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Understanding technology in learning settings based on structurational analysis

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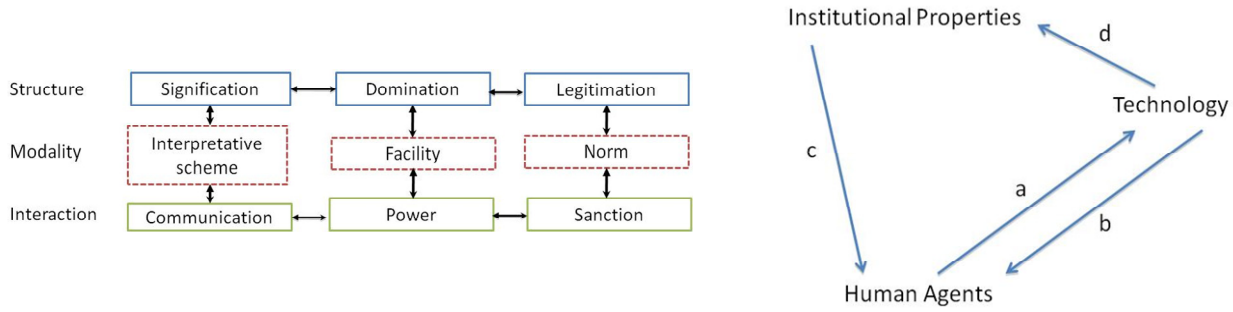
Abstract

The employment of technology within any construction project setting can be understood as the utilization of a mediation mechanism to perform activities and make decisions. The actor-technology relationship is often neglected. This relationship also involves factors such as the technology components that determine the interaction with the users and contextual environments that influence the human action outcomes. Therefore, the employment of technologies conditions the actors' social practices. The technologies facilitate and also constrain the actors' performance of their actions, interpretations, and decisions. These are assumptions borrowed from structurational theories in sociology, which recognizes the dualism between human agency and social structures. Social structures behave as a medium where actors act and they are also the product of the actors' activity. This research takes into account these assumptions and extends them to study the actors' use of information technology within organizations. Particularly, the author applies these assumptions in learning settings of construction cost estimating classes. This research analyzes (1) the influence of technology on actors' actions, (2) technology as a medium of actors' actions, (3) and the influence of actors' social structure. For this purpose, observations in a case study about the deployment of innovative technology to be employed in construction cost estimating classes are described. These observations indicated that students react either positively or negatively according to their understanding and ability to articulate such technology to estimating practices.

Keywords: structurational analysis, mediation, technology, structurational model of technology

1 Structurational analysis theory

Structuration theory is a tradition where social structures are the emphasis of the study, whereas in phenomenological and hermeneutic traditions the human agent is the focus of the study (Rose and Hackney 2003). Anthony Giddens (1984) is the main proponent of this theory. The relationships or bonds between groups or entities of individuals constitute social structures. Social structures constrain the actions of individual actors and, at the same time, the action of individual actors defines and reproduces a structure. Social structures and actors interactions are mutually constitutive duality (Reus 2009). Structurational analysis is based on the assumption of the actor-structure dualism. This duality is shown in Figure 1(a) (Giddens 1984).



(a) Dimensions of duality structure Giddens' (1984)

(b) Structurational model of technology Orlikowski's (1992)

Figure 1. Structurational Analysis Theory

The top layer defines three dimensions of social structures as signification, legitimation, and domination. The social structure can be set through formalization of rules and allocation of resources. The bottom layer described the three dimensions of interaction defined as: communication, power, and sanction. Modality, the second layer, represents the system of the actors' interaction with the social structure. It is what makes interaction possible. Modality has three dimensions, which explains the way actors behave in particular situation. For example, interpretative schemes are employed by the actors to communicate and understand the interactions. In the second layer, facility is related to the concepts of domination and power, such as the one actors exercise upon over the allocation of resources. Norms are referred to as the structure of legitimation, such as rules and obligations. The third layer refers to the way an actor interacts. It represents the actors' actions within the structure. For clarity, consider the following example. A project owner communicates the designer a change order of a project. The designer accepts the request since there is a norm described in a contract that legitimizes the design changes. The owner has the facility to exercise power over the designer. The interpretative scheme tells the designer that any change order should be accepted.

Orlikowski (1992; 2000) proposes an investigation of the relationship between technology and organizations, a duality of technology. She borrows Giddens theory of structuration to show how the implementation and use of technology influences the social and organizational context (Chu and Smithson 2003). She takes into account technology as a socially construct product. Particularly, she defines technology as a production of human action and as a medium of human action. The type of influences on how an actor interacts with technology is indicated in the Figure 1 (b).

The influence indicated by arrow (a) in Figure 1(b) refers to technology as a human action. "Technology only comes into existence through creative human action" (Orlikowski 1992 p. 409). Orlikowski stated that it is only through appropriations of technology by actors that actors' actions play a significant role and it is only through actor actions that technology can be understood. In organizations, for example, she asserts that actors have little control over how to use technology and little discretion over the meanings and elements that influence the interaction with it. These constraints are institutional and they are the ones inherited by the technological artifact.

