

Mental Models: An Interdisciplinary Theory in Teaching and Learning

Amita Kumari

Vinoba Bhave University, Hazaribagh, Jharkhand, INDIA

Parikshit Layek

Sri Ramakrishna Sarada Ashrama Teacher's Training College, Hazaribagh, Jharkhand, INDIA

Rajesh Kumar

Vinoba Bhave University, Hazaribagh, Jharkhand, INDIA

Madhu Singh

Sai Nath University, Ormanjhi, Jharkhand, INDIA

Puja Raj

Sai Nath University, Ormanjhi, Jharkhand, INDIA

ABSTRACT – Mind models are individualized internal images of external reality used by individuals to communicate with their environment. They are built by people on the basis of their unique experiences and views of the world. Mental models are utilized to reason and to decide and may form the foundation of any behavior. They offer the mechanism for filtering and storing new information. A major element of successful natural resource management practice (NRM) is now regarded to recognize and deal with the diversity of views, beliefs and objectives of stakeholders.

Therefore, we will create methods to improve the efficient management and use of natural resources, obtaining a deeper knowledge of how intellectual models reflect complicated dynamic systems internally and how these representations evolve over time. However, the realization of this promise requires the development and testing of sufficient tools and methods to successfully generate these internal representations of the environment. The article presents an interdisciplinary literature synthesis which contributes to the theoretical and practical development of the construction of a mental model. It examines the usefulness and application of the structure in the context of the NRM and includes a discussion of methods employed in the area of elicitation. In relying on the building to give a cognitive component to NRM, significant theoretical and practical difficulties are also addressed.

Keywords: Education; Education Model; Elicitation; Mental Model; Natural Resource Management

I. Introduction

Obtain an understanding of the cognitive factors behind choices, attitudes and behaviors in the field of natural resources management (NRM). These problems and environmental solutions are driven primarily by human decisions and activities. These problems are addressed. Previously, NRM researchers tried to explain behavior by concentrating on stakeholder attitudes, preferences and values. These social sciences do not account for the human ability to forecast results, evaluate connections between causes and effects and thus define their choice of actions, while offering significant insights.

Mental models are regarded as cognitive structures, forming the foundation of thinking, decision-making and comportmentary attitudes, which also detect limits. They are built by people based on their own experiences of life, perceptions and knowledge of the world. They offer the mechanism for filtering and storing new information.

However, each person's capacity to properly portray the world is always restricted and distinct. Therefore, mental models are described as imperfect reality representations. They are also considered inconsistent since they rely on the context and may vary depending on their circumstances. Essentially, mental models have to be extremely dynamic models to adapt and

develop via learning to constantly changing conditions. The conception as dynamic, imperfect models of large systems of cognitive representations recognizes the limiting capacity of humans to conceptualize such complex systems.

Mental models reside within the mind and thus cannot be inspected or measured directly. The field concerned with utilizing the construction for an insight into the inner representations of human beings worldwide is challenged by finding methods of creating a mental model.

We need to know what they are and how they have been conceived in various disciplines in order to comprehend the function of mental models in NRM. The empirical study is based on a theoretical foundation in this topic by providing an interdisciplinary synthesis of the literature on the mental model. This article describes mental models and demonstrates how the building is utilized in different fields. It examines the contribution that the mental model structure may provide in the area of NRM and the key difficulties to achieve this potential.

II. MENTAL MODEL

A. A cognitive representation

Mental models are cognitive representations of outside reality. Initially, psychologist Kenneth Craik (1943) argued that people get a little image of how the world works. The idea is based on a mental model. These models are utilized for occurrences, reasons and explanations. Decades later, in his study on human thinking, the psychologist Johnson - Laird (1983) expanded Craik's concept of a mental model further. A mental model for Johnson-Laird is a method of reasoning in the working memory of the individual. His study, conducted in the field of experimental psychology, supports Craik's thesis that individuals reason using internal model thinking exercises.

