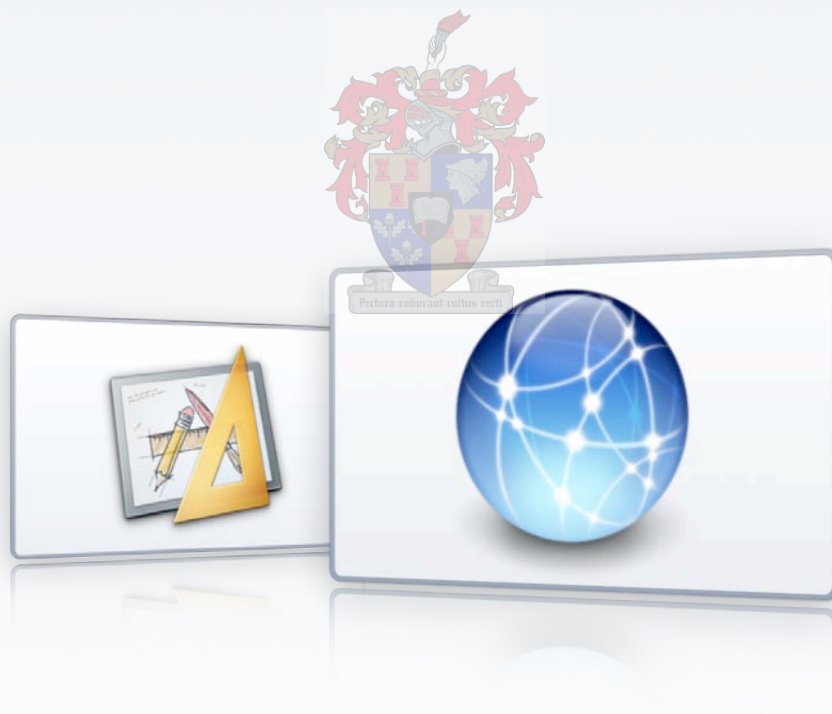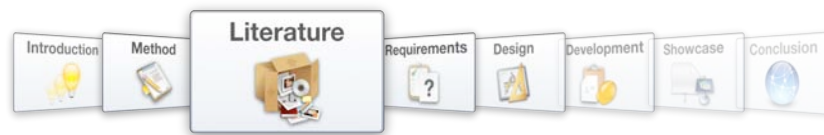# Using Knowledge Networks to support Innovation

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Thesis presented in partial fulfilment of the requirements for the degree of

Master of Engineering Science

at Stellenbosch University

3.2. Knowledge Networks

Networks and Knowledge Management are underlying factors that provide background to the development of Knowledge Networks will be discussed before analyzing the Knowledge Network itself.

3.2.1. Networks

For the purpose of this research, the term "networks" can be interpreted as relationships between individuals, groups, or organizations. In the analysis of such networks, it is important to not only consider the relationships between the network participants, but to also comprehend the entire network.

A "social network" is often defined as "a specific set of linkages among a defined set of actors, with the additional property that the characteristics of these linkages as a whole may be used to interpret the social behavior of the actors involved" (Mitchell [32]). A "social network" is therefore often regarded as a social relationship between actors, which may include individuals or groups, but also organizations or communities.

The relationships that develop between the actors in the network may be classified according to contents (e.g. products or services, information), form (e.g. duration and closeness) and intensity (e.g. communication-frequency). The form and intensity of relationships may be used to determine a sense of the structure of the network (Burt [6]).

Networks do not only possess a structural element but also include a strong cultural element. Relationships between actors are founded on personnel-organizational or technical-organizational interconnections that exist on a long-term basis. These relationships may further be understood as deriving from the autonomy and interdependence of network members, which on an organizational level may be interpreted as the coexistence of competition and co-operation.

Network boundaries may also be defined in terms of the relationships between members but as network members construct relationships socially, these boundaries are often blurred. A growing trend towards greater care for the health of relationships rather than attention to specific network boundaries is developing. This results in enterprises becoming containers of decentralized groups and sub-groups that are continuously collaborating with similar working units all over the world. (Reich [40])

The drivers for the formation of networks include both the intensification of cooperation and limited functional outsourcing. Although these needs may be satisfied with a number of organizational
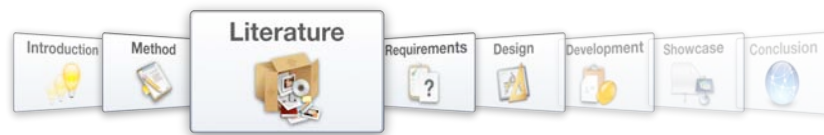
models, networks offer the ability for these processes to occur both horizontally and vertically between actors in the same value chain.
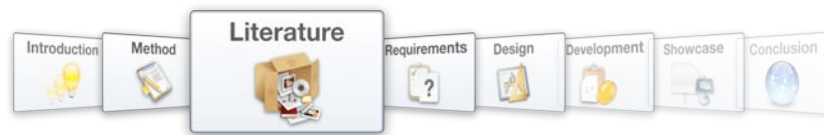
42

3.2.2. Knowledge Management

Integrating networking and knowledge management requires two crucial elements (Seufert [54]):

1. **Knowledge management should comprise a holistic view of knowledge, i.e. the integration of tacit and explicit knowledge.**

   In the modern context knowledge is often thought of as a commodity that is transferable independently of person and context. Many knowledge management strategies therefore try to improve information flow with the intensive use of modern technologies. The potential of innovative technologies for the capturing and distribution of explicit knowledge is undisputed. The value of re-using explicit knowledge as a means of improving knowledge usage efficiency is equally unchallenged. An integrated approach that includes both tacit and explicit knowledge is however required.

   Tacit knowledge is deeply rooted in personal experiences, subjective insights, values and feelings. Communicating and sharing this element of knowledge is therefore a major challenge to any knowledge management strategy and accompanying systems. Tacit knowledge possesses a technical as well as a cognitive dimension. Whereas the technical dimension contains informal, personal abilities and skills, often designated as "know-how", the cognitive dimension includes our mental model influenced by our beliefs, values and convictions. In view of Knowledge Work Process specifications (refer to Chapter 4.1.2), a distinction will be made between the technical and cognitive dimensions of tacit knowledge. The technical dimension will from this point onward be referred to as 'implicit knowledge', with 'tacit knowledge' only referring to the cognitive dimension. Knowledge Networks therefore support effective use of knowledge by making the knowledge and experience of individuals available within its organizational structure.

