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Knowledge management in construction companies oriented on project success factors

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ABSTRACT

A major obstacle to the wider acceptance of knowledge management in Swiss construction companies is that the management of these companies find it difficult to recognize any concrete benefit for their day-to-day business to be gained from applying existing knowledge management concepts. It is important for construction companies to win orders in a competitive environment and to execute these orders profitably for the company and satisfactorily for the customer (project success). The identification and management of success factors in construction processes support project management and help to achieve these goals.

Based on these considerations, the Institute for Construction Engineering and Management (Swiss Federal Institute of Technology, Zurich) has developed a solution for knowledge management in association with leading Swiss construction companies. The solution pursues the approach that knowledge that is valuable for construction companies is the knowledge needed to activate the success factors. This knowledge, which ensures success, is worth managing.

Keywords: Knowledge clusters, construction project, total service contractors, multiple case study, process model, organizational implementation

OBSTACLES FACING KNOWLEDGE MANAGEMENT AND APPROACHES TO IDENTIFYING A SOLUTION

Difficulties facing total service contractors in respect to knowledge management

The primary reasons why general and total service contractors do business are to successfully acquire contracts in their targeted area of business, to realize the customer's performance goals to the latter's satisfaction and in line with the latter's requirements, and to successfully complete the project from the perspective of their own companies (profits, image).

In the effort to achieve these goals, the attitude towards the elements of knowledge plays an important role. For example, "rediscovering" tried and trusted solutions goes hand in

hand with losses of efficiency in finalizing the project, which cause a deterioration in the competitive positioning of the supplier. Literature uses the "resource based view" to address the role played by knowledge within companies, as shown in Zack (1999). Various approaches and models have been developed in the field of knowledge management, especially during the 1990's, all of which aim to support companies in systematically managing their knowledge. Moreover, specialist literature offers a plethora of tools and measures for addressing the individual knowledge management processes of knowledge identification, allocation, preservation, etc, such as intranet, experience discussion groups and databases, as described in Girmscheid and Borner (2001).

Observing construction work in practice has shown that companies are frequently unable to identify any real visible benefit for their day-to-day business from adapting existing knowledge management concepts to reap advantages that would justify the investment of time and money needed to initiate the appropriate measures. Two major stumbling blocks preventing a broader level of acceptance and application of knowledge management in construction companies proved to be the unique character of each building project, and the lack of any practical tools for a company to use to pinpoint the knowledge that was of value to the said company and to identify the real benefit to be gained from systematically nurturing this knowledge.

Approaches to identifying a solution

In view of this situation, the Institute for Construction Engineering and Management (Swiss Federal Institute of Technology, Zurich) has developed the model approach of project-oriented and cluster-oriented knowledge management. The research work forms part of the overall construction system provider (SysBau) research approach developed by the Institute, Girmscheid (2000).

When executing construction projects it has repeatedly been demonstrated that certain actions or decisions taken during the project have had a positive impact that played a major role in influencing the competitive success or success of the project (success factors). From a theoretical angle we know that knowledge only reveals its purpose or benefit when applied to actions, decisions or processes. However, whilst knowledge is based on data and information it is – unlike these two elements – according to Nonaka and Takeuchi (1995) also always linked to people.

As such, the knowledge that is particularly valuable for total service contractors is the knowledge that is needed to guarantee the best possible conversion of the individual success factors into actions that ensure success. This knowledge, which ensures success, is worth nurturing and promoting on the part of the company.

