
CONSTRUCTION INFORMATICS AS EPISTEMIC INFORMATION

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ABSTRACT

Construction informatics is the field of study that addresses the application of information and communication technologies to architecture, engineering, and construction (AEC), by focusing on technology use within the context of a social dimension. This study is concerned with information as content as it is addressed in epistemology – the study of knowledge. Epistemological thinking addresses different questions *related to the conceptualization of information*. This research investigates the characteristics of AEC information defined as epistemic information within a framework of knowledge practices. It explores a new AEC information focus based on knowledge as opposed to the traditional community research efforts based on the use of information and communication technologies, most commonly in computing in AEC, under epistemic thinking. Three epistemological *characterization for construction information*: (1) The validity of the knowledge representation artifacts used for construction information (i.e., how well do the artifacts represent the knowledge that they are designed for? What are the effects of their stability and loss?). (2) The effectiveness of the assumptions made to express both knowledge and knowing through representational artifacts. (3) The flexibility of representational artifacts as actors perform actions and practices by engaging their own perspective (self, physical and social world context conditions). It is expected that this research will define and explain a new model of thinking of knowledge practices within the AEC community. This effort lies on the intersection of a human and computing dimension under the lens of construction informatics. The account focuses on project participants' power of judgment in using domain concepts to carry out actions, which are contextually located and embedded in the domain practices. The account constitutes the construction informatics as an epistemic information framework.

Keywords: construction informatics, epistemic objects, construction information

1 INTRODUCTION

Inconsistency and ambiguity are adverse conditions of project information. They produce disruptive events within the project workflow on any phase of its life cycle. These events require a burdensome and costly treatment in using project information (e.g., data-handling activities, including the creation, transfer, and exchange). Project information are representational artifacts, such as drawings and construction documents. These artifacts are knowledge representation mechanisms. They are used to convey information to other project participants during the project lifecycle. Poor representational artifacts, however, hinder the artifacts' mediating and conveying ability. Poor representational artifacts have inconsistency and ambiguity conditions that requires activities of clarification and inquiry. These are burdensome, time-consuming, and costly activities. In fact, requests for clarification and inquiry are common practice within regular, everyday routines of using project information. Poor representational artifacts disrupt, therefore, the normal and planned activities in the project workflow.

The inconsistencies and ambiguities within representational artifacts imply the actors' awareness of such conditions (disposition to react) and the motivations, interests, or needs (appealing forces) to initiate a discovery process. Awareness is the actors' ability to perceive and draw distinctions of the project information conditions, as they are drawn into the project activity. The discovery process consists of the project actors' search for and retrieval of information to infer plausible explanations for additional elements of judgment. The inferences are made to the inconsistent and ambiguous information by incorporating new meanings to the retrieved and available information. A typical case, for instance, is when project actors make sense of the retrieved data according to their individual viewpoints. The discovery process, which is akin to the process of sense-making (Klein, et al., 2006, Klein, et al., 2006, Thurlow and Mills, 2009, Weick, et al., 2005), also emerges during any workflow project activity. Giving meanings to inconsistencies and ambiguities informs the actors' decisions and enables the continuation of the workflow. However, the discovery is a costly and burdensome activity. It involves building assumptions to be used as elements of judgments in order to base the actors' decisions. Building such assumptions implicates reflecting on and experimenting with the project information at hand. The reflections and experimentation comprise improvisation of actions and practices. If the actor is not successful in the self-reflection and in the experimentation and action reconstruction at hand, the actor is required to seek out input from others with different levels of expertise. This search is a costly and time-consuming process. It significantly uses resources which includes time for the intense coordination among participating disciplines in the workflow.

Building assumptions to be used as elements of judgment, therefore, requires searching for new information to reflect on content (idea or rationale on the domain problem) of project information. For example, instances of representational artifacts express and convey the rationale to the solution of a design problem to inform a contractor the courses of action to accomplish a request (i.e., client request). Instances of representational artifacts indicate the existence of multiple construction documents. Since the rationale to the solution may not be found within a single document but on other informing documents to the design problem about constraints, contextual conditions, and associated representational elements. Documentation refers to the process of describing any construction product or process to the project participants (representational artifacts) through project manuals, technical documents, or a design document.