2. **Knowledge management should take a holistic view on where and how knowledge is created and transferred.**

> The core business activities of working, learning and innovating are the areas where knowledge is most prolifically utilized in modern enterprises. These three activities are however still often strictly separated as a result of their different mental models. Working, learning and innovating however compliment each other from a knowledge flow perspective and an effective approach to knowledge management should take a wide view of these activities. Networking provides an opportunity to overcome knowledge barriers within organizations by cross-linking islands of knowledge and stimulating the evolution, dissemination and application of knowledge. Networks furthermore offer openness and richness that foster a fertile environment for the creation of new knowledge, while also accelerating the innovation rate.
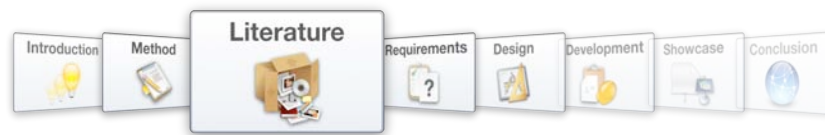
Regardless of whether networking is driven by gaining access to new knowledge, or by creating and transferring knowledge, connectivity to a network and competence at managing networks have become key drivers of a new business logic (Seufert [54]).

Both of these Knowledge Management elements to Knowledge Networks offer crucial insight into global requirements for an information system that wishes to support a Knowledge Network, and will be expanded on in Chapter 4.1.1.

3.2.3. Knowledge Networks

A Knowledge Network may be defined as "a number of people and resources, and the relationships between them, that are able to capture, transfer and create knowledge for the purpose of creating value" (Tichkiewitch [3]). Networks may be distinguished as emergent or intentional. Intentional knowledge networks are constructed from scratch, whereas emergent knowledge networks already exist informally, but have to be cultivated in order to become high-performing. These emergent networks may evolve to include a common language, set of values and objectives between team members.

These knowledge networks are of a social nature and may be supported and transformed by information and communication technology. As these networks of knowledge-sources are continuously being augmented by knowledge gained from learning situations, a knowledge network should be regarded as a dynamic structure rather than a static institution.

A framework for Knowledge Networks comprises the following: (Seufert [54])

- **Actors** (e.g. individuals, groups, organizations)

- **Relationships** between actors (categorized by form, content and intensity)

- **Resources** which may be used by actors within their relationships

- **Institutional properties** (control mechanisms, norms and rules, communication patterns)

Knowledge networks may be conceptualized to have the following three building blocks, as is depicted in Figure 24:
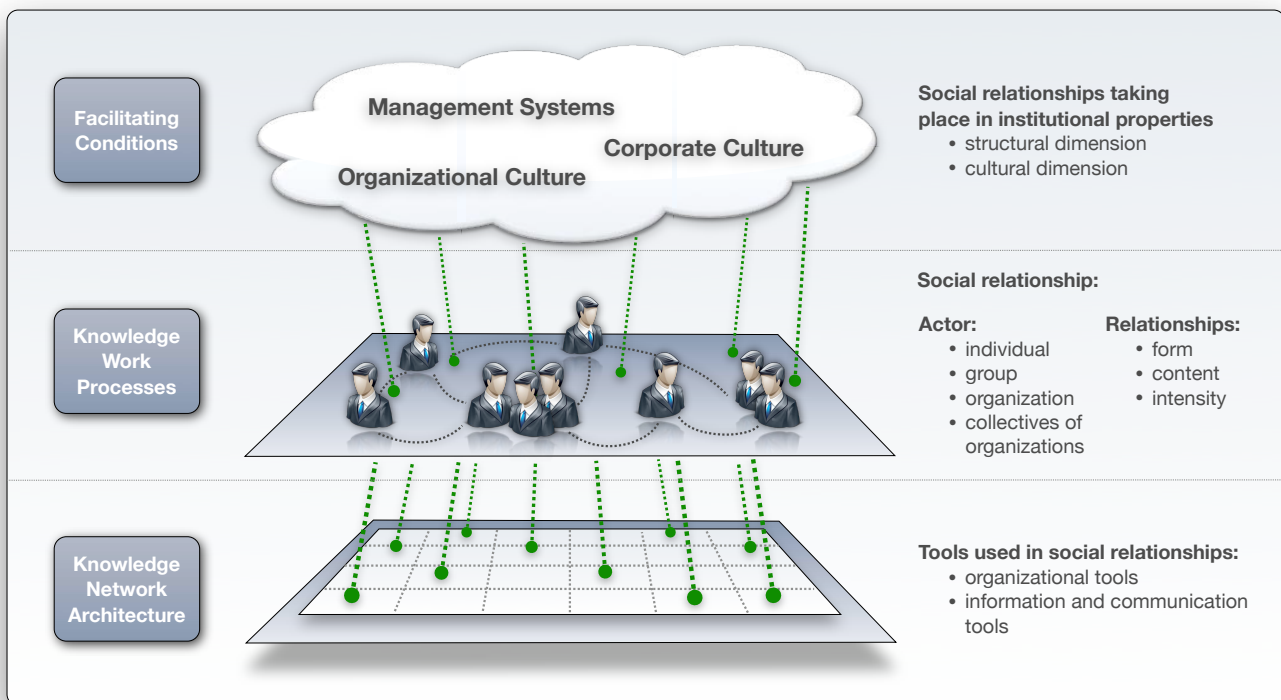

Figure 24 - A framework for Knowledge Networks (Seufert [54])

3.2.3.1. Facilitating Conditions

A knowledge network's facilitating conditions consists of the network's internal structural and cultural dimensions in which knowledge work processes take place. These conditions could therefore act as enabling or inhibiting factors for knowledge creation and transfer.
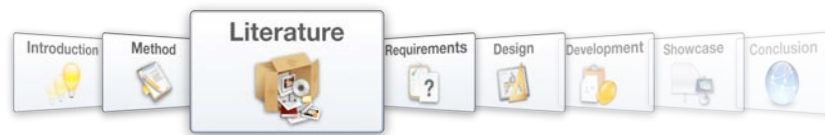
3.2.3.2. Knowledge Work Processes

Knowledge Work Processes comprise social interaction and communication processes on an individual or group level. These processes may be categorized according to the transformation that knowledge undergoes as a result of the activity (Schutte [50]).