However, it is not a single piece of information or a single element of knowledge that is needed to activate success factors but rather a combination (cluster) of various elements of knowledge and data. The concept of "knowledge clusters" was derived as an aid to describing the success factors and the relevant requisite knowledge. Thus, these knowledge clusters can then be studied over the entire process of providing products and services for a construction project (Figure 1).
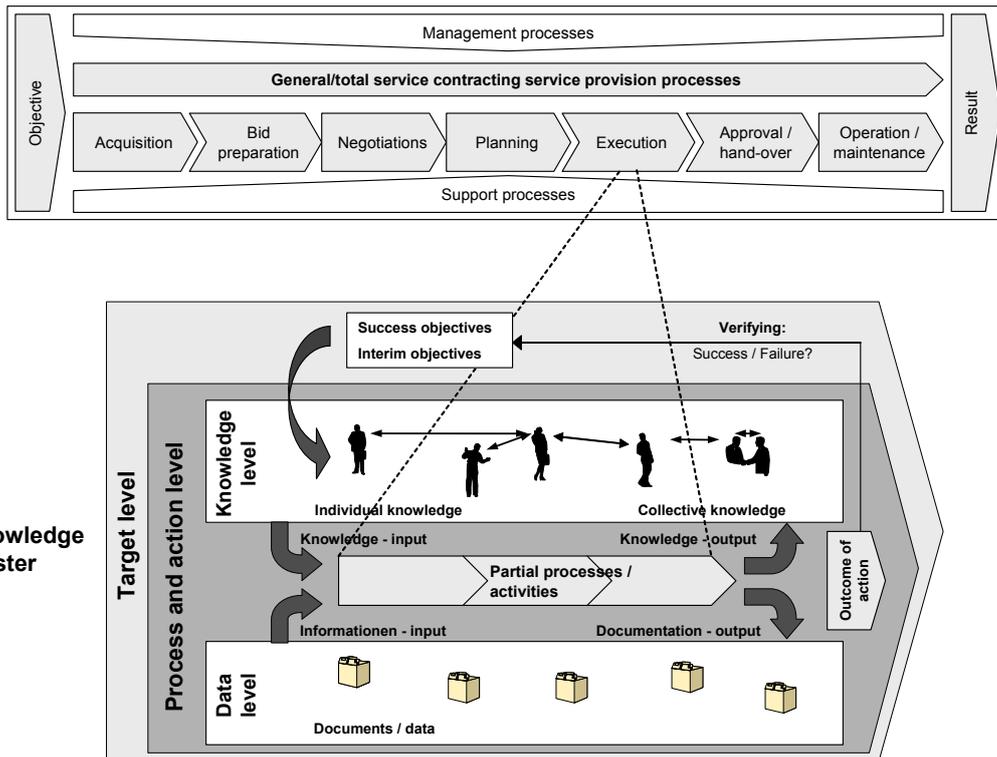
Figure 1: Knowledge cluster modeling

FUNDAMENTAL PRINCIPLES OF THE MULTIPLE CASE STUDY

Objective and definition of the study

The fundamental prerequisite to enable this approach to knowledge management to function at all is that there are success factors, respectively knowledge clusters, which occur similarly or are relevant in several projects of the same type. If all the knowledge clusters from one project were only valid for that one specific case, these could not be reactivated for newly acquired projects and, as such, knowledge could not be managed by this means.

In order to verify this fundamental prerequisite, 4 major and complex structural engineering projects were examined to pinpoint their success factors, respectively knowledge clusters (Figure 2), and compared with each other to identify any similarities or differences, as described in Borner (2003). Pre-determined selection criteria were used to first select 4 structural engineering projects, which were completed by different Swiss total service contractors using varying approaches to the project execution (project development, direct negotiations and total service competition).

When analyzing the success factors, the survey was restricted to the partial perspective of the interaction between the total service contractor and the other parties involved in the project in respect of the optimal achievement of all objectives within a pre-determined target system (competitive and project success), as shown in Figure 2.

