

THEORETICAL CONSTRUCTS FOR IS-CAPABILITY IN AEC

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SUMMARY

The purpose of this paper is to develop a conceptual framework and to explore the possible types of Information System (IS)-capability models especially in the Architecture, Engineering and Construction (AEC) environment. Based on current literature, capability is considered from the perspectives of individual, organisation, and the skill to utilise IS innovations. The different perspectives explain the challenge of improving the IS-capability. Individual capabilities need to be studied when considering intelligence, knowledge formation and capability leading to action. The viewpoints of organisation give insights into decision-making and the implementation of an improvement project. The organisation is examined from the administrative, social, knowledge management, activity and economic assessment viewpoints. Knowledge management was found to be very important when considering IS capabilities. IS-capability can be simplified into organisation, economic development, and technical dimensions. These dimensions have equal importance as IS-innovations are utilised. Organisation needs to be committed, project has to be feasible, and the technical solution needs to be mature to enable employees to utilise them. Finally, it is considered desirable to undertake further research into the area of end user utilization of IS-capability, particularly within the AEC culture.

INTRODUCTION

Future historians will certainly look back to the end of the 20th century as an era of information. This was the time when information was everywhere. Why is it that almost everyone still seems to agree that information is important, that we need it, and that more of it is better? Common sense, however, asks how can we avoid the flow of unnecessary information. One answer is that information on its own is not enough. Instead, information has to be transformed into knowledge. Where does the knowledge come from and how do we cope with, control or manage this knowledge? Knowledge management can be approached from three different directions: firstly from organisational cognition and intelligence; secondly from organisational development and strategy; and thirdly from the organisational information systems and information processing direction (Tuomi 1999). This study makes use of the organisational cognition and intelligence direction as it aims to develop theoretical constructs for IS-capability in AEC. This study concentrates on three areas: firstly how individuals are co-operating and learning; secondly process capabilities and organisations; and thirdly what is IS-capability in AEC.

The relations between intelligence, knowledge, capability and action are shown in figure 1. It says in short that intelligence generates knowledge structures that underlie capabilities that manifest themselves in selective action.

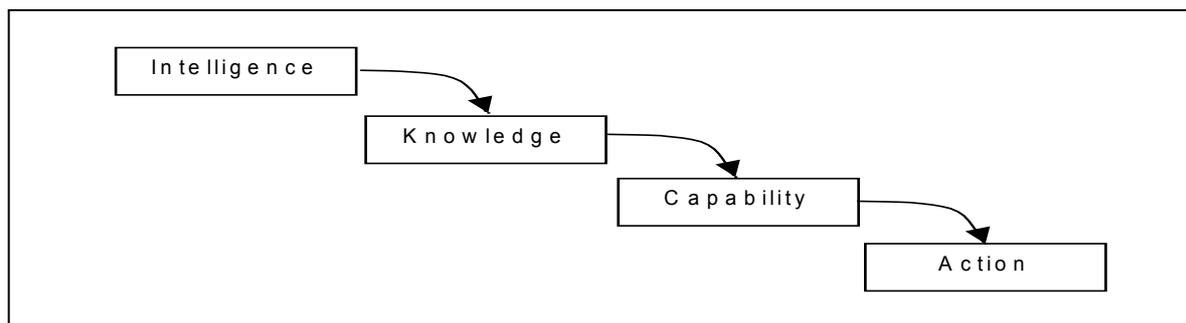


Figure 1 Intelligence as a generator for selective action (Tuomi 1999, p. 122).

PROCESS CAPABILITIES AND THE INDIVIDUAL

During recent years, researchers have been studying learning organisations. The subject that learns is human but not in isolation. The subject is a human-in-society. This means that in practise individuals can use training, experience, habit formations, skill acquisition of the environment and society as sources of knowledge and develop his/her own capabilities more rapidly than he/she could do alone through experience, conceptual thinking and imagination. Interaction of intelligent individuals will result in the development of knowledge that may form the basis of capability ultimately manifesting itself in action.

The study of human knowledge is as old as human history itself and has been central to the study of philosophy and epistemology since the Greek period. When considering intelligence, knowledge formation and capability leading to action, from the perspective of the individual as a learning organism, a theoretical investigation of the development of individual capabilities will be presented. Initially, definition of some terms should be undertaken.