- **Socialization** comprises the exchange of tacit knowledge between individuals in order to convey personal knowledge and experience.

- **Externalization** involves the conversion of implicit into explicit knowledge, and the exchange of knowledge between individuals and a group.

- **Systematization** transforms explicit knowledge into more complex and more systematized explicit knowledge.

- **Internalization** is the conversion of organization-wide, explicit knowledge into the implicit knowledge of the individual.

These four knowledge work processes combine to form a spiral representing all the knowledge creation and transfer activities within the network (Nonaka [34], [35]), as is depicted in Figure 25. The anatomy of these knowledge work processes will be discussed in more detail in Chapter 4.1.2.
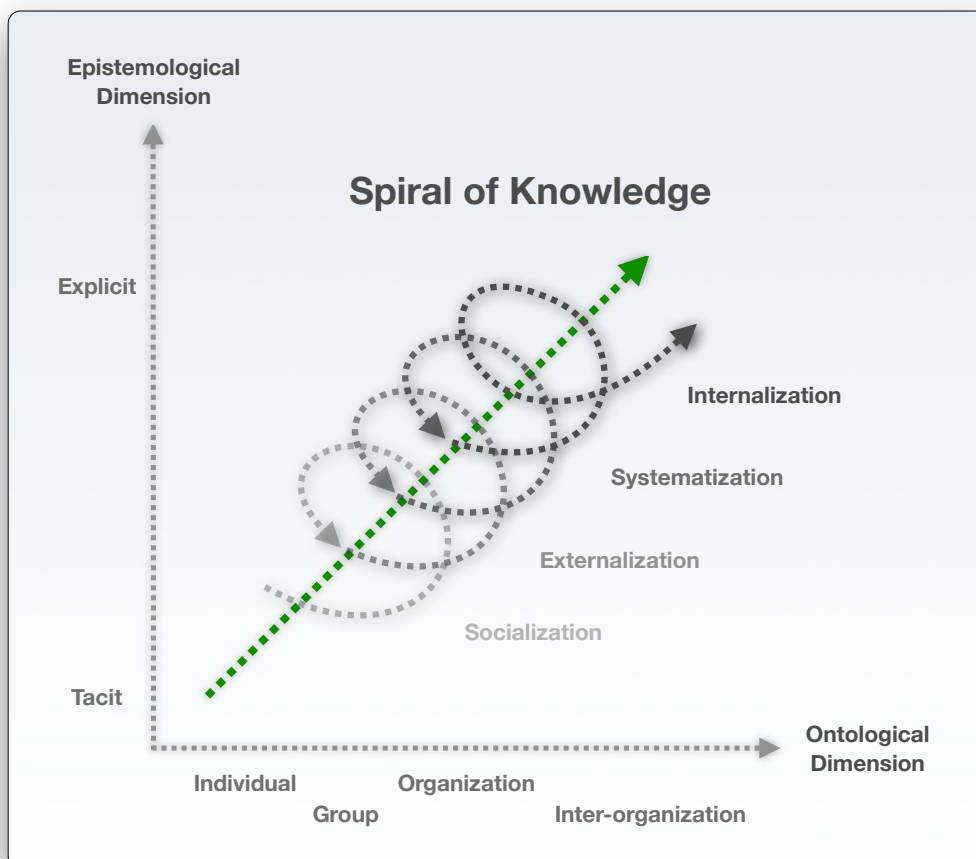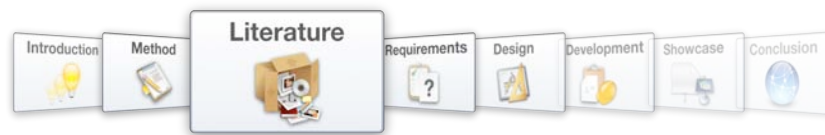

Figure 25 - Knowledge Work Processes as a spiral (Nonaka [36])

3.2.3.3. Knowledge Network Architecture

The Knowledge Network Architecture consists of tools that are used to facilitate social relationships, and include organizational as well as information and communication tools. These tools are aimed at enabling or improving Knowledge Work Processes.

A tool classification framework may be employed to divide the combination of organizational information system tools into four main categories: Communication and Coordination Tools, Organization and Management Tools, Intelligent Tools and Integration and Database Tools (refer to Figure 26). To ensure maximum impact on the knowledge network, these tools are used in combination to form "solution frameworks" (Seufert [54]) instead of operating as modular tools.
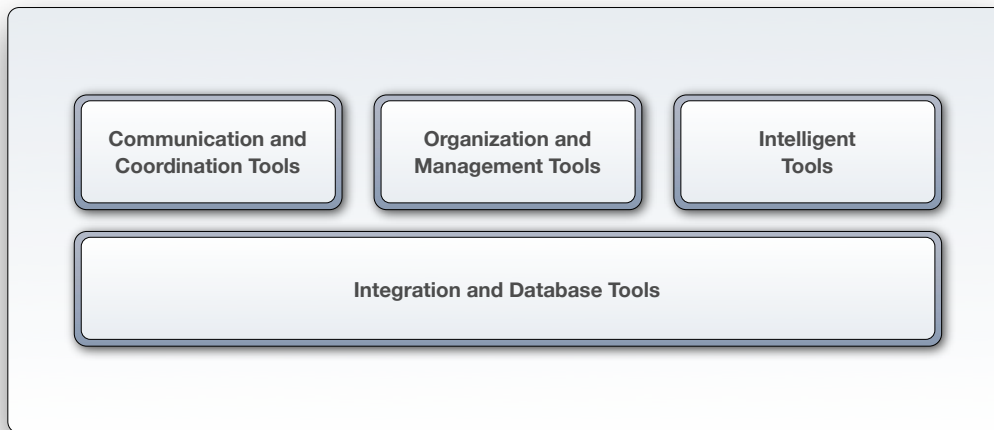

Figure 26 - Classification model for ICT and organizational tools

Integration Tools form the basis of solution frameworks and comprises technical as well as organizational aspects such as the integration of technology, knowledge work processes, knowledge objects (implicit and explicit knowledge), and support levels (individual, network, company).

