randomly trying out different functions and operations of a system, *to overcome bias, to question assumptions, and to clarify facts, instructions, and constraints.*

Selecting relevant cues is often necessary in early stage of problem solving as well, i.e., to pinpoint relevant and useful information and filter out extraneous factors. It is particularly relevant in information searching. As mentioned above, internet has facilitated the way we search for information yet it could be overwhelming at the same time. Hence, being able to select and retrieve only relevant information is important. In addition, the ability to select relevant cues plays a role in retrieving information from our memory. Providing relevant cues, such as with the aid of a help field or prompt [1], would aid users in recalling information like command names and function keys.

Throughout the process of problem solving itself, humans employ various types of strategies and thinking. One of the strategies could be *memory strategies* that could help in remembering and retrieving information learned in the past. Memory also organizes and processes the information. In HCI, the lack of exactness in human memory has caused frequent usability problems to arise. Designers have now improved the design of interfaces, with greater facilitation and help, to compensate human's memory system. For example, features which allow users to search for the best match spelling of a particular item/ word. They serve as a great help for users who may have forgotten how to spell the name or mistyped it [1].

One type of memory strategies is chunking. Chunking refers to *classification of information* into a larger unit. To illustrate, IND PKI GTO could be grouped into meaningful unit of information such as PIN DOG KIT. A classic experiment by reference [13] demonstrated that human could remember more items from a list when the items were grouped to a number of chunks or meaningful units of information. In computer menu display, the menu item selections are structured under a few meaningful categories instead of having each of the item selections displayed separately. This chunking helps to relieve the load on user's memory.

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Nevertheless, computer designers' meaningful chunks do not necessarily translate to user's meaningful chunks, i.e., are the chunks meaningful to the user? [1]. This example illustrates the need for researchers to be mindful when it comes to applying research findings from other disciplines to his/ her field of expertise.

The core of problem-solving involves thinking skills. Two types of thinking skills that humans frequently employ are *deductive thinking* and *inductive thinking*. In deductive thinking, we draw a conclusion from a set of premises. For example:

Any e-mail with a subject line containing the word 'lottery' is spam.

This e-mail has a subject line containing the word 'lottery'. Therefore, this email is spam.

Deductive reasoning is frequently used in thinking about computers and in computer programming. Indeed, the example above could be used to set the rules for filtering spam emails. However, it must be remembered that humans program computers, and consequently computers are subject to human error. One might not want to entirely trust the above filter rule, not because it is illogical, but there are many mitigating external factors that are not taken into account by the rule [2]. For instance, what if the subject line of the email was 'Your manuscript entitled "Lottery" was accepted for publication'?

In inductive thinking, we start from a set of instances and infer a rule. Inductive reasoning involves hypothesis testing (*hypothetical thinking*) as we generate a rule and test it across the set of instances [2]. For instance:

All computers I encountered have Microsoft office. Therefore

All computers have Microsoft Office.

Reference [14] found that this process would be harder if there were many irrelevant instances such as in troubleshooting. With regards to rules, it was found that complex rules, i.e., rules that contain 'and', 'or', and/or 'if', are problematic and difficult [15]. Lastly, we learn more about from negative instances (when things go wrong) than from positive instances (when all things work fine). However, we tend to avoid the negative instances and therefore do not learn from them [16].

Another vital thinking skill to problem solving is creative thinking. There has been extensive psychology research conducted on the topic of creativity over the past decades [17]. Most of the research aims to develop creativity methods to generate unique, creative, and feasible solutions to a wide range of problems. Following it, software and support tools to assist humans in generating creative ideas are developed. One of them is MA/ Casper, Advanced Computer Support for Morphological Analysis.

Furthermore, *generating many ideas, looking from different perspectives, seeing 'big picture'* (PBL emphasizes on holistic view in approaching problems), *'out of box' thinking, flexibility in thinking, novel thinking, and divergent production* are some of the cognitive functions in CFD that govern the generation of innovative solutions.

VI. Metacognition

Metacognition, popularly referred as 'thinking about thinking', was firstly studied by reference [18] and defined as 'one's knowledge concerning one's own cognitive processes' (p. 232). The PBL approach provides many opportunities to develop and practice metacognition by allowing learners to propose a plan for the problem, monitor it during implementation, and, when completed, determine how it went [19]. One application of the concept of metacognition in HCI was demonstrated in a study by reference [20]. They found that participants' metacognitive judgments, such as self-assessment of own knowledge, was predictive of participants' computer performance. Yet, frequency of computer usage (hour per week) did not significantly predict computer performance which contradicts with conventional wisdom that number of hours using computer is a reliable assessment of computer proficiency.

VII. Closing remarks

We opened this paper with an introduction to PBL approach, an introduction to PBL CFD cognitive processes, and their various applications to the field of HCI. Further, we discussed about the concept of metacognition and AI with respect to their application to HCI domain. Hopefully, this paper could serve as an informative source in understanding what PBL approach is and how PBL theories and concepts can be applied to the area of HCI.

As a concluding point, designers and developers of computer systems and tools need to have an integrated understanding of HCI and cognitive psychology as both, knowledge of users' cognitive performance limitations and knowledge of how to design representations, are essential to the successful creation of new tools and artifacts [21].

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