In addition to verifying the suitability of the formulated knowledge management approach, the study also served to illustrate how knowledge clusters could be pinpointed, with the findings also being used to expand the project-oriented and cluster-oriented knowledge management model.
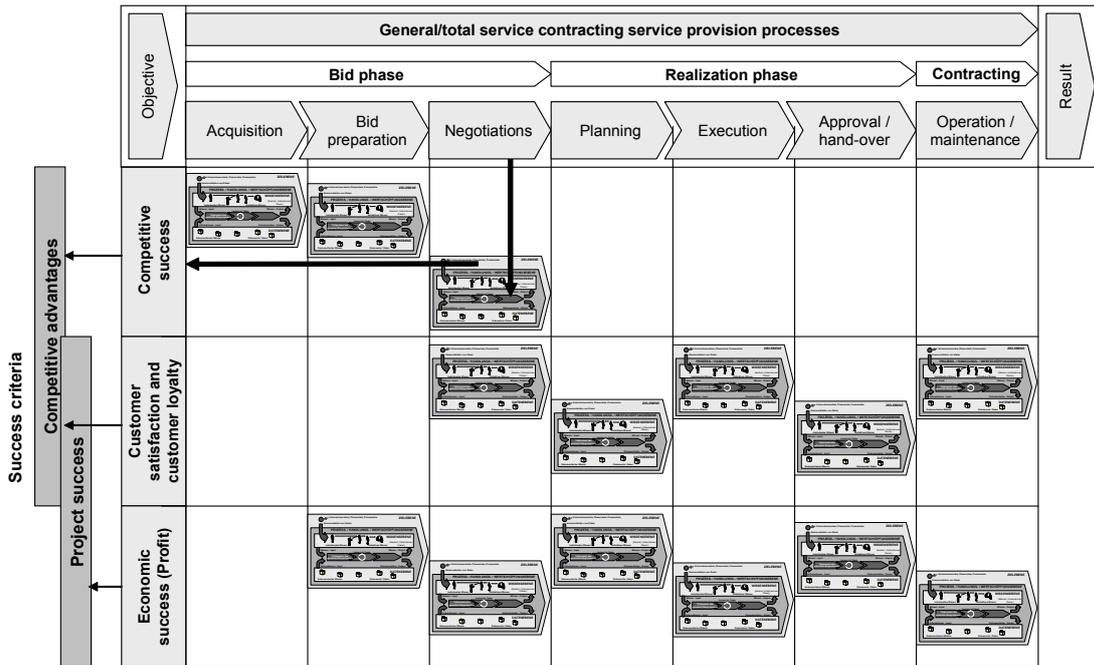
Figure 2: Knowledge clusters studied within the construction process

Research methodology

An embedded multiple case design was chosen for the study, in line with the classification of research designs for case studies according to Yin (1994). One elementary factor in designing multiple case studies is that the research logic should limit itself to replication and not sampling logic. The study in question was conducted in line with the layout illustrated in Figure 3, based on the flow pattern recommended by Yin (1994) for multiple case studies.

Figure 3: Flow pattern of the multiple case study

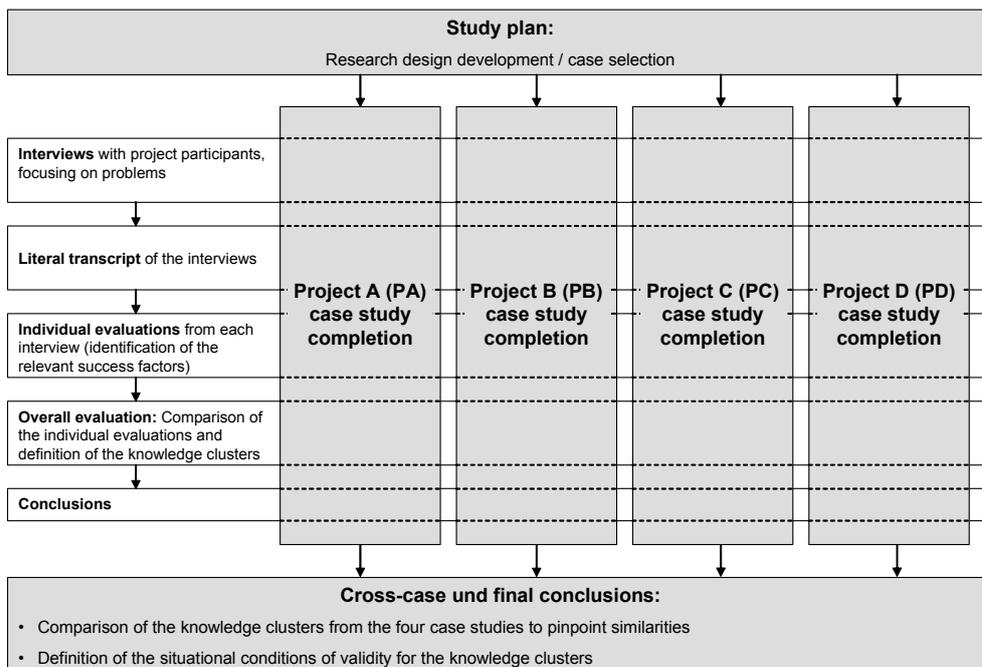The four case studies were conducted using qualitative social research methods, whereby 10 interviews were conducted with the parties involved in the project in case study A, 6 each for case studies B and C and 4 interviews for case study D. Not only were key personnel in the relevant total service contracting company questioned, but also representatives of the developers, users, planners and architects. Overall, therefore, 26 problem-oriented interviews (23 interview partners) were conducted for the entire multiple case study.