From an Information and Communication Technology perspective, systems that aim at supporting a knowledge network should focus on supporting Knowledge Work Processes by providing services for locating and capturing knowledge, sharing and transferring knowledge and especially the creation of new knowledge (Raimann [39]). ICT-tools used to support a knowledge network should furthermore provide for personal and group "work spaces" and the comprehensive management of the network knowledge base as knowledge objects.

The creation of a knowledge portal to provide access to the knowledge network may be realized with modern web-based technologies. This provides a single point of access to the knowledge objects
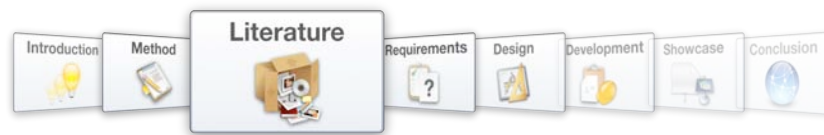
and all underlying systems. Such a knowledge portal should be configurable and adaptable to the needs of knowledge networks as well as the needs of their members. A review of Information and Communication Technologies that may be successfully implemented as part of a Knowledge Network Architecture is provided in Appendix A.

3.2.3.4. Knowledge Network Reference Types

Knowledge networks may be categorized according to the Knowledge Work Process that is most prolific within the network (Seufert [54]) (refer to Figure 27)

- An **Experiencing Network** mainly pursues socialization (transferring tacit knowledge between individuals). It supports the members to exchange their knowledge, best practices, and solutions through common experiences.

- A **Materializing Network** focuses on externalization (transforming implicit knowledge into explicit knowledge) and serves to motivate and stimulate network members possessing implicit knowledge to externalize their experiences and thoughts.

- A **Systematizing Network** mainly deals with systematization (structuring explicit knowledge into explicit knowledge while adding value). This network type produces organizational handbooks, yellow pages, newsletters and training materials as a means of efficiently reusing explicit knowledge.

- A **Learning Network** pursues internalization (transforming explicit knowledge into the implicit knowledge of individuals) and supports the learning, embodiment and application of existing explicit knowledge. New implicit knowledge is created in the process.

While knowledge network reference types suggest possible knowledge network configurations based on the most prolific knowledge work process, these reference types do not imply that other knowledge work processes are not present within the network. This is confirmed by the knowledge generation spiral presented in Figure 25, which suggests that knowledge work processes are linked and that the knowledge network would be incomplete without support for all the processes. By supporting all the available knowledge work processes within a 'balanced' knowledge network, a holistic approach to knowledge (refer to Chapter 3.2.2) is ensured.
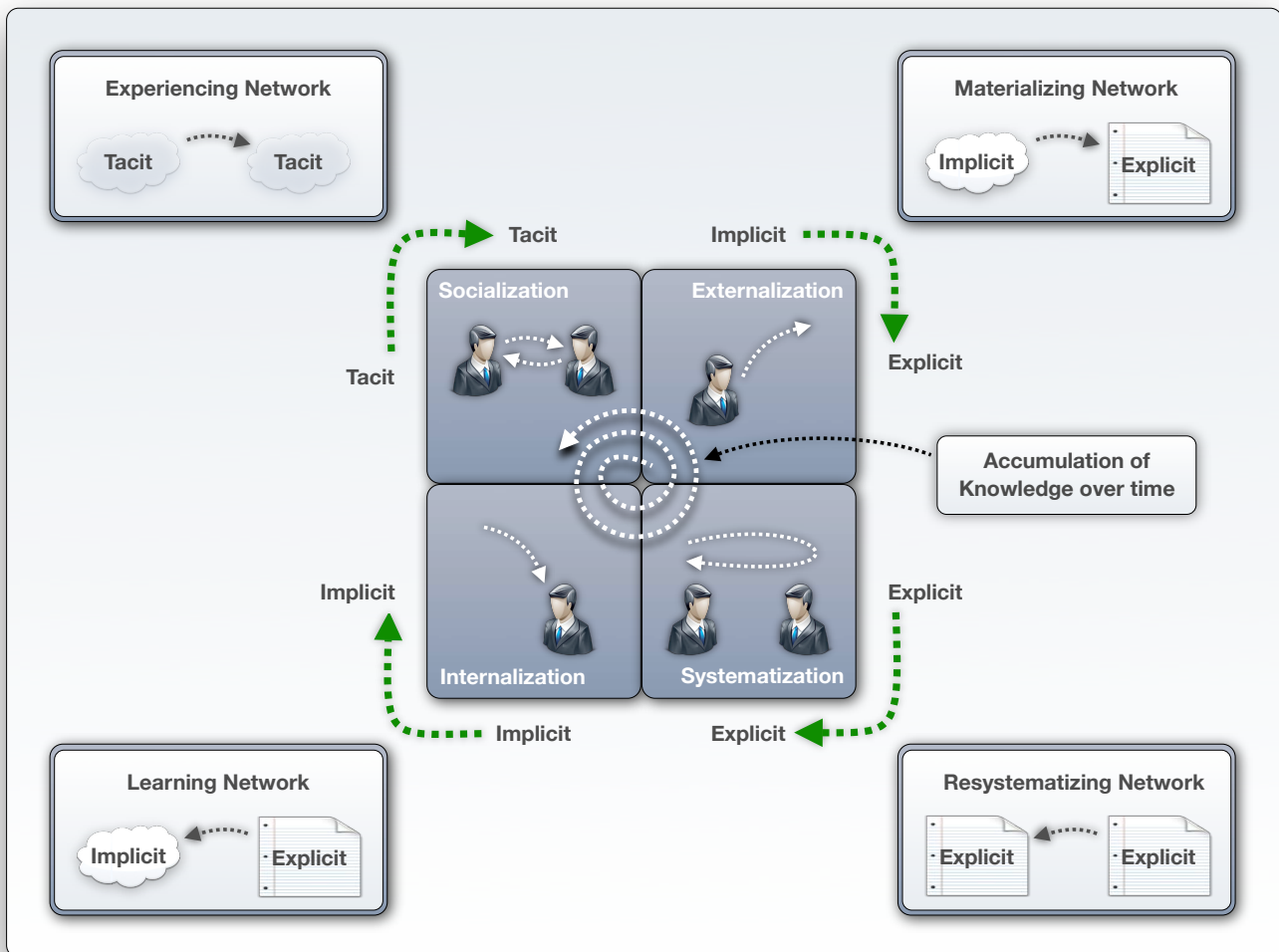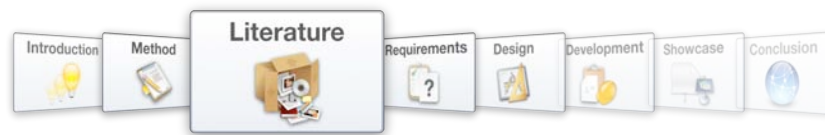
Figure 27 - Knowledge Network Reference Types