1.1 Lack of characterization of information, not a documentation problem

Project information is preserved by means of representational artifacts (e.g., 3D and descriptive documents). They reify, preserve, and reproduce actors' ideas and rationales about a domain problem. Through reification, actor treats an abstraction as a material thing with a homogeneous, undifferentiated character (Chandler, 2000). These artifacts are representations that convey a set of abstractions through models and syntaxes whose purpose is to capture, preserve, and share (distribute) knowledge across participating actors in the project. The representational artifacts are used as a mediating mechanism across local and geographically distributed project actors.

When a creator (designer) determines a solution to a problem, the creator reifies the solution through representational artifacts. The artifact is used as a mediating mechanism and shared with other project participants. For instance, a design of a small-sized building is modeled and represented through a Building Information Model (BIM). The model is a mediating mechanism that provides, for instance, the visualization of the building products. It will be used to solve the coordinating problems of the involved disciplines (architectural, structural, mechanical, etc.) in the project. The BIM is a representational artifact that provides the designer's solution to a design problem (design idea and rationale) and it is shared with other stakeholders. Since the creation of a design model is a solution to a design problem, the model expresses the design intent and the fundamental interaction between the associated elements (contextual constraints).

Associated documentation to the BIM (document specifications) should afford further details of the components of the model. The associated documentation, for instance, contains the basic courses of action (e.g., prescriptive instructions of the construction processes) for the project participants'

interactions with the components of the design (BIM model). The associated documentation may include specifications of the conditions for alternative designs, such as the alternates of certain components of the design. This associated documentation supplements the BIM model to convey the designer's rationale of the solution to the design problem. However, as the model and the associated documentation is shared across project participants, additional details are required to interpret the model, and in turn the designer's intent may be unavailable. The lack of details leads to inconsistencies and ambiguities, which compels the project participants to perform a discovery process to get information regarding the design rationale and its associated components. These inconsistencies and ambiguities may hinder, for example, the actors' decisions and the continuation of the workflow. They may prompt conflicting interpretations on competing resources among project participants. Conflicting intents on competing resources are the preference of one resource over another resource, such as one particular construction product over another with similar standards.

The assumption is that the representational artifacts enable project actors to generate, share, and manage knowledge of their domain practices. The representational artifacts serve as reification vehicles that mediate across project participants to capture, store, and transmit domain knowledge. However, inconsistencies and ambiguities signal failures in the conceptualization of representational artifacts as an effective mediating mechanism to reify ideas, rationales, and abstractions of the domain.

1.2 Challenges and research needs

The challenge of building representation artifacts as mediating mechanism is not with the documentation process *per se*. Documentation is the process of describing any construction product and process through representational artifacts (project manuals, technical documents, or a design document for the project participants). The challenge resides in the method and strategy to characterize the knowledge and domain practices. Fully capturing the design intent (rationale) within representational artifacts seems problematic. These artifacts are knowledge reification mechanisms through a set of elements, rules, procedural and declarative facts. There is an urgent need for a conceptual grounding that characterizes knowledge and domain practices. Since knowledge (the collection of facts, rules, and concepts) and the ability to perform the actions (the capacity to act) constitute a domain practice, their characterization will lead researchers to understand their fundamental ontology. That is the ontology, the contextual and theoretical constructs, of the domain practices. In particular, the ontology should be focus on accommodating and redefining the everyday notion of the building a representational artifact practice.

Research efforts should be aimed at understanding this ontology. The value of focusing on the creation and use of representational artifacts is to enhance the actors' ability to capture, preserve, and share knowledge across project actors. These research efforts should provide the theoretical constructs to build methods and strategies to facilitate the project participants' discovery process. As was previously defined, the discovery process is actors' search for and retrieval of information to infer plausible explanations for additional elements of judgment. Therefore, it is anticipated that the efforts will lead to a reduction in inconsistencies and ambiguities. These efforts are aimed at creating methods to convey the intent of the original design by capturing the actors' deliberated justifications. For instance, since the design rationale of the individual designers' decisions, including the aggregate of such decisions, is mediated through representational artifacts, the resulting new methods may enable a more seamless continuation of the workflow by capturing the designers' deliberated justifications. The resulting methods should address the project participants' understating of the design rationale through material instantiations, as the rationales are conveyed in the representational artifacts. By having signifying components, products, and their associated processes, the representational artifacts stimulate the flux and the search for their meaning.

