Learning the Construction Project Management System (CPMS): An Ontological Method

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Abstract **—** This paper describes an ontological framework for learning the construction project management system (CPMS), systemically and systematically. The framework has five dimensions: Outcomes, Stages, Resources, Processes and Management techniques. Each dimension is defined by a taxonomy derived from the literature and practice. The dimensions are ordered left to right such that a meaningful natural language sentence describing an attribute of CPMS can be concatenated by selecting a word from each column and combining the selected words with the words interleaved between the columns. There are 11,970 potential CPMS attributes encapsulated in the ontology. The paper discusses how this framework can be used by different types of project team members based on their Myers-Briggs Type Indicator (MBTI) for learning the project management system. It describes how the sensers and the intuiters can use the framework for managing information, and how the thinkers and the feelers can use it for making decisions. And thus the project team can use the framework as a common mind map to learn the CPMS. The ontological framework can be adapted to other project management systems by suitably modifying the dimensions and their taxonomies.

Keywords - construction project management; ontology; learning; MBTI; systems approach

I. INTRODUCTION

Today, in the age of globalization, systems thinking is important in almost every discipline – art and architecture, business and biology, climate change and cultural studies, design and development, economics and engineering, medicine and mechanical engineering, and political science and project management, to name a few. Many concepts of systems thinking have become a part of our daily discourse: we metaphorically talk of the whole and its parts, modular designs, synergies, unintended consequences, tipping points, viral effects, systemic failures, chain reactions, virtuous and vicious cycles, systemic meltdowns, and the butterfly effects. As the problems to be solved breach disciplinary boundaries the need for systems thinking becomes critical. A systemic approach to project management in general and construction project management in particular, has to supplement the metaphorical invocation of systems thinking with methodical learning of such thinking.

In an earlier paper we have discussed how: "Construct projection management is a child of project management which in turn is a child of management. It acquires, adapts, and applies techniques from its parent disciplines to improve the efficiency and performance of construction projects. Early in its history project management was anchored on a few key techniques such as PERT (Project Evaluation and Review Technique) and CPM (Critical Path Method); GANTT charts and PERT charts were the icons of project management. Today, the range of specialized techniques deployed has increased dramatically; it includes stakeholder management, scope management, risk management, waste management, and many more. This growth reflects, on the one hand, the increasing scale, scope, and complexity of construction projects, and on the other, the increasing requirements, regulations, and the rate of change of the construction environment. Effectively integrating the portfolio of specialized techniques for managing a construction project requires a systemic approach – a construction project management system (CPMS). Such a system is needed to exploit the interdependencies and synergies between the techniques, prevent shortsighted strategies, avoid dysfunctional unintended consequences, and forestall unrecoverable systemic failures. It has to reckon with the actuality of the complex projects (Cicmil, Williams, Thomas, & Hodgson, 2006)." (Ramaprasad, Prakash, & Rammurthy, 2011)

The challenge of learning CPMS can be illustrated using the parable of the six blind men and the elephant. Each of the men, wanting to know the elephant, touches a different part of an elephant's body and declares the elephant to be like a rock (body), pillar (leg), rope (tail), arrow (tusk), fan (ear), and tree (trunk). While the men are debating their different imaginations a wise man intervenes. He affirms all six imaginations and explains how each is about a part of a whole elephant which they have not seen. The conceit in the parable, however, is that there is a wise person who sees the whole elephant and from whom the blind men can learn.

What if there is no wise person, including the project manager, who sees the whole system? What if everybody's imagination is incomplete? How the system is imagined will determine how a particular project management problem is formulated and solved. For example, is the delay due to a contractor's tardiness or the inefficiencies of transportation in the supply chain? How does one imagine the system from its parts, and fit the parts to the whole – like six blind men without a wise man? The CPMS has to help the project members see the invisible 'elephant' (the system), to make it real, and to help them formulate the problems correctly and solve them, and not solve the wrong problems (Mitroff & Emshoff, 1979). This is our vision for learning CPMS. Without learning the CPMS as a whole, the fragmented learning of techniques can be counterproductive. How well the CPMS is learned will determine how well the project is managed as a whole. We propose an ontological framework for the project members learn the CPMS 'elephant' as a whole and make it visible.