### 3.2.3.5. Knowledge Management perspective on Knowledge Networks

From the viewpoint of a dynamic knowledge management model, important considerations for success of the knowledge networks are (Seufert [53]):

- Interconnect the different levels and areas of knowledge

  Networking previous knowledge with new knowledge creates a rich environment for the creation of more new knowledge. It is therefore essential that individual knowledge types (explicit, implicit and tacit) be combined throughout different levels of the network (e.g. individual, group, organization) and areas of knowledge (e.g. customer knowledge, research and development knowledge).

- Interconnect Knowledge Work Processes and knowledge network facilitating conditions

  By cross-linking knowledge creation and transfer processes with facilitating conditions, knowledge work processes are allowed to develop optimally. Knowledge work processes will
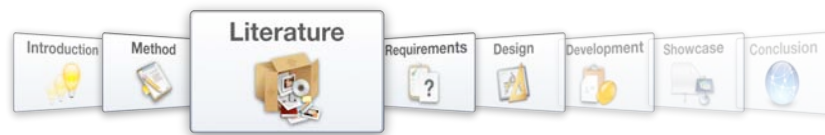
often adapt to the environment that is created for them to function in. By however actively developing and maintaining these facilitating conditions, organizations can create environments that allow and support efficient and effective knowledge creation and transfer.

- **Interconnect knowledge work processes and knowledge network architecture**

    In the modern environment, a single network will often include knowledge creation and transfer processes that take place in different real, virtual or mental locations. Since knowledge increasingly occurs in different time zones and different physical places, knowledge items that can exploit information and communication technology becomes extremely valuable. Organizational structures that can adapt to dynamic knowledge processes add essential value to organizations.

Researchers agree that a positive relationship exists between knowledge networks and organizational development. Knowledge Networks offer firms the opportunity to transform themselves into truly networked organizations. This shift in organizational structure is supported by trends toward a networked approach in innovation models. The same tendency to operate the network within company boundaries do however also exist for knowledge networks, and a new knowledge network configuration that traverses organizational boundaries is presented in the form of integrated knowledge networks.

3.2.4. Integrated Knowledge Networks

It may be observed from the discussion of the Knowledge Supply Chain that a number of role players are involved in knowledge creation and transfer processes. It therefore makes sense for organizations to extend the reach of their knowledge networks according to function and not merely along organizational boundaries.

This supports the open innovation philosophy and Integrated Knowledge Networks are therefore regarded as an ideal knowledge management structure for the support of innovation. The Enterprise Engineering Research Group at the Department of Industrial Engineering, University of Stellenbosch defines an Integrated Knowledge Network (Schutte [50]) as:

"A formal network of organizations that position their systems, processes and people in such a way as to allow for the integrated transfer of information and knowledge between the organizations to support sustainable innovation."
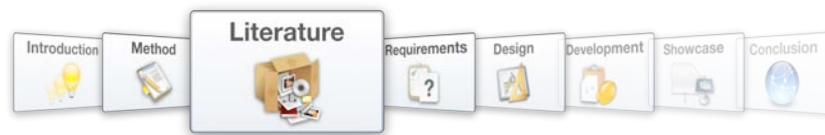
The use of an Integrated Knowledge Network is important to enable inter- and intra-enterprise teams to innovate using their collective experience, and by expanding their knowledge (refer to Figure 16). This collective experience can be exploited only if explicit, implicit and tacit knowledge is created, refined and exchanged, and is captured and structured in a manner that is accessible to all members. This implies the deployment of inter-enterprise knowledge networks. (Schutte [50])
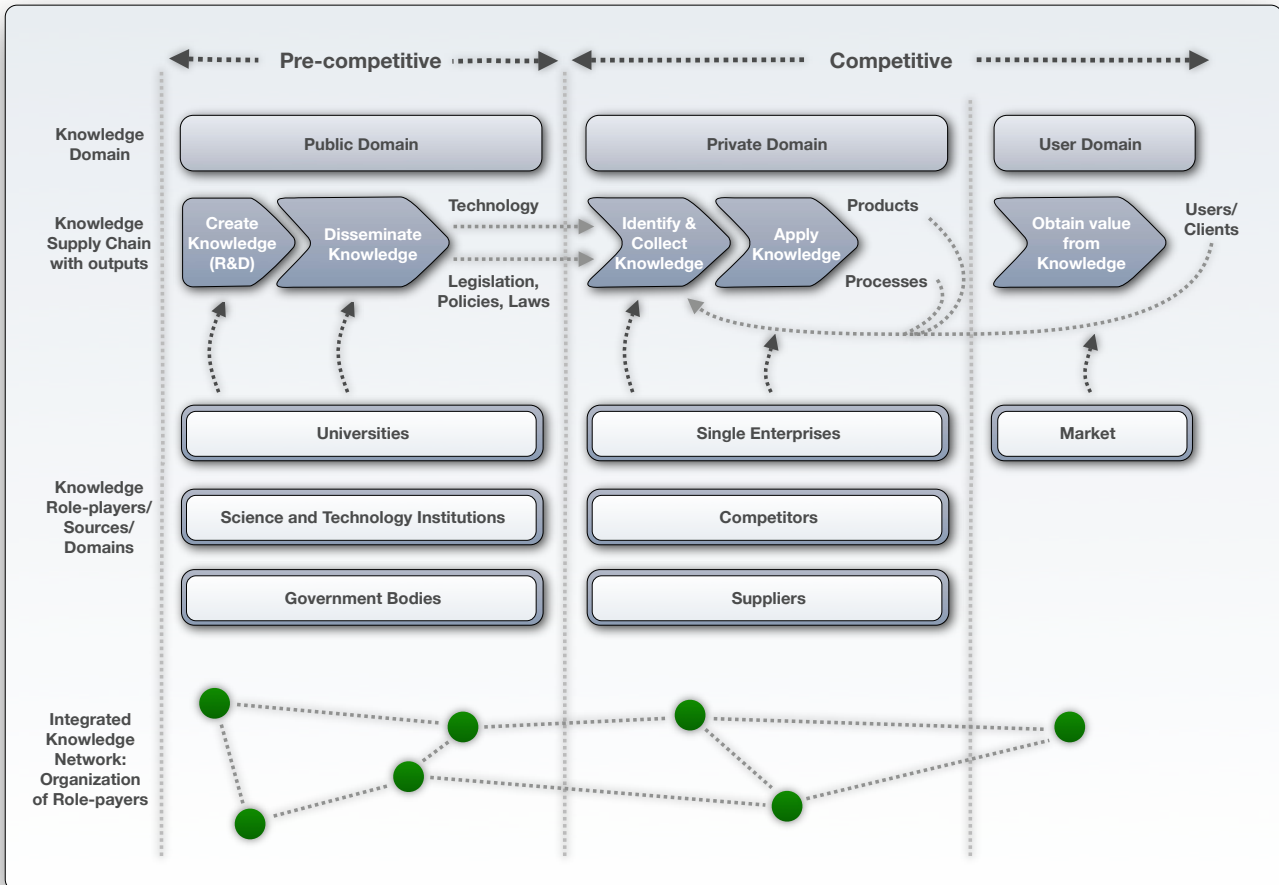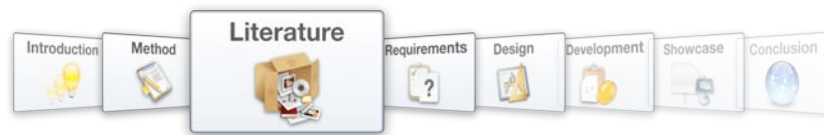

Figure 28 - Components of an Integrated Knowledge Network (Du Preez, Louw [15])

3.3. Refined Problem Statement

The draft of the problem statement for this research that was proposed in Chapter 1.2 may now be reconsidered and refined given the perspectives provided by Chapters 3.1 and 3.2.

Considering the literature review in this chapter, the problem statement for this research may now be defined as:

Innovation within a globalized economy requires that a wide range of role-players along a Knowledge Supply Chain collaborate by transferring and creating knowledge. A mechanism that offers this functionality is required.
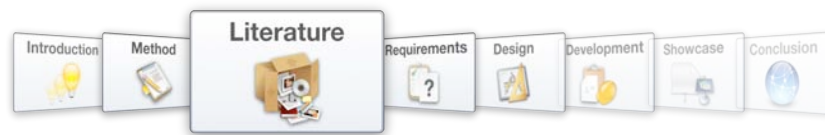
3.4. Hypothesis

The formulation of a hypothesis to solve the problem stated in Chapter 3.3 may be approached as follows:

There is no doubt that innovation capability is essential to any organization that wishes to survive and grow in a modern economy. In order for innovation to be managed effectively, it must be understood that innovation does not only consist of one act, nor is it dependent on a single individual or organization. The innovation process has a distinct life cycle and involves a wide array of role-players.

In order for these role-players to effectively combine and innovate along the material or service supply chain; the knowledge supply chain between them should be managed. This requires a knowledge management strategy that can accommodate the complexity of the interaction between role-players, while also allowing for efficient and agile knowledge creation and transfer processes. The Integrated Knowledge Network satisfies these requirements and is an organizational structure that is ideally suited to knowledge management and ultimately innovation.

Successful implementation and management of a Knowledge Network is enhanced by interconnecting the network's Knowledge Work Processes with its Knowledge Network Architecture. This Knowledge Network Architecture consists of organizational as well as information system elements, the latter of which may be specifically designed for the support of knowledge creation and transfer activities. The structural properties of such an information system can be described in high-level terms by developing an Information System Architecture.

Supporting innovation within an Information System Architecture does however involve more than simply connecting role-players and facilitating knowledge management between them. Successful

innovation management requires an understanding of the full Innovation Life Cycle, and ensuring that a comprehensive roadmap is followed to guide innovation projects that develop within the Integrated Knowledge Network. This roadmap starts at the birth of innovations as ideas, continues through their development as concepts, and extends to their operation as projects that may be exploited to generate further value.

The hypothesis for this research project is therefore:

Innovation may be supported by an Integrated Knowledge Network ICT Architecture that offers the following functionality:

1. Support for all the necessary Knowledge Work Processes needed for knowledge creation and transfer within an Integrated Knowledge Network.

2. Support for the full Innovation Life Cycle of projects that develop within the Integrated Knowledge Network.

The goal of this study is to design an Information System that facilitates an Integrated Knowledge Network, while providing support for the full life cycle of innovation projects that develop within this network.