This research proposes a theoretical framework that provides conceptual grounding to characterize knowledge and domain practices. In particular, the theoretical framework focuses on representation artifacts as content (not the information technologies or the technological artifacts). The framework analytically describes knowledge and capability to perform an action that connotes knowing, as constituents of the everyday domain practices. This treatment is based on assumptions from epistemology

– the study of knowledge. Epistemological thinking addresses different questions related to the conceptualization of information. The review and focus from the epistemology lens will enable the researchers to analyze practices from novel perspective. This perspective considers both the content of representational artifacts and the capabilities generated through actions as provisional. The knowledge and ability required and acquired through actions are understood as provisional. The content of representation and the knowing evolve and emerge from context of the project, such as in the of time, space, or normative. They also evolve from the project actors' motivations. As they are provisional, the content of the representation and the knowing are non-stable. They change as the project actors perform actions and as the project continuously progresses.

2 NEW PERSPECTIVE TO UNDERSTAND DOMAIN PRACTICES

It is anticipated that the proposed theoretical framework will assist the researchers in the understanding of changes in practices. By acknowledging the provisional status, the changing and evolving character of the content of representation, and the knowing to perform an action, there is a natural defining dynamicity of the project domain practices. For example, the use of project information, a domain practice that includes the creation, construction, and interpretation of the representational artifacts, should be seen as a dynamic changing practice. The use of project information is a knowledge-centered action. It is the result of a purposive and reflective practice. Consequently the actions rest on the project actors' abilities to use representational artifacts.

This research views the evolving and dynamic character of the representational artifacts (i.e., the dynamic that includes the potential for change) within a changing and provisional practice. It is assumed that these changes are the result of differences in the actors' skillful performances within the ever-changing project context where the situated actions occur. Therefore the claim is that the use of project information is bound to (1) the ever-changing and evolving character (dynamicity) of project information that is constructed to represent actors' intentions, ideas or rationales, and to (2) the actors' actions that take place in the ever-changing project context and conditions. The claim has an explanatory force to offer insights into the understating of changes in domain practices. The claim would lead researchers to a better understanding of the actors' knowing in the continuous and context located actions of using project information. If the changes are measured with a collective enterprise organization – which is the case for construction project practice – then it is possible to measure changes in such practices. A particular insight on understanding learning from the changes in practices might be anticipated. For example, how the changes in both representational artifacts (instances of domain knowledge) and in the way of performing actions (knowing) might reflect the project actors' ongoing learning.

It is expected that the framework will enhance useful insights about the project participants' ongoing learning through the dynamic and evolving representational artifacts. The framework may get the researchers closer to understand, for example, the use of project information practices (creation, sharing, retrieval). The practice of the use of information is of particular interest since it is central to the construction informatics discipline (see definition of construction informatics in the following sections). It is anticipated that the understanding of learning project practices might help project participants more effectively overcome, in a variety of project contexts, the understanding of rule-based (procedural) and of embodied, skill-based routines. The learning is reflected on the use of more dynamic and evolving representational artifacts within everyday project activities. The learning includes the relation of the project information use and the Information Communication Technologies. In sum, this research investigates the characteristics of information use for architecture, civil and construction engineering, and facility management disciplines, defined as epistemic information within a framework of knowledge and action. This framework searches for the understanding of the representational artifacts' information content and of the actors' knowing within project practice, as both of these characteristics are provisional within a project life cycle.

3 DATA, INFORMATION, KNOWLEDGE, AND KNOWING: DEFINITIONS

3.1 Data

Data, or *datum*, have multiple interpretations as their definitions are built upon theory and practice from other disciplines. Conventionally defined as something raw, on the path from data to information to knowledge, to be gathered for processing or decision-making (Bates, 2005), data within information studies is a “portion of the information environment available to a sensing organism” that is also processed by human beings for social purposes for these research objectives (cf. Bates 2005). This research can assert data as mindfulness representations or signs that have an abstract or material quality and that agent and sensors are able or have the potential to perceive.