Technology as a medium of human action mediates actors' activities, with influence indicated by arrow (b) in Figure 1(b). As actors can chose to employ technology in their practices, technology can condition their social practices. Orlikowski states that technology facilitates social practices, but also constrains them through interpretive schemes, facilities, and norms, as shown in Figure 1(a).

Actors are influenced by the organizational context when acting with technology, which is the influence indicated by arrow (c) in Figure 1(b). To perform their work, actors build the way approach and the conditions to interact with technology in their existing knowledge, resources, and norms.

Orlikowski mentions that institutional properties, such as available resources including time and money, influence actors in the interaction with technologies.

The final influence indicated by arrow (d) involves the way actors act upon institutional properties of the organization when they employ technology. The influence executed in the organization can transform institutional practices or reinforce them. The effects involve the consequences of interacting with technology that transform social structures, see Figure 1 (a).

2 Case study

This case study is an example of the observations of the author regarding the employment of technology in construction estimating classes. Traditionally estimating, or the survey of resources for a particular specific scope of work and the association of prices to the resulting quantity take-offs, has been done manually. Manual operations involve the use of interpretations of paper-based drawings, paper-based specifications, manipulation of recap sheets as a record of quantities, and the use of paper-based catalogs to associate prices to a defined scope of work. These operations that constitute the actor's routine, and the artifacts employed, such as paper-based or electronic drawings, are technologies. Estimators are the interpreters of the artifacts, and they manipulate the information they obtain from such artifacts to calculate a value in terms of monetary variables. The approximate value is the one the construction firm commits to the owner or contractor to perform the scope of work described in the documents.

The employment of information technology has recently permeated the traditional estimating routines, generating changes in the method of work within construction organizations. Although the technology employed to support the estimating activities is not new, the estimating workforce group fall within the category of laggards in the adoption on the basis of innovativeness (Rogers 2003). This lack of innovation features has also influenced instructional settings, as the industry pull of innovative practices is poor. To enhance competitiveness of students, the author introduced technological, innovative elements to the estimating practices within instructional settings. This push was made through the employment of digital drawings, digital specifications, spreadsheets, web-services to access prices of construction products, and a database for enhancing plan reading learning.

The following is the analysis of the structurational theory articulated in learning settings. The analysis employs the structurational theory (Giddens 1984), and it is extended to Orlikowski's framework that recognizes the interaction of users, technology, and organization. To apply the analysis of the structuration theory, the identification of the elements of technology, organizations, and actors are explained (see Figure 1(b)). The value of this investigation is to recognize the importance of the relationship between actors and technology, and the way actors act upon technology. It is expected that this investigation contributes to achieve clarification of the observed differences of the students' or actors' reactions when innovative technology is introduced in learning settings, which ranges from impassivity and apathy to enthusiasm for new estimating practices.

2.1 Actors, technology, and organizations

The Orlikowski's structurational model of technology illustrated in Figure 1 (b) has three components that have institutional properties: (1) actors, (2) technology, and (3) organizations. The analytical distinction between these elements is more transparent for this case study when the relationship actor-representation within the Architecture, Engineering, and Construction (AEC) domain is explored.

2.1.1 Representations and social structures

The use of computers has changed the method used to represent concepts through technology applications, related level of sophistication as a technology use. New methods replace the traditional, paper-based documents employed by construction project participants with digital formats. For

example, the information content of paper-based representations can be replaced by files of parametric models with formats such as Design Web Format (DWF), which supports publishing information within a workflow.

Technology can be employed as a medium to represent construction concepts and as a medium for social practices within a social structure. This social structure can be understood as construction organizations or as a network of construction project actors that constitutes social networks (see Figure 2). These social networks are built at different scales in time and in space and require a dynamic information workflow for exchanging and sharing information. As the contents of information are construction concepts, technology mediates between the actor and these concepts at each end or node of the network. Figure 2 illustrates this communication of information content among construction participants within an organization through representations.

Computers gave engineers the ability to develop higher precision and more complicated models, to replace drawing boards, and to provide ubiquity to support collaboration and communication services (Turk 2001). Although this is a valid claim, independent of the methods and technologies employed to represent information, there is a reification processes that construction participants employ to characterize construction concepts. Once they are represented, the concepts are communicated through a mediating technology. Therefore, construction concepts can be reified and characterized through representations. Concepts are mediated through representations built in visual schemes and symbols assembled in a Building Information Model, or in natural language descriptions within construction specifications. These representations are technologies or artefacts that are a medium for social practices.

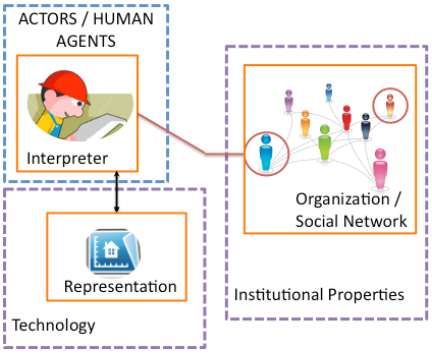


Figure 2. Relating actors, technology and institutional properties.