When asked to describe their CPMS, project members commonly describe its various elements based on their personal experience, research, assumptions, and imagination – each from his or her perspective. Further, when asked to imagine the whole system from these partial, natural- language descriptions of fragments of the system they feel overwhelmed. They are unsure where to begin, how to organize the pieces logically, how to interpret them together meaningfully, and how to translate their insights into action effectively. Their portrait of the system which emerges is incomplete and unsatisfactory. Consequently, they fail to formulate and solve problems effectively. The learning of CPMS has to help them reason systemically and solve problems effectively.

Learning CPMS is important at all levels of project management. For example, the project managers need to know the CPMS to synthesize their knowledge and experience; the project supervisors need it to design and develop systems; and the project members need it to simply understand systems. Project personnel can map their cognition of CPMS using many techniques such as pictorial images, physical models, schematics, cause diagrams, mathematical equations, simulations, and literal descriptions. To this repertoire we add the ontological method. It can be used to generate a natural-language based, concise, and comprehensive map of CPMS. The map is modular and parsimonious, can be scaled to different levels of granularity, and adapted to the desired scope. In the following we will describe the learning of CPMS using the ontological method.

II. ONTOLOGY OF A CONSTRUCTION PROJECT MANAGEMENT SYSTEM (CPMS)

The following description of the ontology of CPMS is from an earlier paper by the authors. (Ramaprasad et al., 2011) Ontologies are used to systematize the description of complex systems (Cimino, 2006) ; they are an "explicit specification of a conceptualization." (Gruber, 1995, p. 908)The following is a brief description of ontological analysis and design:

> *"We will define [an ontology] as a logically constructed n-dimensional natural language description of the problem. The dimensions are derived from the problem statement. Each dimension is independent of the other and is a taxonomy of discrete categories. Each taxonomy may be flat or hierarchical. Further, the order of categories in a particular dimension at a particular level of the taxonomy may be nominal (no particular order) or ordinal (based on some parameter). The stages of progression along the dimension, the sequence of evolution, the progressive part-whole relationships, the scale, etc. are some bases for ordering the categories. Last, a dimension may have sub-dimensions with their own taxonomies. That is, a dimension itself may be hierarchical."*
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> *The ontology is presented as a number of text columns, each column representing a dimension of the problem .... It is in fact an n-dimensional matrix with text entries in each cell. Each column contains categories and subcategories corresponding to the taxonomy of that dimension. A combination of categories or sub categories across all the dimensions, with specified prepositions and conjunctions, is a natural language descriptor of a component of the problem in the form of a sentence, sometimes an awkward sentence. The set of all combinations across all categories – that is all possible sentences – is a closed description of the problem. The full set can have a very large number of descriptors (individual combinations). However, many of the combinations may be irrelevant or meaningless – they may be discarded from further consideration. At the same time some combinations may be novel and creative, providing valuable insights into the problem and its solution.*
>
> *A parsimonious choice of dimensions, taxonomies of dimensions, and selection of combinations (with appropriate prepositions and conjunctions) is essential for effective formulation and solution. The formulation can be modified or extended by substituting or adding new dimensions, new taxonomies, and new categories and subcategories within taxonomies." (Ramaprasad & Papagari, 2009)*

The proposed ontology of CPMS is shown in Figure 1. It has been developed by analyzing and organizing the key dimensions of project management systems embodied in PMBoK (Project Management Institute) and the published literature. We will describe the ontology in the following.

The five dimensions of the ontology are represented by the five columns in the figure. They are:

- Outcomes: These are the outcomes generally desired in projects. They are broadly classified as efficiency and performance outcomes. Efficiency outcomes, in turn, are usually measured with reference to cost and time. While the efficiency of use of other resources could be included in the list (the ontology is easily extensible), most of them usually devolve to cost in the final measurement. Similarly, performance outcomes are measured in terms of quality, safety (Cameron & Hare, 2008), sustainability (Fernández-Sánchez & Rodríguez-López, 2010; Shiers, Rapson, Roberts, & Keeping, 2006), and satisfaction (Forsythe, 2007). The taxonomy reflects the evolution of desired construction project management outcomes – sustainability and satisfaction outcomes are of recent origin. As with efficiency, other categories of performance can be added.