The so called 'native theory,' sometimes known as 'naïve physics,' is another significant field of study based on the construction of the mental model. Research looks at how humans comprehend physical or mechanical systems causing processes. Studies have prompted theorists to argue that analogic thinking forms mental models. According to Collins and Gentner (1987) the individual is able to use a familiar domain while explaining an area he/she is unfamiliar with. This includes inserting an existing mental model into another domain and importing its relationship structure. For instance, an electric current may be explained via a mental water flow model; the bodies and relationships related to the former are mapped to the latter.

Experimental research investigating people's explanations of electricity and water molecules (Gentner and Gentner 1983) (Collins and Gentner 1987) shows that they are certainly using analogies in their cognitive processes. Analog thinking enables individuals to "construct new mental patterns that can subsequently be used to anticipate what should happen in different real-world circumstances" (Collins and Gentner 1987:243). Therefore, mental models function as inferential frames, as first suggested by Craik (Gentner and Gentner 1983).

By recognizing that the cognitive mapping theory originates from research of spatial cognition, Abel et al. (1998) conceive of a cognitive map as a 'spatial mental model.' The process of 'cognitive mapping' is that a person receives, stores, codes and remembers world knowledge. The Craik concept of a mental model also gives reasoning and predicting ability to the process of cognitive mapping: "this allows individuals to generalize and utilize such generalization (or generic knowledge) in different situations on the basis of previous experience" (Downs 1976:69). However, reasoning and prediction processes, rather than experimenting with quality thoughts utilizing symbolic patterns, as suggested by Craik and Johnson-Laird, are carried out via the connections and networks of mental objects, which frequently are called "schematic."

B. A dynamic representation

Mental models are 'working models' (Craik 1943, Johnson-Laird 1983), and therefore dynamic, and are widely agreed in the literature. In literature, the dynamic nature of a mind model is addressed in three respects: reasoning, causal dynamics and learning.

1. Reasoning

A distinguishing characteristic of a psychological model is that it is a computer structure (Rutherford and Wilson 2004). In working memory, a mental model may then be operated like a computer simulation that allows a person to mentally explore and evaluate various options before acting. The work-related memory is the means through which information is selected for thought and learning objectives. Changes to a mental model in the simulation process represent what would happen if these changes were really made.

2. Causal dynamics

In this literature, the second dynamic characteristic of a mental model is 'cause knowledge.' In a dynamic system and naïve theory viewpoint, the ability of a mental model to describe (seen) phenomena cause/effect dynamics is investigated. Researchers interested in systems dynamics utilize a pragmatic way of building the mental model: to better comprehend

complex and dynamic systems in order to enhance their design and their user experience (Doyle and Ford 1998, Moray 2004). In this context, an often-cited concept of mental model is that of Rouse and Morris (1986) who see mental model as functional and think of it as a cognitive structure, allowing a person to define, explain, and forecast the objective, form, and function of a system. In this area a mental model has been designed as a "basic knowledge about the way that a system operates" model, given the emphasis on dynamic phenomena (Moray 1998:295).

3. Learning

Another dynamic characteristic frequently alluded to in literature is the ability of mental models to evolve via experience and learning. The distinction between lay (or student) and expert mental models in terms of the content and organization of knowledge are of interest for researchers, especially from the areas of human computer interface (HCI), education, and organizational studies. Research indicates that the lay understanding is featured, while the knowledge of experts is abstract (DiSessa 1983, Greeno 1983, Larkin 1983). This emphasizes the notion that a mental model is created in the mind of a person as a consequence of biology, i.e. the human mind-inherent capacity and 'learning' (Nersessian 2002). Nersessian (2002:140) says that 'by studying domain-special material and methods you may build the nature and wealth of models and improve your capacity to reason.'