Intelligence is considered an innate aptitude to understand. The Platonist model theorised that it was natural to the human intellect, always engaged as it is in determining under what former headings it shall catalogue any new object. Piaget purported that the child constructs, during the course of development, an individual understanding of the real world and said that, "...intelligence is interactionist in essence" (Turner 1984 pp. 7), however, this Piagetian model ignored the influence of social aspects on cognitive development. Bergson stated "...that the young child understands immediately things that the animal will never understand, and that in this sense intelligence, like instinct, is an inherited function, therefore an innate one" (Bergson 1960 pp. 155). Comparative psychologists purport "...that the more an animal is intelligent, the more it tends to reflect on the actions by which it makes use of things, and thus to approximate to man" (Bergson 1960 pp.197). Knowledge is taken to mean comprehension of a subject whilst capability is taken to be the ability or competence in a subject and finally action is taken as a deed or motion. The Piagetian model linked knowledge to development and stated that for an individual "to know" required the construction of a cognitive structure (Turner 1984). Knowledge is considered to be a competitive resource by Nonaka and Takeuchi, who purport that knowledge creation generates competitive advantage (Nonaka & Takeuchi, 1995 pp. 6). The three characteristics of knowledge creation elucidated by Nonaka and Takeuchi are: firstly, to express the inexpressible; secondly, to disseminate knowledge; and thirdly, that new knowledge is born in the midst of ambiguity and redundancy (Nonaka & Takeuchi, 1995 pp. 12).

One commonly accepted definition of learning is a relatively persistent change in an individual's possible behaviour due to experience. Historically behaviourist-learning models have focused on associative or classical and instrumental or operant learning theories. It is purported by classical conditioning theorists, such as Pavlov, that people are conditioned to respond. Instrumental operant learning theorists, such as Skinner, purported that people learn by trial and error, and that our behaviour is moulded by reward and punishment. Activity theorists, such as Vygotsky, purport that activity theory is a thoroughgoing object relations theory and that the transformation of interpersonal experience into intrapersonal thought processes is the root of all that is specifically human in human psychology. Vygotsky reportedly said "What the child does with an adult today, she will do on her own tomorrow" (Engeström, et. al. 1990 pp. 413). The cultural theory of human nature, within the framework of activity theory, came to prominence during the 1980's under the banner of cultural psychology and is defined as that branch of inquiry that delves into the contextual behaviour of psychological processes (Engeström, et. al. 1990 pp. 87). The inclusion of the interaction between the individual and society provided the impetus for further research into the way individuals learn in society. Social learning theorists, such as Albert Bandura, emphasized internal mental states, such as expectancies, and considered vicarious learning and modelling to be important to the learning process. Foster claimed that cultural reproduction and the transmission of knowledge is related to order, control, stability and change in society, these being the fundamental problems in sociology (Foster 1981 pp. 340). "...teaching children individually need not only accelerate cultural pluralism; it can also strengthen respect for disciplined thought and inquiry and sensitiveness to humane values, and these should act as a counterpoise to social division" (Bassett 1978 pp. 270). A comparison could be drawn between society as a whole and the work environment or more specifically the work environment within the AEC culture. Learning may be driven by either traditional means or by the experience of the individual in society. "Educators may wish to assist individuals to assess for

themselves how they are using their cognitive processes at any one time so as to plan what their next move should be. By these means learners can become involved in the process of their own learning” (Turner 1984 pp.155). Innovative learning theorists, in their view of knowledge creation, emphasise the importance of critical questioning and rejection of the accepted wisdom as a triggering action to innovative learning (Engeström, et. al. 1990 pp. 397) More recently learning theories have emphasized the role of cognitive processes in learning. Zeus and Skiffington assert that our learning process is influenced not only by environment but also by mental events, mental representations, our beliefs, expectations, emotions and intentions (Zeus & Skiffington, 2000). Constructivist learning principles or narrative therapy is seen as a problem-dissolving system and a means of rewriting a person’s story and biography and utilises both the traditional learning techniques and interaction of the learner in society. It purports that the learner is always an active organism, not just responding to stimuli but engaging with them in an attempt to make sense of their world and in so doing generate knowledge internally, not just from external sources. Since the most recent learning theories emphasize the role of cognitive processes in the learning process and include mental events, mental representations, people’s beliefs, expectations, emotions and intentions as influencing factors to change it is considered that learning is a manner of acquiring knowledge, utilising the cognitive approach. Accordingly, it is considered that a cognitive intervention approach would involve application of the latest learning theories. These theories should be learner focused and emphasize learner ownership, to maximise the acquisition of knowledge generally and in particular within the work environment. Cognitive intervention in the form of solution focused therapy, or coaching, is said by Zeus & Skiffington (2000) to be essentially a conversation; it is about learning, a process more about asking the right questions than providing answers. Being a coach is about change and transformation. It is about fostering human beings’ ability to grow, to alter maladaptive behaviours and to generate new, adaptive and successful actions. Coaching is about facilitating the person’s ability to reinvent themselves, – creating new stories, new identities and new futures. It recognises that the self is not a fixed entity, but is fluid and always in a state of becoming. Coaching is a process, where the process is equally important when compared to the ultimate goal.