- Stages: The three broad stages of a project are conceptualization (or visualization), construction, and closing. Each of these stages can be further refined with subcategories, or the dimension can be extended with additional categories. Construction, the object of this research, has been subcategorized into de novo or new construction, demolition, deconstruction, and reconstruction. This choice of subcategories of construction in a project will affect the design of its CPMS. The three stages are sequential with feedback processes linking a subsequent stage to the previous stages, and feed-forward processes linking the prior stages to subsequent stages. Thus, as construction proceeds there could be some reconceptualization based on feedback and the need to adapt to unexpected environmental conditions; and as segments of the project approach closing there could be reconstruction to correct errors or reconceptualization to fit changed expectations. The feedback will help achieve the desired outcomes. Similarly, conceptualization can inform construction, and construction can inform closing through feed-forward mechanisms to obtain the desired outcomes.

- Resources: The seven types of resources a construction project has to manage are time, manpower, material, space, cost, information, and energy. The subcategory of equipment is listed under material to highlight its importance in construction. It must be noted that information is a key resource in any CPMS – the success of the system will depend upon how well it can informate (convert into information) the other resources. Thus, for example, the outcome of CPMS will depend upon the reliability and validity of the information it has about manpower, not on the actual manpower. The taxonomy of resources can be extended with more categories or deepened with refined subcategories.

Process		**Resources**		**Stages**		**Outcomes**		**Management Techniques**
Planning	[+]	Time		Conceptualization	[for]	Efficiency		Stakeholder managemement
Monitoring		Manpower		Construction		Cost		Scope Management
Controlling		Material	[during]	De novo		Time	[using]	Communication Management
		Equipment		Demolition		Performance		Cost Management
		Space		Deconstruction		Quality		Schedule & Time Management
		Cost		Reconstruction		Safety		Procurement Management
		Information		Closing		Sustainability		Tender Management
		Energy				Satisfaction		Human Resource Management
								Logistics Management
								Risk Management
								Change Management
								Contract Management
								Quality Management
								Claims Management
								Vendor Management
								Needs Management
								Integration Management
								Waste Management
								Knowledge Management

Illustrative components of a Construction Project Management System

Planning time during conceptualization for efficiency using scope management.

Monitoring manpower during construction for performance $_{\text{safety}}$ using contract management.

Controlling cost during closing for performance $_{\text{sustainability}}$ using waste management.

Planning cost during constuction$_{\text{deconstruction}}$ for sustainability using waste management.

Figure 1 : Ontological framework of CPMS

- Processes: The three classic processes underlying any project management are planning, monitoring, and control – they form the essence of PMBoK (Project Management Institute). They are listed in that order. The processes are sequential, continuous, and iterative. They form a negative feedback (in the cybernetic sense – not negative reinforcement) mechanism seeking to eliminate deviations from the desired outcomes. Planning specifies the outcomes, monitoring determines the gap between the desired and actual/anticipated outcomes, and controlling acts to eliminate the gap. The processes are almost entirely information-based further emphasizing the role of information resources in a CPMS.

- Management techniques: The dimension lists a range of management techniques likely to be used in a construction project (see for example (Gorse & Emmitt, 2007; Lindahl & Ryd, 2007; Navon & Berkovich, 2006; Price & Chahal, 2006; Schieg, 2006; Yang, Shen, Bourne, Ho, & Xue, 2011). They are listed in the order in which they are likely to be introduced into the project. They also reflect the specialized knowledge needed to manage a modern construction project, a feature further highlighted by the introduction of Knowledge Management itself as a management technique. The techniques are not mutually independent of each other – there is likely to be a strong interaction between them. For example, procurement management and logistics management are likely to be strongly dependent on each other. A CPMS has to minimize the dysfunctional interactions and maximize the functional ones.