C. An inaccurate and incomplete representation

Mental models tend to reflect reality more functionally than completely or accurately. A mental model represents reality in a simplified way, which enables individuals to engage with the environment. Due to cognitive limits, every detail that can be discovered in reality is neither feasible nor desired. Aspects represented by the mental model as well as the knowledge base or current knowledge structures are affected by the objectives and motivation of one individual, as stated above, which may be defined as 'mental models which exist in long-term memory.' In filtering incoming information, mental models play a role thus. The "confirmation bias" hypothesis (Klayman and Ha 1989) argues that individuals are looking for information that suits their existing world view. Information received may strengthen or be rejected outright, current mental models.

III. MENTAL MODEL ELICITATION IN NATURAL RESOURCE MANAGEMENT

In the field of mental models, interest is gaining pace as practitioners are more aware of how many values and objectives are associated with a particular resource and the variety of views by stakeholders about the operation of NRM

systems must be taken into consideration. Mental models are elicited for the following reasons:

- Exploring parallels and variations in understanding of a problem across stakeholders to enhance communication between parties involved
- Integrating various views, including expert and local perspectives, to enhancing overall system knowledge • Create collective system representation to enhance decision-making
- Support social processes of learning
- To discover and overcome knowledge gaps and misunderstandings related to a certain resource
- To increase socially stronger knowledge to assist discussions in complex, multifunctional systems on unstructured issues

For NRM practitioners, the mental model structure is appealing by taking into consideration the ideas stakeholders deem essential or relevant for a field and how those concepts are organized or structured cognitively by stakeholders. This gives insight into the linked and dynamic characteristics of NRM systems for stakeholders. By defining the building as an object-representing cognitive structure in the area of the NRM, Biggs et al. (2008:3) reflects the qualities and dynamic of the objects and the value (cognitive and emotional) of the individual in objects, relationships and dynamics.

In the area of natural resource management, a number of elicitation methods were employed for various objectives. The bulk of the methods employed are based on the premise that the mental model of a person is a network of concepts and connections. Some methods have been developed to lead the interviewee via a diagrammatic interview to a network representation of the mental model. The researcher must recreate or deduce, using oral interview data or questionnaire data, the network in other methods.

A. Direct elicitation

The methods for direct elicitation require respondents to express their knowledge of a particular topic. Participants may be requested to use photos, phrases and symbols to create a diagram of their mental model or to give existing ideas in a deck of cards and to organize them into an image. The assistance given to participants by the nature of the elicitation process for an external representation of their mental model offers an instant way of verifying the absence of indirect elicited methods.

The conceptual content map (3CM) procedure was proposed by Kearney and Kaplan. This method requires participants to

select ideas that they think are essential for a field and then ask them to arrange them in a spatial and visual manner that shows how they understand that field. Spatial mapping is very compatible with the processing of human information. The mapping activity helps people to examine their own cognitive organization as they are dealing with the job (Austin 1994). This position is backed by research that indicates that cognition is based not only on language but also on images and that verbal and imaginary thinking is conducted by 2 different but partially linked systems (Kearney and Kaplan 1997:595). In the area of NRM the 3CM method has been used to examine nature in the framework of forest management of various actors' viewpoints (Austin 1994, Kearney et al. 1999, Tikkanen et al. 2006). In order to assess the similarity and dissimilarity of stakeholder opinions, the analysis includes a mix of qualitative and quantitative processes.

IV. CHALLENGES IN APPLYING THE MENTAL MODEL CONSTRUCT TO NATURAL RESOURCE MANAGEMENT

The mental model structure has the capacity to offer individuals an insight into natural processes and therefore the management of natural resources. It offers a method that enhances our capacity to comprehend human motives, for example attitudes, values and beliefs, which have been shown to be restricted in other social sciences. A number of scientific problems need to be solved in order to realize this promise.

The problem of elicitation is a first difficulty, which presents a variety of relevant issues of methodological study. What are the relative strengths and disadvantages of mental model generation directly and indirectly, and specific methods of excitation and analysis? Are various techniques appropriate to different settings and purposes? How do they meet the problem of accurate external representation of ways of thought that are seldom accessible? How effective are they in their own rights and how much does the social scientist's ability to perform and understand the elicitation process rely on them? To what degree can interpersonal variables such as trust and honesty influence the elicitation process and, thus, the outward representation of and future usage of a mental model? From the existing literature these issues cannot be addressed easily; the writers will carry out additional study.