3.2 Information

Information has a large number of different meanings based on the theoretical and analytical framework that they embrace. Within the human communication framework, a classical definition is that of the Shannon (1948) and Shannon and Weaver (1998), in that communication refers to the degree of uncertainty present in a message within a situation by establishing a correlation between the input and output along a communication channel. The constructs of their communication model consisted of an information source (the source’s message), a transmitter, a signal, an information receiver (the receiver’s message), and a destination. Shannon provided a conceptualization of information through the transformation of information into a physical parameter capable of quantification (Aspray, 1985). Shannon further emphasizes the efficiency of the representation through mathematical models to reduce the uncertainty in the message.

From the semiotic account, where a collection of signs, images, words, and symbols is associated to the perception of an agent, information is framed within significances of language, culture, and norms. The images, words, and symbols are used to communicate meanings to intelligent, social agents who have the ability to respond to previous experiences. A semiotic treatment of information in AEC domain focuses on the understanding of the role of representations. The emphasis is on the dynamic relations among subject, object, and interpreter, as Pierce proposed. Simply stated, information involves triadic essential elements: (1) a form that is embodied in an object to communicate to (2) an interpretant through the mediation of (3) a sign. Interpretant is the subject that provides the translation to the sign using certain features that signify its object to generate and shape our understanding (Edited by Mats Bergman & Sami Paavola 2003). The use of representations in the AEC domain is realized within a spatial temporal dimension, so that the signification process for this domain is realized within a physical environment. For an introduction to the semiotics concept within the AEC domain, see Mutis and Issa (2008).

Within the information studies, the concept of information is based within the nature of its use, which creates a difficulty in drawing distinctions between the information and knowledge concepts (Savolainen, 2009). The discipline of information studies defines information as “the pattern of organization of matter and energy that has been given meaning by a living being” (Bates, 2005). Bates’ term, pattern of organization, from the aforementioned definition contributes to clarify the ontological debate regarding the specification of the quality of information (between abstract or material quality). The term is tantamount to a semiotic concept, interpretants. Interpretants have sensory apparatuses that independently process the patterns of organizations provided by the sensory inputs. Pierce defined interpretants as the mental effect of the object of the sign, as it was created by the sign and perceived by the interpreter (Bergman and Paavola, 2012).

From the epistemological formulation, information is based on the data perceived by an agent within a particular state whose value is ascribed to the agents when they judge its contents (Primiero, 2007). Information is conveyed by propositional contents – any propositional content is a judgment act that is grounded in a conceptual system. This conception implies that information is dependent on the receiver’s states, of the sources, and of the nature of the data. The epistemic definition, therefore, conveys the idea that the meaningfulness of the content of data depends of the agent’s knowledge state so any subjective or

preferences of data cannot be assumed as given in the datum. The meaning of data is constructively ascribed to the agent's rational procedures.

Information from epistemology can have two different treatments, as stated in Cetina (2010): The first regards information according to its use; such as it is within communications and information technologies. The second is considering information as knowledge, such as the cultural practices of information. Within epistemological thinking, information is commonly treated as uninterested data, where knowledge involves the interpretation, judgment, and explanation of that data.

3.3 Knowledge and Knowing

Inadequately captured by any definition from epistemology – the study of knowledge and justified belief (Steup, 2012) –, knowledge, in general terms, is the cognitive ability to respond to familiar signals or signs from the external world through highly complex conscious or unconscious experiences. Knowledge is gained from perception, association, and reasoning by cognitive agents. It involves a self-conscious judgment based on appreciation of context or from theoretical framework, and includes the agent's ability to draw distinctions concerning the activity at hand (Bell, 1999). Knowledge is the individual capability in the service of some purpose to draw distinctions, within a domain of action that embraces the awareness of a situation, based on appreciation of theory or context, or both (Tsoukas and Vladimirou, 2001).

Although in the aforementioned definitions knowledge is a comprised set of concepts and agents' propositions, it is suggested that the state of knowing must also be acquired to perform an action within a practice. Project participants, for instance, should have the acquired and confirmed set of concepts to deploy them through actions. Knowing, or the state of knowledge, is the action as part of the knowledge itself. Knowing is an epistemic work done by agents' actions (Cook and Brown, 1999). Furthermore, knowledge and knowing are inextricably embedded in all domain practices as practices are a collection of physically bounded and situated social actions engaged by a community (Orlikowski, 2002). The actions may be individual, performed by a single actor, or collective, performed by a project organization.