The dimensions are ordered left to right such that a meaningful natural language sentence describing an attribute of CPMS can be concatenated by selecting a word from each column and combining the selected words with the words interleaved between the columns. Three illustrative sentences are given at the bottom of Figure 1, with subscripted words used to indicate subcategories in the ontology. They are:

- Planning time during conceptualization for efficiency using scope management: A CPMS which plans for time as a resource at the conceptualization stage itself while managing the scope of the project will likely increase the time efficiency of the project.
- Monitoring manpower during construction for performance $_{safety}$ using contract management: A CPMS which has built in provisions in the contract for monitoring the manpower for safety (for example, training for safety and use of safety equipment) is likely to increase the performance safety of the project
- Controlling cost during closing for performance $_{sustainability}$ using waste management: A CPMS which controls closing costs using waste management techniques to ensure sustainability is likely to be effective in performance $_{sustainability}$.
- Planning cost during construction $_{deconstruction}$ for sustainability using waste management: A CPMS which helps plan for deconstruction costs to assure performance $_{sustainability}$ using waste management techniques.

There are 11,970 potential CPMS attributes encapsulated in the ontology. Ideally a CPMS should emphasize all of them; practically it will likely focus on a subset selected based on the characteristics of the project and its environment. The challenge in designing a CPMS is to include the key attributes and exclude the less important ones. The ontology will help make these systemic choices systematically by displaying all the possibilities. However, in doing so, one has to consider the interactions among the categories of a dimension and between dimensions. These interactions play an important role in the dynamics of CPMS. In the following we will discuss some illustrative interactions.

Though one may seek to maximize both efficiency and performance, there is usually a tradeoff between the two. For example, there is a threshold beyond which quality, safety, sustainability, and satisfaction are likely to become cost and time prohibitive (Love & Irani, 2003; Rosenfeld, 2009). It is necessary to know the relationship between these measures to be able to make an informed choice. These choices may have to be revisited at each stage, namely: conceptualization, construction, and closing. New information which becomes available as the project progresses has to be factored into the tradeoff. Thus, an architect may be compelled to compromise on the high expectations for quality he/she had set during conceptualization due to lack of the requisite skilled labor during construction – acquiring the labor could be cost prohibitive.

A variety of management techniques may be deployed to establish the profile of desired outcomes. Stakeholder management could help determine the priorities of the architects, the designers, the builders, the customers, the regulators, etc. Quality management can be used to set quality requirements while needs management can be used to set user/customer expectations. The diverse techniques will likely provide a wide range of outcome criteria, some of which may be in conflict with one another; it is necessary for the CPMS to reconcile them to ensure a convergence of outcome measures.

It is the task of the project manager to map the outcome measures to the resources as part of the process of planning, monitoring, and controlling the project. The precision and accuracy of the mapping will depend upon the project, the environment, and the knowledge of the CPMS. For this reason knowledge management (listed as a technique) (Senaratne & Sexton, 2008) can play a key role in the CPMS. At the same time the absence of or incorrect information/knowledge can be the source of uncertainty and risk, necessitating systematic risk management.

Thus, the ontology provides a framework to systematically explicate the interactions between and within dimensions. In addition to documenting the known interactions it compels the project manager to consider that may have been overlooked: for example, 'planning information during conceptualization for performance safety.' If safety is a high priority outcome it would behoove the people conceptualizing the project to proactively plan for information to ensure the same. Otherwise, the information may not be adequate or appropriate to monitor and control safety.

In summary the ontology is a concise, comprehensive, and comprehensive framework for imagining the CPMS. In the following section we will illustrate how the ontology can be used to learn the CPMS.

