

Preface

We dance around in a circle and suppose, while the secret sits in the middle and knows. (Frost, 1971)

It is the laborious life of scientific research that requires us to continually presume, then find support for our presumptions, which either stand the test of time or fall prey to falsifying evidence only to be replaced by new ideas and discoveries. It is this scientific track as described by Popper (1963) that has been followed by scientists taking them from the early days of inventions to current-day knowledge, always following a specific track. First the ideas, then testing, followed by the formation of theories, and after a science reaches a stable state of affairs, the fruits of that knowledge are reaped in the form of applications and inventions that people can benefit from.

I do not think there is any thrill that can go through the human heart like that felt by the inventor as he sees some creation of the brain unfolding to success.... Such emotions make a man forget food, sleep, friends, love, everything. (Nikola Tesla, 1856-1943)

Cognitive science as a field has gone through a long period of discovery and knowledge in its various forms and areas of focus. The findings have stabilized over the years to be able to predict and advise on how best to interact with

the human mind, even if on a limited scale. This book aims to bring together the contributors whose respect for the human mind has led them to take the fruits of this science into account while laboring to design systems that interact with that form of magnificence.

Consequently, this book comes as an expected step forward along the natural path of research that starts with pure theory and ends with concrete designs, development, and assessment of tools. Yet, it is to date unprecedented as it contains an organization of the efforts put forward by researchers and designers of novel approaches into five main streams that feed into a larger river. These streams are partitioned in a fashion that is adequate to the human cognitive machine.

For the first of these, we may notice that all humans start their interactions with the world by utilizing their various senses for perceiving, storing what they perceive in their memory to recall it at a later date. The second investigates the organization of stored information in human memory and the cues that cause someone to recall them in addition to the symbols and analogies that are formed between concepts and their names or concepts and other concepts. The third studies mental reasoning, which is the path followed from what is given to the cognitive system until it gets to the deductions it can make based upon that and this process, if repeated, may cause an interaction with the outside world. This interaction may be in the form of trial and error with the outside world along the path of discovery learning. The fourth stream identifies the individual differences between cognitive characteristics where some individuals may have certain strengths, weaknesses, preferences, or even feel more comfortable interacting with a particular type of system. The fifth and last stream includes real-life case studies that are tested in actual classrooms.

The chapters of this book are therefore representatives of each of these five streams of research in this field in order to cover all possible directions within cognitively informed systems. However, representing each of the five main branches does not imply that these chapters will exhaust all the relevant questions, but instead only act as suggestions of the vast possibilities that may follow along the five main branches.

The first of the streams represents work on perception, recall of images, the effects of externalization of information, and how that interacts with recall during problem solving.

Teresa Chambel et al. in Chapter II exhibit one such direction by altering the classical display of video for learners and presenting them instead in a hyperlinked fashion. The various movie clips can be navigated and learners are allowed to go and review a particular scene or to seek further details

through another such link. The system also allows collaboration within different student groups if they can watch the same movie or reference the same movie clip link. Such work allows researchers to identify how learning from a movie takes place and what parts of the movie may influence learning the most, consequently informing cognitive learning theory of the particularities that are discovered through the application of this approach.

Verhaart and Kinshuk introduce in Chapter III a proposal of how video clips could be stored in memory in multiple representations. Their work complements what is presented in Chapter II by exhibiting the practicality of the approach. In this chapter, the representations are autogenerated and allow the user of the system to retrieve the images in a manner that does not necessitate recall of all details as in using thumbnails to facilitate the retrieval of images. Thumbnails provide the necessary cues to stimulate the recall of a desired object that the searcher forgot parts of its details such as when searching for an image while having forgotten its name.

Chapter IV, on the other hand, as introduced by van Nimwegen et al., has more of an interest in how externalizing rules that have to be followed during problem solving influence what students recall at a later date. This work is extremely informative in that it shows how computer users who follow clear instructions are relieved of the cognitive load imposed by the task they are doing, but at the same time accomplish the task without learning how they did that. Students who were tested several months later revealed that the information presented to them during the problem-solving process affects what goes into their long-term memories from the learning process.

The second of the streams studies the mental representation of concepts, metaphors, and language. The mental representation of concepts is extremely difficult to study even in the field of cognitive science, so one solution is to attempt to organize information in a way that seems most suited to it and to evaluate how that organization aligns itself with human mental representation. Another issue is that of how words are used to “mean” certain concepts or, in a more general view, how analogies or comparisons of different concepts are made. Along this track, three chapters are offered.

In Chapter V, George offers an intuitive organization of a forum that is used for discussions where the links of the forum are places such that they are accessible when a student goes to a relevant lesson. The aim is to show learners how to access what is discussed on that particular topic or relevant topics. The goal is to identify how concepts are related to each other and, in turn, to reflect that by enforcing the links between the various forum contributions to allow a faster, simpler access to students who wish for further feedback or

discussion. Here, the main issue is that of relevancy of the learned materials and how it relates to what is discussed.

Tretiakov and Kaschek, conversely, offer a point of view in Chapter VI that is novel in that it offers an interface that may work with various tutorial systems without requiring any alterations to the actual tutorial system. The interface offers the ability to select various metaphors or concept names and to describe them through analogical comparisons. The aim is to explain to students through a means that allows them a deeper understanding of the concepts that would in turn allow them to make deductions based upon the analogies made.