The learner is always seen as an active organism, not just responding to stimuli, but seeking them out and engaging and grappling with them in order to make sense of the world. Knowledge is generated internally, not just from external sources. Barnard maintained that knowledge consists of two parts, firstly, logical, linguistic content and secondly, behavioural, non-linguistic content (Nonaka & Takeuchi, 1995 pp. 36-37). Nonaka emphasises that new knowledge always starts with the individual and is transformed into organisational knowledge (Nonaka & Takeuchi, 1995 pp. 13). The difficulty may lie in individual’s ability to generalise newly acquired knowledge in relation to the more broad ideals of society. This should be the focus of future research. That is, investigators must examine the IS capability models being utilised by end users, particularly in the AEC culture together with how the solution-focused approach utilised at an individual level can be applied in the workplace and particularly within the AEC culture.

PROCESS CAPABILITIES AND THE ORGANISATION

Sarshar (et al. 1999) pointed out that information technology (IT) and other enablers need to fit within a business context of process improvement. They developed a framework of Standardised Process Improvement for Construction Enterprises (SPICE) to support the construction companies in improving their processes. The aim of SPICE is to reveal the maturity level of the process in the construction company and describe the next maturity level. SPICE describes the major process characteristics of an organisation at each maturity level, without prescribing the means for getting there. The key processes need to be demonstrated with the five process-capability features:

- (1) Commitment to perform – this typically involves establishing organisational policies. Some require organisational sponsors or leaders.
- (2) Ability to perform – this describes the preconditions (adequate resources, appropriate organisational structure and training) that must exist to implement the process completely.
- (3) Activities performed – describes the activities, roles and procedures necessary to implement processes. It typically involves establishing plans and procedures, performing the work, tracking it, and taking corrective actions
- (4) Analysis and evaluations – describes the basic evaluation practises that are necessary to determine the status of a process. In other words controlling and improving the process.

(5) Verifying implementation – this verifies that the activities are performed as planned. (Sarshar et al 1999b, p. 382)

Process capability features in SPICE (Sarshar et al.1999, p. 382)	Features in TIMI-barometer (Enkovaara et al. 1998)	Views in Organisations	Individual capability (e.g. Knowles 1980, Ojala 1993, Venkula 1988, Peltonen et al. 1994)	Knowledge capital (Tuomi 1999)
Commitment to perform - organisational policies - sponsors or leaders	IT-Management - commitment - IT strategies - IT as a success factor	Administrative - Commitment and control - design of strategy and structure - effective distribution of labour - information processing	Commitment to perform - own responsibility - manager's support	
Ability to perform - resources - organisational structure - training	IT skills Motivation Infrastructure Used software Structured information - paper format or digital format or meta data	Social - communication and collaboration - power - trust - institutions - organisational culture Economical - resources - network of value creation and transaction	Competence -knowledge tacit/focal/explicit -understanding -technical skill -communication skills & contacts to experts -attitude -values -interest Situation in the personal life	Human capital - competence - attitude - intellectual agility Structural capital - internal structure - renewal capability - external structure
Activities performed - establishing plans and procedures - work performance - tracking work - corrective actions as necessary	Processes - core processes - quality - customer view - IT in processes - Effect of IT	Activity - business process - work process - task co-ordination and scheduling	Experiences of mistakes and success Learning capacity - personal capacity - orientation type of personality - meaningfulness of the situation - energy and methods	
Analysis and evaluations - evaluation of the status of the process - controlling and improving the processes	Evaluated benefits - customer satisfaction - time - quality - cost - co-operation - motivation	Economical assessments - business system - company in competition - network of value creation and transaction - global environment		
Verifying implementation - are activities performed as processes describe - review of management - quality assurance			Ability to verify the success	