III. LEARNING THE CPMS

Learning project management by the participants has been critical to the success of a project to date; learning the project management system will be critical to the success of the project in the future. In addition to the traditional individual cognitive learning it entails situated learning – learning in the field, the situation where it is applied; action learning – learning from the actions and their outcomes through feedback (Ramaprasad, 1983); and social learning – learning in the social context of other project team members and stakeholders. Sense (2007b, p. 405) "argues that project learning and the learning competency development of project practitioners are most appropriately pursued through the creation and maintenance of supportive situated learning environments within projects." We agree with the "theoretical proposition" that "the emphasis should also be directed towards the situated (or social and practical) dimension of learning within each project context, rather than be confined to the narrow consideration of learning as only a cognitive process." (Sense, 2007b, p. 411)We argue that the ontological method for learning CPMS can facilitate "practitioners' systematic and communal reflection on their learning practices and helps develop their skills in 'learning how to learn'. " (Sense, 2007b, p. 405) It can help "to take account of the situated lived realities of those working in the sector." (Chan & Räisänen, 2009, p. 907) Further, the project members' conception of their work can affect their performance of the work. (Chen & Partington, 2006) The ontological method for learning CPMS can aid all types of learning and help the members imagine project management work systemically and systematically. It can help refine their cognitive map of the project and hence their effectiveness in the project (Ramaprasad & Mitroff, 1984).

Two underlying dimensions of learning, irrespective of the type of learning, are: the type of information used and the method of information processing. The Myers-Briggs Type Indicator (MBTI) (Briggs-Myers & McCaulley, 1985)is a widely used framework for describing these dimensions. It has been used to study learning (Sense, 2007a), teaming (Chi & Chen, 2009), and career development (Madter, Bower, & Aritua, 2011) in project management.

In MBTI the type of information used in learning is labeled as sensed (S) – obtained through simple abstraction (Ramaprasad & Mitroff, 1984) using the five senses , or as intuited (N) – obtained through reflexive abstraction (Ramaprasad & Mitroff, 1984) of the sensed and other information. Sensed information is raw, intuited information is pre-processed. For example: While a child beginning to read learns to sense the letters of a word before constructing the whole word, adults intuit the whole word directly without necessarily sensing the letters individually. Similarly, a project member may be extremely adept at sensing all the project problems individually but unable to intuit a pattern from the. On the other hand, another project member may be able to intuit a problem without articulating the sensed symptoms of the same. The interaction of these two types of people – the senser of symptoms and the intuiter of problems – are both essential for effective project management. The method of information processing in learning is labeled as thinking (T) emphasizing cognitive processing or feeling (F) emphasizing affective processing. Thinking is logical feeling is alogical. A thinking project member can be the logical anchor of solving project problems based on past experience, learning to date, and the learning from others; while the feeling member can be the affective anchor understanding the perspectives of the people involved, extracting a common thread, and generating a consensus. Sense (2007a, p. 36) paraphrases the four modes as follows: "…a sensing person (S) is more inclined towards seeking the fullest detailed experience of what is immediate and real. An intuitive person (N) seeks the broadest view of what is possible and insightful. A thinking person (T) likes to make decisions based upon rational and logical planning and a feeling person (F) likes to make decisions based upon harmony among subjective values."

For the sensing person the CPMS ontology provides a framework for categorizing and organizing the detailed data he or she collects (the 'letters' of project management) – a theory about practice; and for the intuitive person it provides a framework for painting the big picture highlighting the emphases on the different dimensions and categories (the 'words' and 'sentences' of project management) – a theory for practice. Project members with sensing as their dominant character would access, gather, analyze, categorize, arrange, attribute and allocate information in appropriate manner for achieving solutions. With their questioning mind and inquisitiveness, sensing personnel would check and recheck data for their correctness, and hence would have more valid information. Sensing persons are likely to be proactive and systematic in managing information. They are also likely to be efficient in delegation and solution driven. Project members with intuition as the dominant character, on the other hand, are usually far sighted, and interested in abstract information. They can see through the systems and are oriented towards theory rather than regular practice. They are considered to be good resources for designing solutions and recommendations. They are efficient in delegation with empowerment. They are driven by deliverables rather than means to reach them. They are very articulate in their substantiation of their actions.