The proposed Integrated Knowledge Network ICT Architecture will be developed by designing an Information System Architecture to ensure that all the necessary functionality is included. The specifications of this Information System Architecture are determined in Chapter 4 and this requirement set subsequently guides the design of the Information System in Chapter 5. The physical development of the designed Information System is covered in Chapter 6 and a demonstration of the Information System's functionality as proof of the hypothesis is provided in Chapter 7.
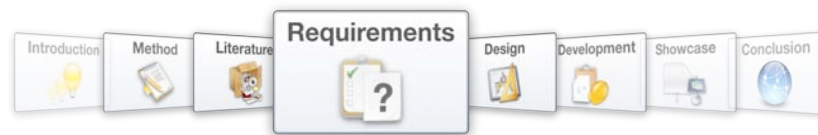
Chapter 4

Requirements
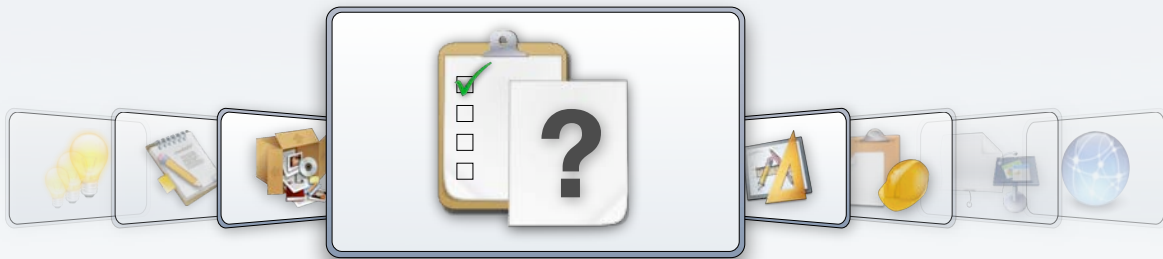
SDLC Step 4: Requirements Analysis

"Analyzes user needs and develops user requirements.
Creates a detailed Functional Requirements Document."

- Wikipedia

Chapter 4 derives a specification of the proposed solution's functionality in the form of an Information Systems Architecture.

As was discussed in the problem statement in Chapter 3.3, the goal of this study is to design an Information System Architecture that supports an Integrated Knowledge Network, while also providing support for the entire life cycle of innovation projects that develop within this network. A multi-layer approached will be used to ensure that both these requirements are accurately met in the proposed solution.

The Information System Architecture requirements of an **Integrated Knowledge Network** will be considered first, after which a similar set of requirements will be derived for the **Innovation Life Cycle**. Combining these requirement sets provides an **Information System Architecture specification** that is used to develop the Information System that serves as a proposed solution for the problem stated in Chapter 3.3.

Note: During this Requirements Analysis process, each requirement that is identified will be numbered for the purpose of referencing in subsequent chapters.
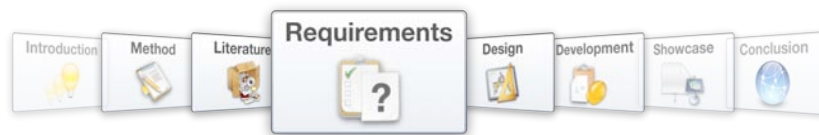
4.1. Knowledge Network Support

Knowledge networks, and therefore Integrated Knowledge Networks, are implemented by using a number of building blocks (refer to Chapter 3.2.3). When designing an information system architecture to support such a network there are two of these building blocks that are prerequisites, namely the **Knowledge Network Architecture** and the **Knowledge Work Processes**. Support for several of the other facets to knowledge network implementation, e.g. management systems and organizational culture, will be introduced in the discussion of support for these two main requirements.

4.1.1. Knowledge Network Architecture

A Knowledge Network Architecture consists of organizational and information system tools that combine to form "solution frameworks" (refer to Chapter 3.2.3.3). When considering the requirements of a solution framework that supports an Integrated Knowledge Network, the following observations are made:

- Integrated Knowledge Networks serve as an organizational tool that combines individuals, groups and organizations to form a network that is not limited by organizational boundaries. This network should therefore be able to accommodate actors with a variety of different backgrounds and perspectives.

- The level of diversity among the actors in the network does not only stem from organizational background, and may include differences in location and time zone.

- Web-based technology allows for the development of information systems that are accessible from anywhere in the world. Many of these technologies encourage the development of online communities that may include members with diversity in organizational affiliation, location and knowledge profile (refer to Appendix A).

- Web-based applications offer an array of functions that may be used as an effective Integration Toolset (refer to Figure 26 in Chapter 3.2.3.3) to form the basis of a Knowledge Network Architecture (Seufert [54]).

- Content Management System technologies (refer to Appendix A) offer a variety of content management approaches that are ideal for the management of a network knowledge base. These content management approaches may furthermore be customized to accommodate the diverse range of actors (knowledge objects) and relationships that combine to form a Knowledge Network.

Combining these observations leads to a definition of the Knowledge Network Architecture solution framework that will be implemented in the proposed Information System Architecture:

An online information system that simulates a network model of actors and relationships in the way it manages content.

Requirement #0
Online Environment

Required by Chapter:
- *4.1.1*

0

A more detailed design of this solution framework is achieved by considering the following key elements:

4.1.1.1. Holistic approach to knowledge

Knowledge is not only represented in the form of explicit knowledge (refer to Chapter 3.2.2). Implicit and tacit knowledge represents a large portion of the knowledge that exists within a system. The network model should therefore be configured in such a way
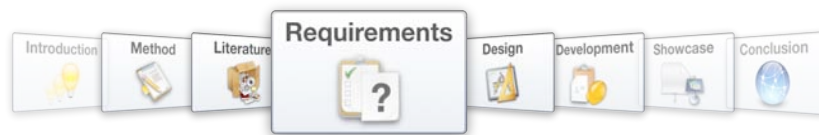
Requirement #1
Holistic approach to Kowledge

Required by Chapter:
- *4.1.1.1*

1

that the actors that carry knowledge of these different types are incorporated into the system and then empowered to interact.

The network setup employed by the information system should also be of such a nature that it stays as generic as possible, thereby allowing the system to be used in a number of different contexts and industries.

4.1.1.2. Knowledge object support

Supporting different kinds of knowledge inevitably creates the need for the support of different knowledge objects as actors or nodes within the network. These knowledge objects may include people (users), industries, teams, documents, forums, concepts and ideas.

> **Requirement #2**
> **Knowledge Object support**
>
> **2**   *Required by Chapter:*
> - *4.1.1.2*

The information system should be able to store information on each of these objects in a way that allows for them to be treated as simple nodes within the network. Knowledge objects will have certain generic characteristics in common, while differentiating in such a way that tailors each type of node to the object that it is representing. For instance, people and documents should be able to connect as network nodes, but should be different in terms of types of metadata captured.