An issue strongly linked to this question of elicitation concerns the 'Action Theories' of Argyris and Schon (1974). This is how we can tell whether the mental model chosen reflects the 'spoused theory' or its 'theory in use' (what they say) of the interviewee? The ultimate differences between them are frequently responsible for disputes between so-called behavioral models and mental models. If mental modelling is

supposed to be a cognitive process on which rationale, decision making, and behavior are founded, it is the "theory-in-use" form of the mind model, which we are most interested in, in certain instances, depending on the study objective.

V. CONCLUSION

Using the structure of this mental model, individuals are conceptually attracted to the environment around them in order to get insight into how people conceive and, therefore, are willing to take action. An approach to cognitive mental model extends beyond the preferences, objectives, and values of the stakeholders in relation to a particular resource to provide a good picture of the functioning of natural resources systems. This image tells us not only which ideas stakeholders see as essential to a particular problem, but also how these concepts are cognitively structured and how they interact dynamically. It provides an insight into how individuals understand a system, how the system thinks it can react to interventions and how it may interfere. Compared between the similarities and differences in knowledge, the total understanding of the system and collective action may be improved across time and place.

Theoretical evidence continues to suggest that individuals really utilize mental models to reason and make forecasts about the world around them within the areas of psychology and cognitive science. However, a number of difficulties remain in order to properly position the building within the NRM domain. One of the first challenges is to continue improving mental modelling techniques. NRM domain systems are complex and dynamic and operate on a variety of time and space levels. The methods of elicitation must thus be able to include this complexity and must be able to reflect people's thoughts clearly and legitimately. While additional research has much to offer, such as system research and risk communication, to evaluate the relative advantages of current technologies and to create new methods that are suitable for NRM. Actors from a variety of socio-cultural backgrounds within the NRM setting are usually varied. Therefore, eliciting methods must address NRM's interpersonal variety and complexity of actor interactions. An approach to rich mental models in NRM might therefore aim to develop communication and co-operation among actors by utilizing mental models to help one another (Abel et al. 1998). It would guarantee that mental models may be generated holistically that goes beyond biophysical and tangible process mental models to include people's knowledge of governance and interactions between actors, including trust and different values.