Similarly, for the thinking person the CPMS ontology provides a framework for systematically and systemically analyzing the large number of concatenations of categories across dimensions encapsulated in the ontology; and for the feeling person it highlights the compatibilities and conflicts between the different combinations at an aggregate level. They translate the ontology as theory into practice in different ways. Thinking personalities have significant advantage on giving judgments and creating options for problem resolution from a detached point of view. From the gathered data, these types of people would assist in analyzing data, interpret them and pass judgment based on facts placed through systematic exploration and insights. These types of people would logically place data and would go by the rules of the project and assist in decision making. Persons with feeling as their dominant function empathize on the situation to serve decision making. These personalities would look at the needs of the people and for them the

CPMS ontology would be catalyst in converting data into meaningful actions. It would help them heuristically analyze – feel through – the intended and unintended consequences of any contemplated action.

IV. DESIGNING A LEARNING CPMS

The two dimensions of MBTI are considered to be orthogonal thus resulting in four styles, namely: Sensing-Feeling (SF), Sensing-Thinking (ST), Intuitive-Feeling (NF), and Intuitive-Thinking (NT). The four styles are shown schematically in Figure 2, and in the context of this paper they have been labeled evidence-based synthesizers (SF), evidence-based analyzers (ST), ontology-based synthesizers (NF), and ontology-based analyzers (NT) respectively. The evidence-based synthesizers use sensed data to get a feel for the project; the evidence-based analyzers analyze the sensed data to obtain insights about the project; the ontology-based synthesizers fit the intuited data into the ontology to get a feel for the project; and the ontology-based analyzers use the ontology to analyze the intuited data systemically and systematically. In the following we will discuss how the ontology of CPMS can accommodate the four different learning styles of the project members based on MBTI.

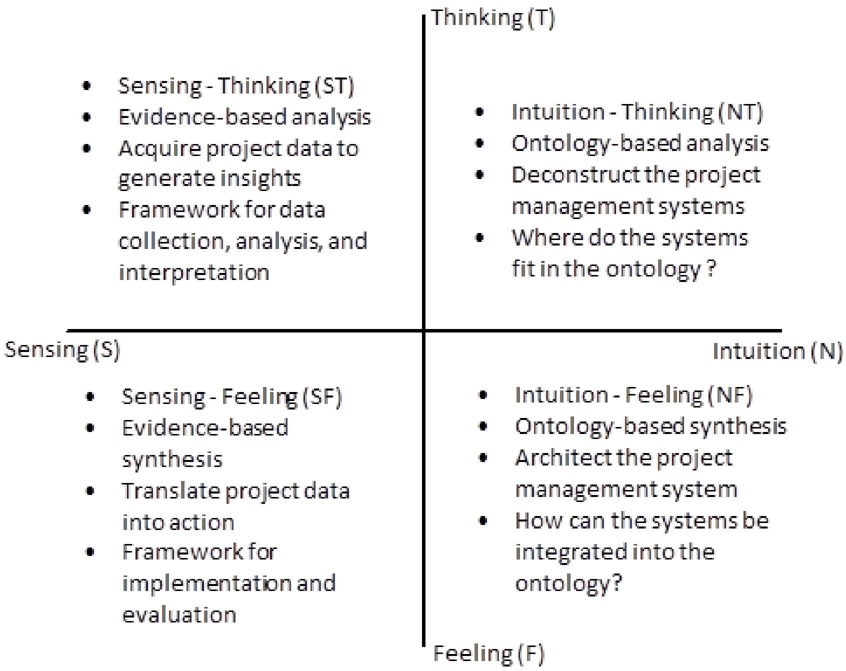

Figure 2: CPMS and MBTI

Thus the ontology of CPMS can aid the learning of CPMS in different ways, according to their own cognitive types. The versatility of the ontology is its parsimonious encapsulation of the complexity of the CPMS, and the ability it affords the user to study the system from different perspectives at different levels of granularity. In the following we will discuss how using the four MBTI types shown in Figure 2 one can design a learning CPMS using the ontology as a foundation.