Case descriptions

The structural engineering projects that were examined featured the relevant project characteristics listed in Table 1.

Table 1: Overview of the project characteristics of the selected cases

Project	Relevant characteristics of the projects
Project A (PA)	• Project development by a promoter working with a famous architect • Direct negotiations on the part of the promoter with a single selected total service contractor • Tenant alone had responsibility for completing the interior • Sale of the construction project to an investor (public developer) during the completion phase • Total service contractor completed the basic works and the tenant finalized the interior
Project B (PB)	• Potential developer's plans to expand were well known • Total service contractor secured an ideally located plot of land early on • Total service contractor supported the developer during the initial stages (organization of ideas competition, negotiations with third parties, clarifications, first concepts) • Pre-project planning conducted by this total service contractor • Definitive award of the contract to the total service contractor on the basis of the cost estimate based on the pre-project planning • Realization as total service provider
Project C (PC)	• Preliminary study and pre-project planning drawn up by the developer and an architect, who was selected from a competition of architects • Organization of a total service competition with pre-qualification • Realization as total service provider
Project D (PD)	• Developer needed 1000 workplaces within a short space of time • Pre-selection of suitable total service contractors, specialist planners and architects • Organization of a total service competition with prior formation of teams on the basis of a list of participants drawn up by the developer • Organization of a workshop over several days incorporating all parties involved, following conclusion of the total service contract • Realization as total service provider

FINDINGS FROM THE MULTIPLE CASE STUDY

Fundamental principles for comparing the knowledge clusters identified from the four case studies

15 knowledge clusters each were pinpointed in case studies A and C and 13 each in case studies B and D. Once these knowledge clusters had been identified, they were cross-compared using replication logic.

It was necessary to first define the relevant criteria on which to base a comparison of the knowledge clusters to reveal any similarities. The following criteria were defined on the basis of the knowledge cluster modeling (Figure 1), all of which had to be fulfilled by various knowledge clusters from the different case studies in order for these to be deemed sufficiently similar or even identical:

- Identical allocation of the knowledge cluster activity to the relevant process of providing products and services on the part of the service provider.
- Similarity of the knowledge cluster activities in the knowledge clusters being compared.
- Similarity of the outcome of actions respectively impacts achieved by actually executing the knowledge cluster activities. These outcomes serve to support the success targets of acquiring the contract, satisfying the customer and earning a profit for the company.

Once the identified knowledge clusters had been compared from every angle of each individual case study to the knowledge clusters from the other three case studies, these were then subdivided into case-specific knowledge clusters and cross-section knowledge clusters.

Case-specific knowledge clusters

Case-specific knowledge clusters – Case study A:

- Advice to the customer regarding possible solutions during the first contact
- Active incorporation of the customer's needs into the project
- Clear definition and demarcation of the individual work categories
- Minimization of possible losses of knowledge at personal interfaces
- Serious preparation, procurement of fundamentals and planning execution

Case-specific knowledge clusters – Case study B:

- Services to resolve the developer's initial problems were offered at an early stage / Securing an ideally located plot of land
- Close involvement of the developer in the project and definition of the customer's needs at all levels
- Careful preparation of the execution and discipline on the part of the subcontractors with regard to deadlines

Case-specific knowledge clusters – Case study C:

- Offering the customer supportive services at an early stage
- Actively responding to the needs and expertise of the developer / Channeling requirements
- Clear regulation of the planning permission process

- Particular attention to awkward aspects and minimization of errors thanks to the total service contractor's experience
- Careful preparation of the execution / execution planning
- Transfer of knowledge between project development (competition) and realization

Case-specific knowledge clusters – Case study D:

- Increasing the initial speed of the competitive teams by activating existing contacts
- Organizing a workshop to capture the customer's needs and integrate them into the project / involving the developer
- Minimization of knowledge losses thanks to personnel consistency throughout the project
- Careful preparation of the execution of construction elements with special quality requirements
- Cross-section knowledge clusters
- Cross-section knowledge clusters can be subdivided into qualified cross-section knowledge clusters, which occurred in two or three cases, and unqualified cross-section knowledge clusters, which were equally valid for all four case studies.