VI. References

- [1]. Cambridge University Press, Cambridge, UK.
- [2]. Gentner, D., and D. R. Gentner. 1983. Flowing waters or teeming crowds: mental models of electricity. Pages 99-130 in D. Gentner and A. Stevens, editors. *Mental models*. Lawrence Erlbaum, Hillsdale, New Jersey, USA.
- [3]. Greeno, G. J. 1983. Conceptual entities. Pages 227-252 in D. Gentner and A. Stevens, editors. *Mental models*. Lawrence Erlbaum, Hillsdale, New Jersey, USA.
- [4]. Hall, R. I., P. W. Aitchison, and W. L. Kocay. 1994. Causal policy maps of managers: formal methods for elicitation and analysis. *Systems Dynamics Review* 10:337-360.
- [5]. Hodgkinson, G. P., A. J. Maule, and N. Brown, J. 2004. Causal cognitive mapping in the organizational strategy field: a comparison of alternative elicitation procedures. *Organizational Research Methods* 7:3-26.
- [6]. Hollnd, J. H., K. J. Holyoak, R. E. Nisbett, and P.
- [7]. Jagathkar, A. and Jain, D. (2020) "Digitized Education: A New Social Divide between Rural and Urban India", *IARS' International Research Journal*, 10(1). doi:10.51611/iars.irj.v10i1.2020.115.
- [8]. Jain, D. (2019) "DON'T KILL INNOVATION: CONCEPT TOWARDS A NEW ACADEMIC WORLD", *IARS' International Research Journal*, 9(1). doi:10.51611/iars.irj.v9i1.2019.98.
- [9]. Johnson-Laird, P. N. 1983. *Mental models*.
- [10]. Johnson-Laird, P. N. 1989. *Mental models*. Pages 467-499 in M. I. Posner, editor. *Foundations of cognitive science*. MIT Press, Cambridge, Massachusetts, USA.
- [11]. Kearney, A. R., and S. Kaplan. 1997. Toward a methodology for the measurement of knowledge structures of ordinary people: the conceptual content cognitive map (3CM). *Environment and Behavior* 29:579-617.
- [12]. Kearney, A. R., G. Bradley, R. Kaplan, and S. Kaplan. 1999. Stakeholder perspectives on appropriate forest management in the Pacific Northwest. *Forest Science* 45:62-73.
- [13]. Mathevet, R., M. Etienne, T. Lynam, and C. Calvet. 2011. Water management in the Camargue Biosphere Reserve: insights from comparative mental models analysis. *Ecology and Society* 16 (1):43. [online] URL: <http://www.ecologyandsociety.org/vol16/iss1/art43/>
- [14]. Moore, G. T., and R. G. Golledge. 1976. *Environmental knowing: concepts and theories*. Pages 3-24 in G. T. Moore and R. G. Golledge, editors. *Environmental knowing: theories, research and methods*. Dowden Hutchinson and Ross Inc, Stroudsburg, Pennsylvania, USA.
- [15]. Moray, N. 1998. Identifying mental models of complex human-machine systems. *International Journal of Industrial Ergonomics* 22:293-297.
- [16]. Moray, N. 2004. Models of models of...mental models. Pages 506-526 in N. Moray, editor. *Ergonomics: major writings*. Taylor and Francis, London, UK.
- [17]. Morgan, M. G., B. Fischhoff, A. Bostrom, and C. Atman, J. 2002. *Risk communication: a mental models approach*. Cambridge University Press, New York, New York, USA.
- [18]. Nersessian, N. J. 2002. The cognitive basis of model-based reasoning in science. Pages 133-153 in P. Carruthers, S. Stich, and M. Siegal, editors. *The cognitive basis of science*. Cambridge University Press, Cambridge, UK.
- [19]. Osborne, R. J., and M. M. Cosgrove. 1983. Children's conceptions of the changes of the state of water. *Journal of Research in Science Teaching* 20:825-838.
- [20]. Ozesmi, U., and S. L. Ozesmi. 2004. Ecological models based on people's knowledge: a multi-step

- fuzzy cognition mapping approach. *Ecological Modelling* 176:43-64.
- [21].Pahl-Wostl, C., and M. Hare. 2004. Processes of social learning in integrated water management. *Journal of Community and Applied Social Psychology* 14:193-206.
- [22].Quinn, N. 2005. How to reconstruct schemas people share. Pages 33-81 in N. Quinn, editor. *Finding culture in talk: a collection of methods*. Palgrave Miller, New York, New York, USA.
- [23].R. Thagard. 1986. *Induction: processes of inference, learning, and discovery*. MIT Press, Cambridge, Massachusetts, USA.
- [24].Rabac, K. and Jain, D. (2021) "STUDY ON PROJECT MANAGEMENT IN EMOTIONAL INTELLIGENCE", *Amity Journal of Professional Practices*. Florida, USA, 1(01). doi: 10.55054/ajpp.v1i1.459.
- [25].Raheja, S. and Jain, D. (2021) "AN EMPIRICAL STUDY OF SELECTED INDIAN COMPANIES' TALENT MANAGEMENT", *Amity Journal of Professional Practices*. Florida, USA, 1(01). doi: 10.55054/ajpp.v1i1.461.
- [26].Rickheit, G., and L. Sichelschmidt. 1999. Mental models: some answers, some questions, some suggestions. Pages 9-40 in G. Rickheit and C. Habel, editors. *Mental models in discourse processing and reasoning*. Elsevier, Amsterdam, The Netherlands.
- [27].Rouse, W. B., and N. M. Morris. 1986. On looking into the black box: prospects and limits in the search for mental models. *Psychological Bulletin* 100:349-363.
- [28].Rutherford, A., and J. R. Wilson. 2004. Models of mental models: an ergonomist-psychologist dialogue. Pages 309-323 in N. Moray, editor. *Ergonomics major writings: psychological mechanisms and models in ergonomics*. Taylor and Francis, London, UK.
- [29].Samarapungavan, A., S. Vosniaudou, and W. F. Brewer. 1996. Mental models of the earth, sun and moon. *Cognitive Development* 11:491-521.
- [30].Sterman, J. D. 1994. Learning in and about complex systems. *System Dynamics Review* 10:291-330.
- [31].Sterman, J. D. 2000. *Business dynamics: systems thinking and modeling for a complex world*. Irwin McGraw-Hill, Boston, Massachusetts, USA.
- [32].Stone-Jovicich, S. S., T. Lynam, A. Leitch, and N. Jones. 2011. Using Consensus Analysis to Assess Mental Models about Water Use and Management in the Crocodile River Catchment, South Africa. *Ecology and Society* 16(1):45. [online] URL: <http://>
- [33].Strauss, C., and N. Quinn. 1997. *A cognitive theory of cultural meaning*. Cambridge University Press, Cambridge, UK.