Simply put, the ontology makes the CPMS 'elephant' visible to all the project members. It provides a common framework to fit all project members' perspectives even if they focus on only parts of the CPMS and are interested in different levels of detail. Thus a member working on stakeholder management can see his or her relationship to the member working on claims management. Similarly, the project manager can focus on the big picture – the whole ontology, the project supervisors on the smaller pictures – parts of the ontology including a few dimensions and interactions between them, and the project field members on the most detailed picture – a few categories and subcategories and the interactions between them. By fitting their perspectives into a common framework the members will be able to learn about their own domains of expertise as well as about the domains on which they are dependent. During such exchange and learning from each other, should the members discover redundancies or gaps the ontology can be easily modified to accommodate them. Moreover, any change can be quickly and easily communicated to all the members. Thus, a new management technique can be added to the ontology by adding a corresponding category to the last column. The implication of this addition to the other dimensions will have to be considered by the project members.

A learning CPMS should ideally consist of a proportionate mix of:

- Intuition-Feeling (NF) members who can synthesize the perspectives using the ontology, architect the CPMS, and fit the different management systems in the ontology;

- Intuition-Thinking (NT) members who can analyze the CPMS using the ontology, deconstruct the project management systems, and locate the different systems in the ontology;
- Sensing-Thinking (ST) members who can analyze the evidence from the project, acquire the data to generate insights about the project, and use the ontology as the framework for data collection, analysis, and interpretation; and
- Sensing-Feeling (SF) members who can synthesize the results of the analysis of evidence, translate the results into action, and sue the ontology as a framework for implementation and evaluation.

As the MBTI authors (Briggs-Myers & McCaulley, 1985) constantly emphasize, no one type is better than the other. All four are required to develop an effective learning CPMS. Moreover, there is no one ideal CPMS 'elephant'. Thus the CPMS will have to evolve through the interaction of the project, its members, and the environment.

V. CONCLUSION

We have presented an ontological method for learning the Construction Project Management System (CPMS). The method can be used to map and manage the evolution of a CPMS systemically and systematically. The paper presents an ontology of CPMS and discussed how different types of project members, based on the four MBTI types, can use the ontology. Last, it discusses how the four types could collaborate using the ontology to design a learning CPMS.

In our earlier paper (Ramaprasad et al., 2011) we have discussed how the intra- and inter-dimensional interactions can be systematically articulated from the ontology and studied. Mapping the interactions and color coding them can generate a 'heat map' which can show the hot spots and the cold spots in the project management system. Such maps can facilitate feedback and learning.

The ontology we have presented in the paper is one of many possible. The proposed CPMS ontology can be refined, modified, or radically redesigned depending on the needs of the user. Ultimately the ontology has to mirror the project and the project the ontology. The ontological method for learning CPMS is more important than a particular ontology. Further, the method is generalizable to other project management systems; we have focused on construction project management based on the domain expertise of two of the three authors. The dimensions and the taxonomies constituting the dimensions will have to be redefined based on the type of project being managed.

MBTI is a measure of a trait of an individual. Many other traits of the individual's personality, his or her state during learning, strategies for learning, and the structure of learning can affect the learning of the CPMS. These other factors may attenuate or accentuate the learning style induced by MBTI (Posner & McLeod, 1982). For example, under stress of a project deadline a normally intuitive person may emphasize sensing of the ground truth and a feeling person may suppress his or her natural style and emphasize extremely rational thinking. The lack of consideration of these factors is a limitation of these paper and we hope to address them in the future.

REFERENCES

Briggs-Myers, I., & McCaulley, M. H. (1985). *A Guide to the Development and Use of the Myers-Briggs Type Indicator*. Palo Alto, CA, USA: Consulting Psychologist Press.

Cameron, I., & Hare, B. (2008). Planning tools for integrating health and safety in construction. *Construction Management and Economics, 26*(9), 899-909.

Chan, P. W., & Räisänen, C. (2009). Editorial: informality and emergence in construction. *Construction Management & Economics, 27*(10), 907-912.

Chen, P., & Partington, D. (2006). Three conceptual levels of construction project management work. *International Journal of Project Management, 24*(5), 412-421.

Chi, Y.-L., & Chen, C.-Y. (2009). Project teaming: Knowledge-intensive design for composing team members. *Expert Systems with Applications, 36*(5), 9479-9487. doi: 10.1016/j.eswa.2008.12.015

Cicmil, S., Williams, T., Thomas, J., & Hodgson, D. (2006). Rethinking Project Management: Researching the actuality of projects. *International Journal of Project Management, 24*(8), 675-686.