Table 2: Summary of the qualified cross-section knowledge clusters

Brief description of the knowledge cluster	Similar knowledge clusters from			
	PA	PB	PC	PD
Proof of experience and references from earlier and similar projects	X		X	X
Constructive collaboration with the architect to incorporate desired alterations (reaching a consensus)	X			X
Efficiency and transparency thanks to lean project organization and clearly structured planning process		X		X
Coordination of interfaces during the provision of the products and services		X	X	
Incorporation of changing needs of the customer / flexibility	X	X	X	
Identification and minimization of risks and potential mistakes at an early stage / quality control	X	X		X
Specific award criteria in case of difficult tasks	X	X	X	

A cross-reference revealed that the following five unqualified cross-section knowledge clusters were equally relevant for all four case studies:

- Identification of potential areas of optimization on a competitive project and cost-effective inclusion of the same in the bid
- Risk minimization prior to signing the contract (cost-covering calculation and identification of qualitative problems before agreeing the contract)
- Transparency on the part of the total service contractor towards his customer (with regard to requests for alterations)
- Promotion of a constructive atmosphere of cooperation within the team
- Serious approach to providing warranties and eliminating defects

Conclusion from comparing knowledge clusters

After conducting the cross-case it was possible to take a closer look at the number of case-specific knowledge clusters and cross-section knowledge clusters.

Table 3: Number of case-specific knowledge clusters for each case study

	No. of identified knowledge clusters	No. of case-specific knowledge clusters
Project A	15	5
Project B	13	3
Project C	15	6
Project D	13	4

A study of the cross-section knowledge clusters revealed that 7 of these occurred equally on two or three of the examined projects (qualified cross-section knowledge clusters) whilst 5 of them were equally relevant for all four of the cases studied. As such, the conditions under which this study was conducted revealed that approximately 1/3 of the relevant knowledge clusters from any one project only related to the specific case of the project studied, whereas approximately 2/3 of the knowledge clusters were valid for several projects.

In consequence, the approach of using knowledge clusters to manage the knowledge of total service contractors revealed that the fundamental prerequisite was fulfilled in respect of the suitability of the approach, since some 2/3 of the knowledge clusters were equally valid for several structural engineering projects, and could therefore have been activated for specific use on these projects.

On the basis of replication logic, the situational conditions, under which the specific or cross-section knowledge clusters occurred in the context of the study, respectively the valid criteria were moreover defined by cross-case. These criteria are important subsequently for determining whether each knowledge cluster is even relevant or valid for the next specific case when applied once more to a new structural engineering project.

Conclusions from the contents of the knowledge cluster analysis

From the point of view of content, the five cross-section knowledge clusters are of particular relevance. When trying to win contracts the identification of potential areas of optimization on a competitive project and the use of intelligent solutions to achieve additional customer benefit in the bid would seem to ensure success. Moreover, the success of all projects was affected by the fact that the future development of market prices was realistically estimated when drawing up the bid, and that attention was paid to overcoming the contract risks.

An important factor in the realization of the projects seems to be that the customer is actively involved in the project, and that the contractor adopts a fair, open and transparent attitude towards the customer. The interpersonal relationships among the members of the team should also not be underestimated in order to ensure a constructive and cooperative atmosphere. According to the studies, it would also seem to be important that a lack of seriousness in handling the warranty obligations following the hand-over of the construction project can cause lasting deterioration in any customer satisfaction that had been established up till that point, which, in turn, can impact the contractor's image.

The developer's feeling of security and his faith in the contractor's performance is therefore of major importance in ensuring both a trouble-free and successful completion of the project, and customer satisfaction.

IMPLICATIONS FOR A PROJECT- AND CLUSTER-ORIENTED KNOWLEDGE MANAGEMENT MODEL

Reactivation of knowledge clusters for new structural engineering projects

In order that the knowledge clusters identified from completed structural engineering projects can be applied to new structural engineering projects, the results must be collated in such a way as to ensure that the suitability of the potentially applicable knowledge clusters can easily be verified.

In order to gain an overview over the ongoing identification of new knowledge clusters from completed construction projects it is necessary to collate the results in a "cluster pool". Whereby a cluster pool can have a variety of shapes and sizes, ranging from a collection of appropriate paper printouts to a collation of the information in databases or on the intranet.