Table 1 Features in capability studies. (Naaranoja 2001)

Table 1 compares the features of process capability of SPICE to those of IT capability in TIMI barometer and individual capabilities and views in organisation. The study shows that in the main approaches the organisational views are found. The main views are administrative, social, economical, activity, and economical assessment. The TIMI features were created to assess the maturity of the IT utilisation in the company.

We can distinguish several foci and levels of analysis in organisational analysis. When focal actor is the owner, the organisation is seen as an economic entity that exists to make profit. When the focal actor is top management we discuss decision-making, goal setting, command and control structures, information flows, and organisational renewal. When the focal actor is a collective of workers, organisational processes, division of labour, co-ordination of activities, communication networks, institutions, commitments and culture look prominent. When discussing the organisation as such, the organisational structure, cybernetic input-output models, and interorganisational models emerge as natural issues that need to be studied. Rosenböjer (1998) studied development of ability and willingness to organise resource mixes for productive actions in three levels: the firm, relationship and network. He found financial, physical, human, technological, reputation and organisational resources in this development. Although, his study focused on distribution in the fine paper sector in the United Kingdom, the idea of analysing capability development in levels is usable. In addition, the importance of reputation needs to be remembered as process is improved.

Within organisation, we have several perspectives in knowledge. Firstly, knowledge can be seen as an accumulated *resource* that underlies capabilities. Knowledge makes some types of performance possible. The accumulated possibilities for action we can call competencies (Tuomi 1999, p. 294). Secondly, knowledge can be viewed as a structure that *constrains* activity, and that makes some actions effective. Thirdly, knowledge can be viewed as a *product*. As a product, knowledge can change existing constraints for actions, and lead to development. In the extant literature on knowledge management, the focus has been often on the resource perspective. However, at the same time the knowledge has also been viewed as a product. Therefore, it has been assumed that a design or a document can be valuable as such, without considering the activity in which this value is realised. Often two types of knowledge resources have been distinguished: human capital and structural capital. The idea has been, for example, that human competencies “walk out every night” and whereas structural capital “stays in the company”. In economical terms it has been considered that human capital can only be rented, whereas structural capital can be owned by the company (Tuomi 1999).

The analysis presented in table 1 emphasise the importance of studying the capabilities in order to understand how the capabilities of an organisation influence on those of an individual. It is also important to study how the human capital can be “saved” in the organisation by IS that recreates the knowledge. The features of capability are complex but we can simplify them in four different dimensions: commitment, ability to perform, the processes of the activity, and ability to evaluate the activity. It is most important to learn from the past projects. This can mean, for example, saving the assessment results of the process in the project databank in order to remember the lessons learned.

IS-CAPABILITY

Naaranoja (2001) traced IS-capability from the features of SPICE, TIMI, and views in organisations, individual capabilities, and knowledge capital. IS-capabilities in FM are proposed to have three main dimensions (table 2):

- economic development
- organisation
- technical.

This view is believed to help in assessing quickly the capabilities of the company and its co-operators in AEC network. The dimensions are not independent since the information system may help the organisation to improve its other capabilities. Economic development affects the possibilities to improve information systems. However, the dimensions may be studied in separation.

The economic development aspect is understood here in a rather broad way. The scope is: how well the economical aspects like the strategies support the use of innovations. The financial and other resources are an important factor. It is important to be able to fit IT within a business context of