Cimino, J. J. (2006). In defense of the Desiderata. *Journal of Biomedical Informatics, 39*(3), 299-306.

Fernández-Sánchez, G., & Rodríguez-López, F. (2010). A methodology to identify sustainability indicators in construction project management--Application to infrastructure projects in Spain. *Ecological Indicators, 10*(6), 1193-1201.

Forsythe, P. J. (2007). A conceptual framework for studying customer satisfaction in residential construction. *Construction Management and Economics, 25*(2), 171-182.

Gorse, C. A., & Emmitt, S. (2007). Communication behaviour during management and design team meetings: a comparison of group interaction. *Construction Management and Economics, 25*(11), 1197-1213.

Gruber, T. R. (1995). Toward Principles for the Design of Ontologies Used for Knowledge Sharing. *International Journal Human-Computer Studies 43*(5-6), 907-928.

Lindahl, G., & Ryd, N. (2007). Clients' goals and the construction project management process. *Facilities, 25*(3/4), 147-156.

Love, P. E. D., & Irani, Z. (2003). A project management quality cost information system for the construction industry. *Information & Management, 40*(7), 649-661.

Madter, N., Bower, D. A., & Aritua, B. (2011). Projects and personalities: A framework for individualising project management career development in the construction industry. *International Journal of Project Management*.

Mitroff, I. I., & Emshoff, J. R. (1979). On Strategic Assumption-Making: A Dialectical Approach to Policy and Planning. *The Academy of Management Review, 4*(1), 1-12.

Navon, R., & Berkovich, O. (2006). An automated model for materials management and control. *Construction Management and Economics, 24*(6), 635-646.

Posner, M. I., & McLeod, P. (1982). Information Processing Models-In Search of Elementary Operations. *Annual Reviews in Psychology, 33*(1), 477-514.

Price, A. D. F., & Chahal, K. (2006). A strategic framework for change management. *Construction Management and Economics, 24*(3), 237-251.

Project Management Institute. *A Guide to Project Management Body of Knowledge, Fourth Edition*. Newton Square, PA, USA: Project Management Institute, Inc.

Ramaprasad, A. (1983). On the Definition of Feedback. *Behavioral Science, 28*(1), 4-13.

Ramaprasad, A., & Mitroff, I. I. (1984). On Formulating Strategic Problems. *Academy of Management Review, 9*(4), 597-605.

Ramaprasad, A., & Papagari, S. S. (2009). Ontological Design *Proceedings of DESRIST 2009*. Malvern, PA

Ramaprasad, A., Prakash, A. N., & Rammurthy, N. (2011). Construction Project Management System (CPMS): An Ontological Framework *Proceedings of Research & Academic Conference on Project Management*. Pune, India: PMI.

Rosenfeld, Y. (2009). Cost of quality versus cost of non-quality in construction: the crucial balance. *Construction Management & Economics, 27*(2), 107-117.

Schieg, M. (2006). Risk management in construction project management. *Journal of Business Economics and Management, 7*(2), 77-83.

Senaratne, S., & Sexton, M. (2008). Managing construction project change: a knowledge management perspective. *Construction Management and Economics, 26*(12), 1303-1311.

Sense, A. J. (2007a). Learning within project practice: Cognitive styles exposed. *International Journal of Project Management, 25*(1), 33-40. doi: 10.1016/j.ijproman.2006.06.004

Sense, A. J. (2007b). Structuring the project environment for learning. *International Journal of Project Management, 25*(4), 405-412. doi: 10.1016/j.ijproman.2007.01.013

Shiers, D., Rapson, D., Roberts, C., & Keeping, M. (2006). Sustainable construction: the development and evaluation of an environmental profiling system for construction products. *Construction Management & Economics, 24*(11), 1177-1184.

Yang, J., Shen, P. Q., Bourne, L., Ho, C. M. F., & Xue, X. (2011). A typology of operational approaches for stakeholder analysis and engagement. *Construction Management and Economics, 29*(2), 145-162.