If the contractor is now targeting a new structural engineering project, the following steps must be followed to reactivate any knowledge clusters:

- Right from the start the decision must be made in principle as to which acquisition strategy is to be applied: Should the contractor become involved in the project development at an early stage, or has the project development already been completed by the developer and other third parties, resulting, for example, in the decision to organize a total service contracting competition?

- On the basis of the specific project conditions stipulated for the new structural engineering project (e.g. type of project execution, customer's performance targets, general conditions, project participants, project organization) the individual conditions of validity of the knowledge clusters identified during earlier projects now need to be examined to verify that they comply with the new situation, resulting in the pinpointing of those knowledge clusters, which are applicable to and relevant for the new project.

- A resource schedule needs to be drawn up for the individual, applicable knowledge clusters, i.e. a determination of the appropriate ramifications for their use.

- And lastly, the individual knowledge clusters need to be activated at the right point in time (during the process of providing the products and services) and in the right places, respectively the project management team needs to control the activation of the same.

- Following completion of the project, the effectiveness of the steps taken needs to be assessed from the perspective of how successful they were, new knowledge clusters need to be identified and this information needs to be added to the cluster pool by means of a feedback process.

Expansion of the project- and cluster-oriented knowledge management model

The steps indicated so far for identifying and describing the knowledge clusters from completed projects and for activating valid knowledge clusters on new projects "only" serve to ensure that the success factors are consciously activated on new projects and,

as a result, only potentially raise the chances of successfully winning the contract, achieving customer satisfaction and earning a profit for the company.

In order to achieve a real process of improvement or even development, a further step at the "strategic development level" needs to address the following points:

- Verify what knowledge is needed to activate the individual knowledge clusters

- This verification should reveal which knowledge has already been sufficiently processed internally or is already in the hands of the relevant colleagues, and which knowledge first needs to be developed or improved. The outcome reveals the potential areas of improvement and development with regard to the individual knowledge clusters.

- Prioritize the knowledge clusters

- Derive suitable measures for realizing the potential for improvement or development (e.g. strategic cooperation agreements, advanced training schemes, etc.)

- Approve and implement appropriate measures to improve or develop each knowledge cluster

An appropriate process model for project- and cluster-oriented knowledge management for total service contractors can now be sketched on the basis of the findings that have so far been discovered (Figure 4).

Reflections on the organizational implementation

The knowledge management processes should be controlled by so-called "knowledge managers" from a central point within the company. If the company does not wish to set up a proprietary organizational unit to do this, the quality management unit could assume the responsibility.

Consequently the knowledge manager would hold closing talks with the project and construction managers following the completion of a structural engineering project in order to determine the success factors. Moreover he would incorporate appropriate questions into the interview with the customer at the end of the project. Once the knowledge clusters have been described, he would compare the pinpointed knowledge clusters with the knowledge clusters identified during other structural engineering projects and look for any similarities. After determining the relevant conditions of validity for each knowledge cluster, the knowledge manager would then add these new findings to the cluster pool and manage the same.

At the strategic development level the knowledge manager would examine the knowledge needed to activate the individual knowledge clusters and derive the relevant areas of potential improvement or development on the basis of the same. After consultation with the management, the knowledge manager would prioritize the knowledge clusters and define suitable means of realizing the potential improvement and development. These measures would be submitted as a proposal to the management. As the knowledge clusters represent success factors, direct justification can be given as to which benefits would result for the company from implementing the relevant measures (cost vs. benefit).

PROJECT EXECUTION AND SERVICE PROVISION LEVEL

Newly launched (ongoing) project services
Execution phases project m
Knowledge clusters
Total service contracting service provision processes
Acquisition / Bid preparation / Negotiations / Planning / Execution / Operation/maintenance
Support processes
(m1) (m2) (m3) (m4) (m5) (m6) (m7) ...... (my)
Projects characteristics (m)

Completed project services
Execution phases project n
Success factors
Total service contracting service provision processes
Acquisition / Bid preparation / Negotiations / Planning / Execution / Operation/maintenance
Support processes
(n1) (n2) (n3) (n4) (n5) (n6) (n7) ...... (nx)
Projects characteristics (n)