Language and symbols can be understood as interpretative schemes that are employed as a medium to communicate representations, see Figure 1 (a). The actors' employment of such schemes is used as a method to communicate construction concepts within a structure of signification. Conceptual models such as standards, for example, structure information to define the meaning of construction concepts. They are aimed for actors who have the same view on the concepts and subsequently take actions. Within Giddens (1984) theory, the models are interpretative schemes that are shared by the actors within a signification structure to share an understanding. Therefore the actors are able to share the construction concepts and understand each other within a structure of signification. The construction specifications, for example, are formal descriptions of concepts expressed in natural language, which corresponds to the interpretative scheme in the Giddens' layer. The specifications express a designers' desired behavior from a concept. The specifications represent the purposes committed with the concept, and they are organized within a model to be effectively communicated within a social structure. The model organizes the formal descriptions of the designers' desired behaviour about a concept. The model represents the order of actions to be taken by the actor.

2.1.2 Interpreters and designers

Actors have different roles according to their level of technical knowledge. Within a lower technical knowledge, they act as interpreters of the representation. As shown in Figure 2, these actors are interpreters and can be users of software tools at the application level when they employ computer application technologies. These actors ignore the complexity of the underlying level of the technologies. Students within learning settings are examples of interpreters at a lower knowledge level.

At a higher knowledge level, the designer is an actor who builds the representation and explicitly sets the constraints of the concepts, with the purpose of anticipating them in the context of the project. The designer employs common models, standards, and vocabulary to communicate such representations. The objective is that multiple actors ultimately recognize the constraints. However, setting a common model or vocabulary limits the final user's view, since the designer constrains the representation according to his or her social and physical contexts.

2.1.3 Structurational model of technology

In learning settings in estimating, students learn to understand and master a routine for further practice. Routines are "the habitual, taken for granted character of the vast bulk of the activities of day-to-day" (Giddens 1984 p. 36) social practices. The question is whether technology, as a medium of actors' action (see Figure 1 (b)), constrains or facilitates the performance of the students' learning of such routine. Although the instructor introduced the technology in the classroom to facilitate learning estimating practices, the instructor did not mandate that the students employ such technology. For example, the students were given the freedom to choose whether to manipulate drawings from paper-based formats or electronic-based format in order to identify and quantify construction products. As the structurational theory states, actors or human agents are required to act and may opt to employ such technology or may opt not to.

The instructor (the author) observed the advantages in employing digital- over paper-based drawings as well as the advantage of employing computer applications for quantity take-off. In the same way, the instructor illustrated to the students the limitations of employing computer applications for their take-offs. For some students, the employment of technology had a negative effect on their performance on learning to identify and quantify construction products from digital drawings. For others, the positive effect and their use of technology use had a positive impact on their productivity. According to the structurational theory, technology enables and also constrains. This is an implication that is often not recognized and the students' decision to use or not use such technologies is an example of the positive or negative effect. In teaching estimating practices. There are contextual factors that should be considered, as it is affirmed by this structurational theory.

Figure 1 (b) shows the influence of actors' actions within the organization. Actors are influenced by the institutional contexts, or institutional properties of their settings (Orlikowski 1992). It is required then to investigate the actors' conditions that influence their interactions with technology. It is central to understand within this theory that technology cannot define the actors' social practices, but rather it is the actors' contexts that influences their practices. Extending Orlikowski's ideas in her framework for this case study, the students build knowledge from their previous experiences and react to new technologies according to their understanding and ability to articulate such technology to estimating practices. When the functions and forms of the technology are designed, the designers should take into account the users' or actors' conditions. This is a challenge for the instructor in the learning setting since he or she has to accommodate the level of sophistication of technology to the students' context.

Arrow (d) in Figure 1(b) of Orlikowski framework indicates the manner in which actors influence the institutional properties of an organization. Her framework states that the employment of technology may reinforce or transform the institutional properties. When it is employed within the organization, technology is an enacted environment (Weick 1979). Technology is "conditioned by an

organization's structures of significations, domination, and legitimation" (Orlikowski 1992 p. 411). Within instructional settings, the incorporation of technology within the classroom challenges the *status quo* of the traditional methods of imparting knowledge and skills of the subject matter to students. Students or actors are not aware of this effect, but the instructor must validate his or her approach of appropriating technology in the classroom.

3 Conclusions

The identification of organization, actors, and technology are central to define the interactions with technology in learning settings. Examples are the actors' tensions in deciding to employ or reject an innovative technology. The representations as technological artifacts and the role actors play within the social structures are central in understanding the complexities of appropriating technologies. As was discussed previously, the provision of representations such as visual schemes constrains actors' interpretations. However, if actors do not have the ability to choose to use other mediating mechanisms, or simply opt not to use such technology, there is a reduction of the autonomy and capability of the actors to act and make decisions. The exploration of this complexity promises a better understanding of actors' interactions to communicate information within a social structure.

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