Transforming Research

Manuscript Processing Footprints

A. Journal Volume/Issue Details

This manuscript is published in Vol. 15 No. 01 2025 issue of IARS' International Research Journal (I'IRJ).
This is a Peer Reviewed (Refereed) International Journal published by IARS' Press Australia (International Association of Research Scholars)
The Volume/Issue is a regular issue of the journal published in February 2025 Available at: <https://research.iars.info/index.php/curie>.

B. Copyright, License, and Publishing Rights

- IARS' Press Australia (International Association of Research Scholars) respects the rights of the authors of research content published with IARS' International Research Journal. The "First Publication Rights" (FPR) to the original work accepted for publication at IARS' International Research Journal is granted to the Publisher of the Journal but copyright for all work published in the journal is retained by the author(s). Works published in the Journal are distributed under a Creative Commons Attribution 4.0 International License (CC BY 4.0). (This license lets others distribute, remix, adapt, and build upon your work, even commercially, as long as they credit you for the original creation. This is the most accommodating of licenses offered. Recommended for maximum dissemination and use of licensed materials.)
- After publishing the content with IARS' International Research Journal, the author holds complete right on the content for its amendments and reuse in any form. IARS' International Research Journal confirms that author(s) holds the copyright of the content.
- Author(s) grant(s) permission for their work to be indexed in part/full form in commercial and non-commercial indexes. Author(s) grant(s) permission for their work to be harvested in part/full form in commercial and non-commercial archives and distributed through them. Author(s) grant(s) permission for their work to be translated in part/full form in any language and republished and redistributed. Author(s) may enter into separate, additional contractual agreements for the non-exclusive distribution of the published version of the work, with an acknowledgement of its initial publication in this Journal.
- It is the responsibility of the author(s) to secure all necessary copyright and/or permissions for the use of third-party content in their manuscript(s). Author(s) have declared the same at the time of submission of manuscript and 'may also be required' to provide written evidence of this permission anytime in case required for any purposes.
- Publications Ethics and other Terms and Conditions as mentioned on official website of IARS' International Research Journal.

C. Last Plagiarism Report



Settings: Quotes Excluded, Bibliography Excluded

Mental Models: An Interdisciplinary Theory in Teaching and Learning 1 part - 3,506 words	Amita Kumari	8%
---	--------------	----

Exemption / Relaxation by Editor: None

D. Processing Track

Date of Submission	30 November 2024
Date of Final Review	17 January 2025
Date of Acceptance & Schedule	17 February 2025
Date of Publishing	28 February 2025

----- ○ -----