KNOWLEDGE MANAGEMENT LEVEL

Verification of applicability and activation of the knowledge clusters

Cluster pool

Identification and description of the knowledge clusters

Ge. knowledge characteristics

STRATEGIC IMPROVEMENT AND DEVELOPMENT LEVEL

Performance and strategic characteristics of the company

Verification of knowledge needed, potential areas of improvement and development, measures

Knowledge and competence characteristics of the company

Environment / industry / market

Organization / management

Decision maker

Action maker

Project n

Project m

Adjustment of organization and strategy

Positioning of services

Adjustment of priorities and objectives

Intend

Cluster classification

Verify

STRATEGIC TARGET LEVEL
• Acquisition of contracts / competitive sucess
• Customer satisfaction and customer loyalty
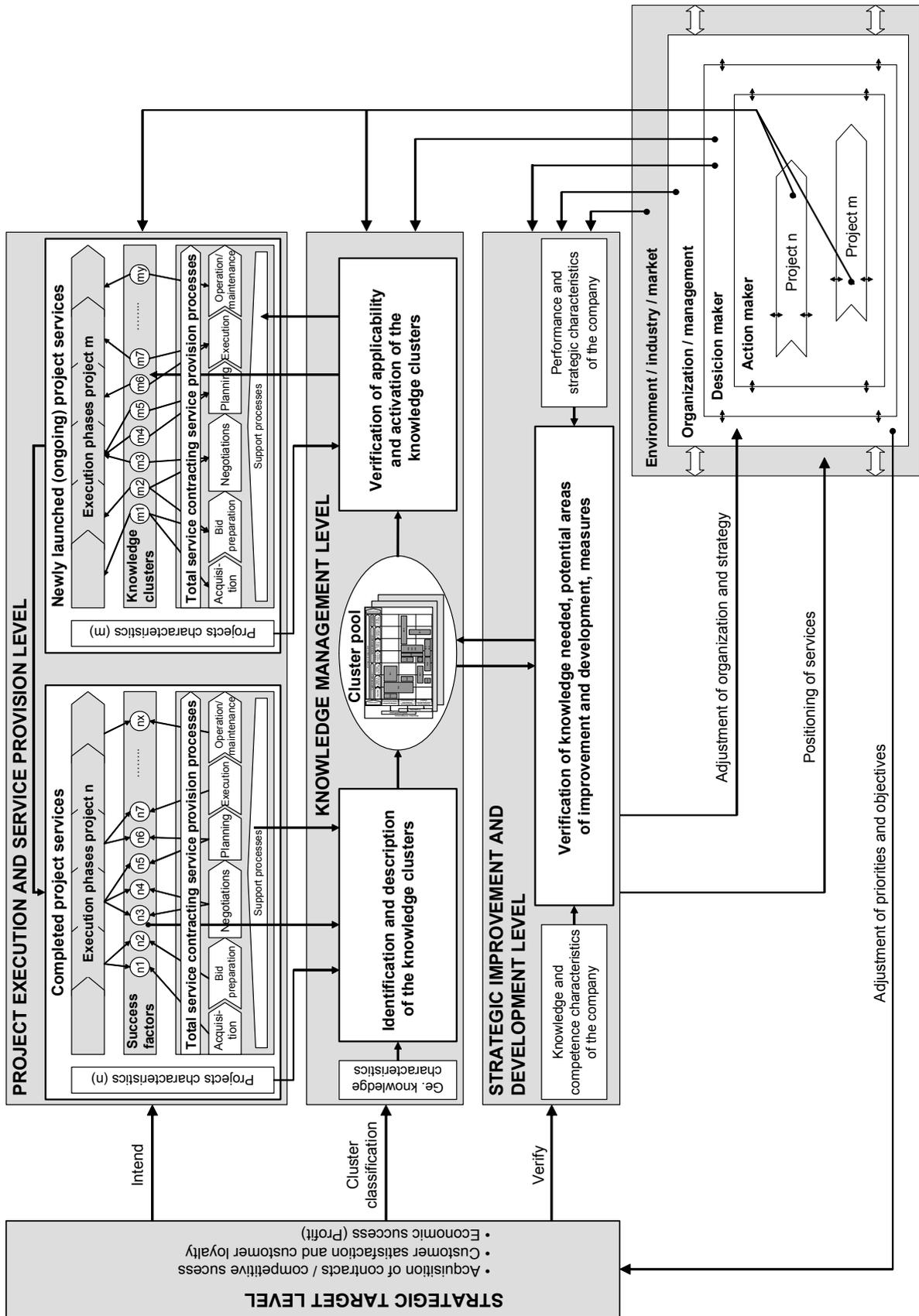• Economic success (Profit)