Epistemic work counts for both the required stock of concepts (knowledge) and the knowing of processing actions. Epistemic work involves, therefore, the actors' conceptual activity (cognitive) and their actions, as they possess the knowledge regarding the domain problem at hand. Information use, for instance, is an inherited part of an action or practice (Savolainen, 2009). As such, it is an epistemic work. Therefore, there is a strong connection between knowledge and action. Knowledge is not treated as a synonym of information in this present research, such as the concept viewed as information to be collected, stored, and retrieved by information system (i.e, knowledge processed by information systems). The stock of concepts is the knowledge required to carry out actions in the physical world. Knowing involves two conditions, the ability (capacity) to act – as actor(s) are aware of the situations in context – and the concepts that substantiate and enable such ability, which evolves into actors' actions.

4 EPISTEMOLOGICAL ACCOUNT OF CONSTRUCTION INFORMATICS

Informatics is the academic field that embraces the challenges of computing, such as the effective use of computers within contexts of other domains. The advancements in computing are informed by computer science. In particular, as computer science as a discipline matures, research on computing is informed by other disciplines (Groth and MacKie-Mason, 2010). Construction informatics as a discipline has been known as Information Technologies in construction (IT in construction) or as Communication and Information Technologies (CIT) in architecture, engineering, and construction and facility management. Building on the definition of Turk (2006), we refer to construction informatics as the field of study that addresses the application of information and communication technologies to the architecture, engineering, construction, and facility management fields of study, by focusing on technology use within the context of a social dimension, including project organizations, project networks, and project organization, and by building computing based applications aimed at solving complex problems to directly impact the projects during its whole life cycle.

Construction informatics uses computational thinking to solve discipline problems by broadening insights from research inquiry to people, computing, and information technology systems, including their intersecting and emerging research focuses. Construction informatics is a comprehensive discipline. It provides a broad view of the scope of the architecture, engineering, and construction and facility management fields of study. This research refers to this comprehensive concept as *construction information*. For instance, as the field of construction engineering and management considerably intersects with practical and social sciences, research on informatics would aim knowledge management issues beyond the simple computational dimension with a focus on the human and social aspects of knowledge (El-Diraby, 2012). Construction informatics offers new mechanisms to benefit the construction industry; in particular, on processing, communication, creation and management of information, common collaboration, legal, and standardization infrastructures (Turk, 2006).

4.1 Construction Information within epistemic thinking

Within the epistemic thinking perspective, the definition of construction information is based on the characterization of information and contextually located actors' knowledge actions within the domain practices. That is on the representation artifacts as content and on the defining knowledge and capability to perform an action that connotes knowing. This construction information definition includes the aims of the construction informatics discipline. This characterization suggests the examination of construction information from the epistemic thinking. In particular this characterization refers to the following principles:

- (1) The validity of the knowledge representation artifacts used for construction information (i.e., how well do the artifacts represent the knowledge that they are designed for? What are the effects of their stability and loss?).
- (2) The effectiveness of the assumptions made to express both knowledge and knowing through representational artifacts. Knowledge and knowing are reified through representational artifacts to meet the actors' needs, motivations, and opportunities at hand (e.g., the understanding and sharing of a design).
- (3) The flexibility of representational artifacts (since they are built to share and express ideas or rationales of construction problems), as actors perform actions and practices by engaging their own perspective (self, physical and social world context conditions). Flexible representational artifacts should enable actors to accomplish knowledge practices as the actors' knowing (ability to perform the actions) changes along the ongoing and contextually placed project practices.

This research defines these construction information principles (validity, expressiveness, and flexibility) to provide a foundational support to the conceptualization of construction information under two mutually constitutive and reciprocal positions. The first is information content, as it is conveyed by propositional contents – any propositional content is a judgment act that it is grounded in a conceptual system. This judgment is the actors' conceptual activities (cognitive). The second is actors' actions, as they involve construction information use, built on knowing how to process such actions. Knowing involves two conditions, the ability (capacity) to act – as actors are aware of the situations in context – and the concepts that substantiate and enable such ability. Knowing enables the necessary conditions to the perform actions.

The validity, expressiveness, and flexibility are critical defining characteristics of ongoing changing and evolving representational artifacts. The consequence is that the use of construction information is bound to its ever changing and evolving character (dynamicity). Project actors deliberate on the ongoing changing and evolving representational artifacts. This deliberation take place in epistemic information practices (knowledge practices). The actors' needs, motivations, and opportunities at hand are mediated through the representational artifacts. These eliciting features gradually establish the evolving character of dynamicity of construction information. They leads actors to purposive and reflective actions.