IS-CAPABILITY IN A COMPANY	
ECONOMIC DEVELOPMENT	
Processes	Quality of processes Evaluation of processes Improvement plans and priorities
Strategies	Business strategy (where and why) IS-strategy (what is required) IT-strategy (how can it be delivered)
Economical situation	Ability to invest Ability to carry the risks
Customers and Suppliers	Requirements of the customers Types of customers Collaboration with suppliers
ORGANISATION	
Knowledge capital	Human capital - competence - attitude - intellectual agility Structural capital - internal structure - renewal capability - external structure
Commitment	Institutional factors - attitude of the business field - attitudes in the human network Administrative factors - communication and collaboration - power/trust - institutions /organisational culture
TECHNICAL	
Current IS infrastructure	Age of computers, local network, Email, Internet, shared databases, windows environment, etc.
Current IS software	Used software: bookkeeping integrated or not with operative and/or service tools ?
Current data structure	Form of data paper documents/digital /shared databases used by staff; customers; collaborators
Benefits and costs of the current IS	Does IS help to make good decisions? Efficiency Effectiveness Performance
Ability to assess: possibilities and risks of IS-innovations	Improvement capabilities Is it possible to make a big technology jump?

Table 2 IS-capability in a company.

process improvement. Based on these factors the company needs to be able to create a priority list how IS can be improved.

The capability of the organisation is related to features like commitment and ability to perform (compare process capability). Commitment to perform can be described by *administrative and institutional factors*. Administrative means here the ability of the organisation to distribute labour to the development task given and commitment and control habits of the organisation. Institutional factors are communication and collaboration skills, power, trust, institutional factors and organisational culture. *Knowledge capital* describes the ability to perform a feature in the organisation. Knowledge capital is the sum of human and structural capital. Human capital is the sum of competence, attitude and intellectual agility. Structural capital is the sum of internal structure, renewal capability and external structure (Tuomi 1999).

The technical aspect aims to describe which kind of factors enables the use of IT-innovation in a company. There is studied what kind of benefits are gained in organisations nowadays by using IS, for example, how does IS improve decision-making. Experiences help the company to specify what is needed and how the new IT should work. Especially, the ability to tell the software vendors the needs and wishes of the company are important when selecting a new system.

Evidence is found that the level of domination of these dimensions varies in organisations affecting the IS-utilisation. For instance, if the organisation dimension of IS-capability dominates the utilisation, the benefits of IS may remain moderate though the organisation tests and uses several different kinds of IS. If the organisation stresses the benefits of the IS-innovation and do not ensure the utilisation skills of the organisation, the managers may have difficulties with the motivation of their employees. This type of challenge can be seen as the employees have difficulties to find time to learn to use the IS. The companies do not measure IS benefits, although companies say that they distinctly benefit from the IS-utilisation. The technical dimension of the IS capability cannot dominate either the utilisation since nobody can fully know the possibilities, since the IS develop so fast. The companies also assert it difficult to follow the technical development and keep their systems updated. (Naaranoja 2001)

The needs of the company have to give direction to the IS-strategy. However, it is important to gather the technical capability by utilising IT and studying IS-possibilities. Though IT-skilled individuals have an important role, it is even more important that all the employees want to learn from each other and skilled people are utilised to a maximum in this process. The question is not who is better but how to hasten the learning and create a positive attitude towards ongoing change.

CONCLUSIONS

This theoretical paper describes IS-capabilities of individuals and organisations in general and in particular within the AEC environment. The paper points out that the capability development should happen at the individual, company and network level. It is considered that organisations operating within the AEC environment would benefit by initially determining precisely what the requirements to support their processes are. One methodology that could possibly be utilised to achieve this objective is to prompt organisations to write a story about what is considered to be an ideal IS.

IS capability dimensions (economic development, organisation, and technical dimensions) need to be improved even-handed since the optimal benefits of IS require knowledge of the business, capable organisation, and sound IS. If one of the dimensions is dominating the development project the results of the pilot may be successful but the wider community may, however, have difficulties in utilising the results.

It is considered that the focus of future research should be in studying:

- individual's ability to generalise newly acquired knowledge in relation to the more broad ideals of society, in general, and the AEC culture, in particular.
- organisation's ability to select the IS tools that become economically feasible and that the individuals are motivated to utilise.
- what different types of IS-capabilities in AEC may exist and their connections with the success of utilisation of IS.
- what kind of variation is likely to be present in different kinds of facility management (FM) companies.
- the linkage between the formation of IS-implementation teams and implementation success. For example, what role the team plays in the economic development dimension of IS-capability. How is the project team formed? Is the project team able to affect the overall capability? How do they affect it?

If the research was undertaken in these areas it is anticipated that IS capability would have increased potential for improvement providing further potential for increasing individual job satisfaction and ultimately leading to increases in productivity, especially within the AEC environment

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