Ardissono and Gena classify users of the system they built into two levels: novice and expert users. In Chapter VII, they describe how they collected historical data on associations between different information needs that frequently occurred together and utilized the results to make suggestions to users of either of the two knowledge levels adaptively through the system. The time it takes users to access their particular informational needs was greatly reduced through utilizing this historical data of associations that are based on previous requests from the system. Here, knowledge is drawn from past usage in the form of cognitive associations and then applied to the design of this system.

The third of the streams is concerned with mental reasoning. Although some may assume that mental reasoning takes place with analogies, the form discussed in Chapter VI presents the analogies and checks whether students access them. It does not investigate the deductions made. However, the following chapters allow students to make choices, and based upon these choices they attempt to analyze the choices that must be allowed for students and how this can be achieved within the limits of current computer systems.

Chapter VIII, as presented by Tattersall et al., presents a system that studies how students choose the path sequences they follow during learning. It then draws a map of their choices and tries to deduce the most successful paths that were followed. This is then used to suggest to students possible future steps while allowing students the full choices of whether to follow these suggestions. Notice that it is unlikely here that all paths will converge to a single one, as learners are known to have cognitive differences, so this study is likely to illuminate how differences may emerge in the sequences of lessons students follow to achieve more efficient learning.

Chapter IX, by contrast, is presented by Lee, to focus on student collaboration during constructivist study. She uses a blackboard setting to promote scaffolding as represented in presenting partial information to students and allowing them to discuss and attempt to arrive at conclusions based upon the

information they could gather on their own. Here, there is no imposed structure to the knowledge presented, and instead learners must discover it on their own, and the only structure imposed is that by the scaffolding offered by moderators who participated in shaping the discussions and ensuring they are going in the right direction.

However, Beynon and Roe, in Chapter X, offer a contrary view indicating a serious flaw with current programming issues when it comes to applying constructivist approaches. They give a very detailed presentation of the constructivist approach in addition to explaining the core differences between the current programming paradigm and the basic requirements of constructivism. The difference seems to lie between giving learners a goal to accomplish, where they have to draw a plan of how to reach it, and when they are given an environment and no plan is possible other than discovery while their conclusions emerge spontaneously. An interesting perspective here on cognition is that this may relate to what is currently described as cognitive insight as represented as the moment of discovery.

The fourth stream is concerned with individual differences whether they exist within different cognitive characteristics or whether they exist within genders or whether they exist in the frequency and types of errors students may make.

Chapter XI, as presented by Triantis and Pintelas, describes a multiagent architecture where a mobile agent represented by the user interface interacts directly with the learner and seeks to provide whatever is needed by that learner. This agent is able to accomplish this by interacting with other agents that exist in the background with the aim of requesting tutorials from them according to the learning needs of the student. This approach is similar to providing a representative who provides custom designs to each individual accessing the system, to reduce search time, in addition to providing a user-friendly environment and reducing any anxieties that may exist prior to learning.

Morgan and Trauth, on the other hand, present in Chapter XII a detailed analysis of the digital divide between those who have access to the Internet and those who do not take advantage of the digital world. Their emphasis in this particular chapter is on the differences within each gender rather than between the two genders. Their particular focus is on the words used while running Web searches on search engines. People's individual selections of words that are used to represent the concepts they are searching for may differ and therefore impact their use of these search engines and possibly even impact the use of the Internet as a whole. The choice itself is a cognitive one, which is made based on what that particular individual deems as the most

appropriate to describe the concept desired, but this may not correspond to the same choice made by the designers of the various Web sites.

Liu, in Chapter XIII, studies through a Bayesian model the occurrence of guessing in student responses in tests. The study concludes that the level of similarity between the items in the test itself and those presented in the course materials play a crucial role in affecting the amount of successful guesses that students may make. If on the other hand the number of correct answers is fixed in various trials, guessing is yet again affected. This particular chapter identifies, the false positives that may emerge in tests and assists in isolating these especially when evaluating tutoring systems or in student assessments.

The last stream is concerned with a real-world study of the effects of technology on student science achievement. Although the previous chapters are all informative, the whole book and all the ideas proposed have one goal in mind—namely to benefit those who use the systems.

Hilton presents in Chapter XIV a study on 1,194 students in a high school in California. One of the main conclusions made is that the use of technology does affect learning. The main problems exist in how the technology is used, as using it in one way may encourage the amount of learning made while using it in another may hinder learning. This is a clear indicator that care must be taken when designing tutorial system to take into account all cognitive characteristics that may influence learning, because ignoring them may lead to undesired consequences.

The main conclusion that one arrives at is that this book presents practical work that is being done today to bring the findings of a mature science to the world of reality. Various approaches build upon dispersed findings made in perception, reasoning, memory, and so on, to present the world with cognitively informed systems. The book comes as a natural consequence of the evolution of science, and it is not likely to be the last that will be geared toward this particular target. As systems grow more aware of the cognitive state, they are more likely to better serve and be more aligned with what they are built to achieve. The progress continues.

References

- Frost, R. (1971). *The road not taken*. New York: Henry Holt.
- Popper, K. (1963). *Conjectures and refutations: The growth of scientific knowledge*. London: Routledge & Kegan Paul.