Construction information is built to represent actors' intentions, ideas, or rationales. They are instantiated through representational artifacts. However, these artifacts evolve and change within a reflective and intentional domain practice. The representational artifact evolution and change are revealed through the representations' unfolding nature (Cetina, 2001), typified when actors continuously find

absences of some representational element, relevant contextual conditions, and other meaningful representations. The actors' needs, interests, and motivations make actors to search for and find these absences in an unfolding representational artifact.

Project actors continuously change the knowing or the actor's ability and knowledge to perform an action, which includes the knowing how or the way to perform an action. Knowing reflects change in actions as actors not only commit to purposively reflective practices but also to actions of improvisation and experimentation, in order to satisfy their needs, motivations, and opportunities at hand according to the project contextual conditions. Therefore, there is on-going change within their epistemic practices as the knowing changes.

4.2 Epistemic assumptions for construction information

The assumptions within the epistemic thinking layout the conceptual grounding to build methods and strategies aimed at adopting representational artifacts that adequately express knowledge (e.g., a solution to a design problem, or a response to a design request). These methods and strategies will enhance the capability of the project representational artifacts to convey contextual and relational information, since these capability may be required, for instance, for disambiguation and semantic enrichment. For example, the resulting methods and strategies may facilitate project actors to choose representation artifacts not by their degree of sophistication of their formalization but on the way to use the representations (i.e., by assisting the actor's knowing-how within a particular action) in order to meet the actor's purpose. Epistemic thinking will inform the use of construction information within project practices and the research on the effective use of computing and information technology systems. It also has the potential to contribute to advancements in computer science, since these advancements might be driven by problems that are investigated within other domains (Groth and MacKie-Mason, 2010).

Critical to understand the proposed construction informatics framework is the exploration of its constructs and their associated roles in the framework. The three proposed framework constructs are (1) the participating project actors' (social agents') knowledge, (2) knowledge practices, and (3) representational artifacts. Figure 1 shows an explanatory scheme of these constructs. Construct 3 (representational artifacts) relates the underlying three epistemological assumptions and the principles of the construction information. The constructs are originated from the underlying assumptions of epistemic thinking as illustrated in the Figure in the grid.

Drawing from the epistemic characterization of information developed by Knorr Cetina (2010), three epistemological assumptions are inferred for construction information. The assumptions particularly substantiate the explanation of knowledge practices within project activities. Knowledge practices are centered on the representational elements and the contextual conditions used in project activities, including the representational elements associations that imply meaning (i.e., information content from the construction information representational artifacts). As such, the assumptions for construction information are: (1) the continuous changes and the non-conforming patterns in representing the reality; (2) the method of expressing representational correctness, throughout cycles of knowledge creation and annulment as representational artifacts are created, revised, used; and (3) the process of production – as it leads to stable and reusable knowledge and the effects of creation and loss of value as knowledge is revised.

These underlying assumptions fundamentally outline the roles of the constructs. These roles are built from inquiries that continuously and fundamentally extend the actors' knowledge. An example is the inquiry on a representation-artifact for its use, when actors choose a representation to accomplish a certain purpose. As particular project actors (social agents) create, process, and manipulate the representations, they define the associated knowledge domain practices and the knowing to perform the action as the project progresses. The framework constructs, therefore, respond to inquiries on the practices of knowing (i.e., what type of knowledge practices characterize construction information?). All of these knowledge practices include the analytical dimensions of interpreting data and explanations of information, as they are enclosed from the project actor's background and assumptions (i.e., theoretical understanding of a problem at hand).