Figure 4: Process model for project- and cluster-oriented knowledge management for total service contractors

In the case of newly acquired structural engineering projects, the knowledge manager would assume the role of coach. Once the conditions of validity had been verified, he would – at various stages in the project - draw the attention of those internal parties responsible for the project (calculation, competitive team, project manager) to the relevant knowledge clusters at the right point in time, and would advise them on using the knowledge clusters, whilst at the same time pointing out any tools, which might have been developed for the purpose. By doing so, an activation and consideration of the success factors, respectively knowledge clusters, can be guaranteed. The actual activation of the knowledge clusters during the execution of the project should then be controlled by the project management team.

CONCLUSION

Two major stumbling blocks preventing a broader level of acceptance and application of knowledge management in construction companies proved to be the unique character of each building project, and the lack of any practical tools for a company to use to pinpoint the knowledge that was of value to the said company and to identify the real benefit to be gained from systematically nurturing this knowledge. For this reason, the Institute for Construction Engineering and Management (Swiss Federal Institute of Technology, Zurich) has developed a model approach for a project-oriented and cluster-oriented knowledge management process that focuses on these requirements and, as such, should make it possible to incorporate knowledge management into companies' everyday business. By doing so, these companies should be put in a position where they can exploit further potential for improvement when rendering their services and, in consequence, ultimately increase their competitive strength.

A multiple case study was conducted in collaboration with various Swiss total service con-tractors to obtain further practice-related findings to be used for developing project-oriented and cluster-oriented knowledge management, and to verify the efficiency of the knowledge cluster approach, whereby four major and complex structural engineering projects were analyzed to identify their relevant success factors and knowledge clusters, which were then assigned to the individual phases of the overall construction process.

Once the relevant success factors respectively knowledge clusters of each structural engineering project had been pinpointed using qualitative social research methods, they were subsequently examined to identify any similarities. These examinations revealed that about 1/3 of the knowledge clusters relating to any particular project were only actually valid for that one specific project under examination, whilst about 2/3 of the knowledge clusters were valid for several projects (cross-section knowledge clusters). This proved that the knowledge cluster approach was fundamentally suitable, since once these cross-section knowledge clusters had been pinpointed, they could have been specifically activated for the other projects.

Identifying, describing and discussing the knowledge clusters within the value creation process of a construction project enabled conclusions to subsequently be drawn using logical thought processes, which were valid for a project-oriented and cluster-oriented knowledge management model for the process of providing products and services on the part of total service contractors. This project-oriented and cluster-oriented knowledge management model is based on corporate objectives and profit targets whilst at the same time allocating the success-oriented knowledge clusters to the individual phases of the company's overall process of providing products and services, whereby it is important to take the specific discriminating stages and elements of the various types of project execution into consideration. These findings and knowledge are then put to specific use in acquiring and completing new construction projects.

REFERENCES

Borner, R. (2003) *Win-Win-Erfolgsfaktoren bei Gesamtleistungen - Erfolgsorientiertes Wissensmanagement in GU- und TU-Leistungserstellungsprozessen.* Institut für Bauplanung und Baubetrieb, ETH Zürich, Zürich.

Girmscheid, G. (2000) Wettbewerbsvorteile durch kundenorientierte Lösungen – Das Konzept des Systemanbieters Bau (SysBau). *Bauingenieur* 75, 1/2000, 1 – 6.

Girmscheid, G. and Borner, R. (2001) Einsatz und Potenziale von Wissensmanagement in Unternehmen der Bauwirtschaft. *Bauingenieur* 76, Mai 2001, 256-260.

Nonaka, I. and Takeuchi, H. (1995) *The Knowledge-Creating Company*. Oxford University Press Inc., Oxford.

Yin, R. K. (1994) *Case study research: design and methods*. Sage Publications, Thousand Oaks.

Zack, M. H. (1999) *Knowledge and Strategy*. Butterworth-Heinemann, Boston.