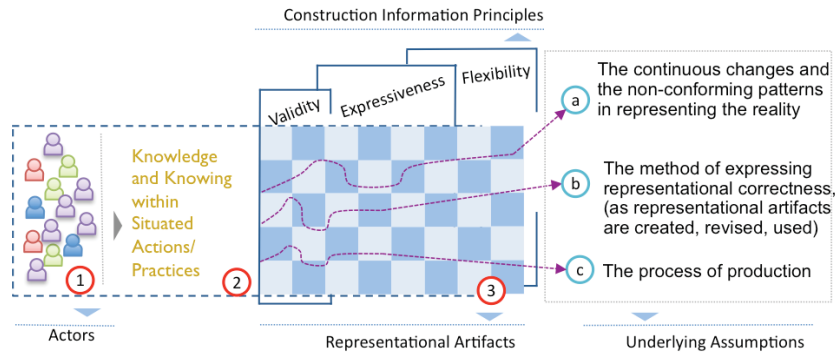


Figure 1: Framework constructs: construction informatics as epistemic information

4.3 Future transformation of knowledge

The proposed framework for construction information recognizes that the content (ideas, rationale) of the representational artifacts are not fixed mechanisms to represent the designer’s reality, beliefs, or experiences. The representational artifacts adapt to changes in the environment and to new and unanticipated requirements, as these representations evolve within a project life cycle. The epistemic settings (Cetina, 2007) (settings of knowing) are open in the present to their transformations in the future (e.g., the epistemic practices change as a construction project advances in its life cycle). Designing a construction product is a knowledge practice that reproduces knowledge into the particular construction product (i.e., the product design contains a rationale with rules, constraints, and requirements). The knowledge practice is mostly repetitive and stable in the present. Under epistemic thinking, the actors’ exercise of their expertise should include the promotion of the future transformation of knowledge. The knowledge practice should be open to its future changes. For instance, the inclusion of a consensus activity is a strategy for promoting the future transformation of knowledge within the epistemic thinking. This strategy enhances the understating of concept changes; for instance changes in construction products, construction processes, and project activities. The challenge, therefore, is to design a mechanism that routinely applies the future concept transformations within the knowledge practice.

Figure 2 illustrates the changes of a representation artifact (epistemic object). The changes outline the future knowledge transformation of the epistemic object (the Walt Disney Concert Hall Designed by architect Frank Gehry (Gehry, 2012)). The changes are defined within a cycle of creation and destruction (Cetina, 2010), as knowledge is transformed along the phases of the life cycle of a project.

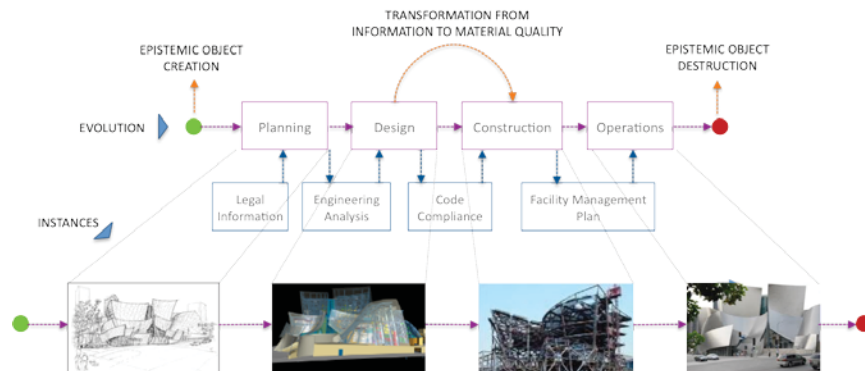


Figure 2: Transformation of knowledge of an epistemic object

5 CONCLUSION AND FUTURE WORK

The proposed epistemological account of construction informatics outlines the relevant aspects of the use of construction information by building an analysis from epistemic thinking. The account focuses on project participants’ power of judgment in using domain concepts to carry out actions, which are

contextually located and embedded in the domain practices. The account constitutes the construction informatics as an epistemic information framework. It is anticipated that the framework will enable project actors to create strategies and methods of using information in a variety of contexts and conditions, as this variability is a natural, defining feature that permeates construction projects. The account is built on an ongoing inquiry process to understand construction information (representational artifacts), and the epistemological account recognizes the dynamic and ever-changing character of the representational artifacts. For example, the framework may be used to build a method to analyze an actor's assessment time of using representational artifacts, through an analysis of judgments on the 'knowing-how' to perform an action. The inquiry process is reflected in the continuous search of the knowing-how to use information within a situated action, since a set action(s) is embedded within the domain practice.

In sum, the proposed framework provides conceptual grounding to build methods and strategies to facilitate the distribution (sharing) of the knowing within project practices with a focus on the use of construction information across construction project actors. It is expected that the methods will contribute to new insights into the effective use of construction information. This effort lies on the intersection of a human and computing dimension under the lens of construction informatics.

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