4.1.1.3. Inter-organizational Flexibility

The network model should be able to include actors from a variety of organizations, thereby facilitating the multi-organizational needs of an Integrated Knowledge Network. The network model should furthermore be adaptive and flexible to make it as responsive as possible, thereby delivering the agile Knowledge Supply Chain that is needed for a rapid innovation rate. By taking advantage of networks' inherent capability for horizontal and vertical

> **Requirement #3**
> **Inter-organizational Flexibility**
>
> **3**   *Required by Chapter:*
> - *4.1.1.3*

integration of nodes, knowledge is disseminated faster. Implementing a network decreases knowledge hiding and although knowledge objects will be classified, they should never be restricted beyond security needs.
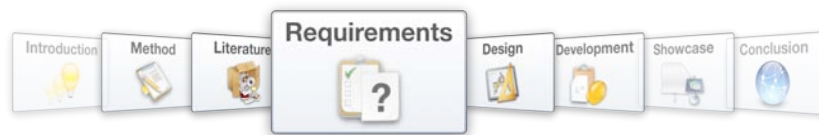
The organic growth of the network should also be catered for, leaving the network open to extendibility. In practical terms this could be in the form of simply increasing the number of natural network objects through knowledge development, or even connecting the network to other similar networks. Any barriers to entry of the network that are not absolutely necessary because of the strategic alignment of the network should be removed, thereby exploiting the participative organic nature of networks.

4.1.2. Knowledge Work Processes

Supporting Knowledge Work Processes within in a Knowledge Network ICT Architecture is vital to the support of the Knowledge Network as a whole (refer to Chapter 3.2.3.2).

4.1.2.1. Socialization

Socialization involves the transfer of tacit knowledge from one individual to another (refer to Figure 29).
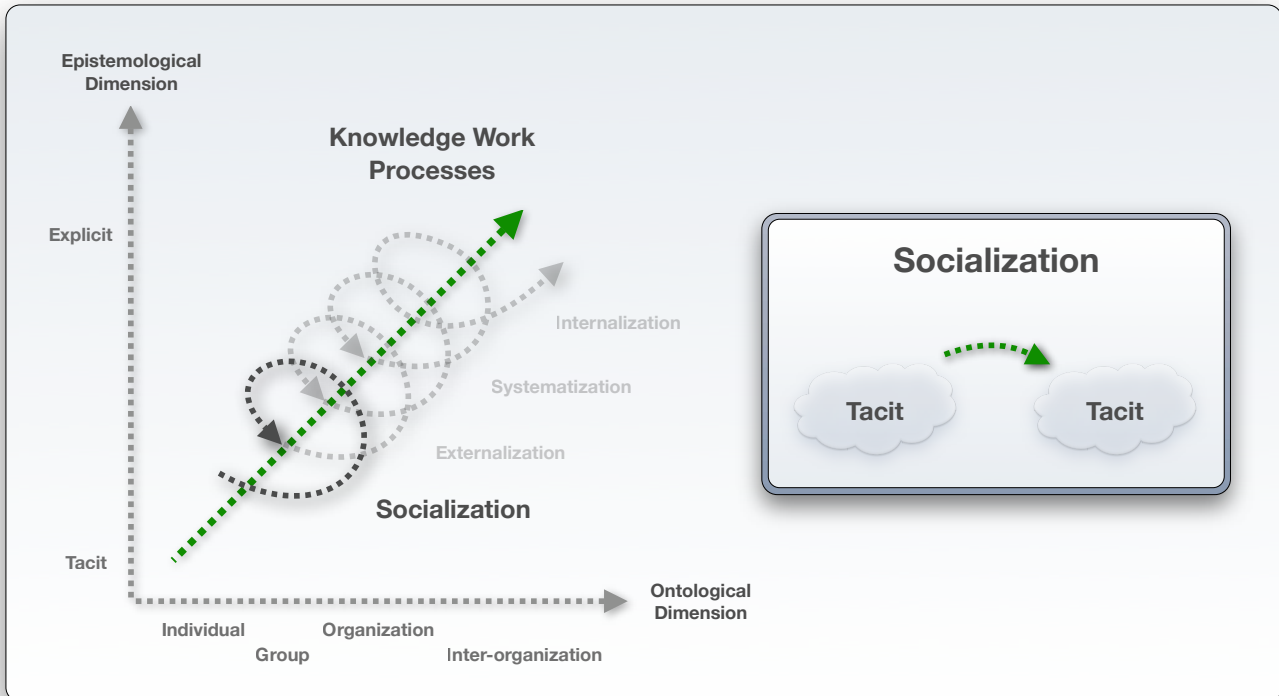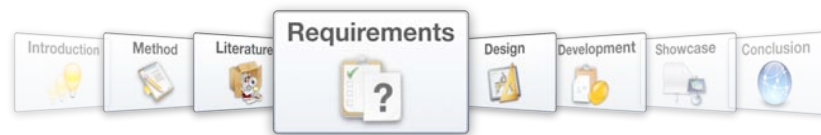

Figure 29 - Socialization: Transfer of tacit knowledge

The articulation and sharing of tacit knowledge is arguably the hardest knowledge work process to support within an Information System Architecture. Personal relationships, interaction and experience

gained through common project activity are generally regarded as the best approach to tacit knowledge exchange (Nonaka [35]). The cultivation of a knowledge culture that is widely supported by all the actors within the knowledge network is an important prerequisite for the development of these relationships. Network users should understand the advantages of tacit knowledge exchange for their own development as network nodes, but also that they are contributing to the knowledge base by enriching other members.

Although face-to-face contact is the ideal form of socialization, an information system architecture can offer functions that facilitate socialization.

The proposed Information System Architecture should include the following features to enable support for socialization:

- Interaction and teamwork

  Joint activities offer excellent opportunities for socialization and tacit knowledge exchange. Users should therefore be able to work together on projects within the proposed information system. Project outputs should also be captured in a format that can be integrated with the network knowledge base. Project feedback in terms of best practices, solutions and opportunities will enrich the knowledge network.

  Requirement #4
  Interaction and Teamwork

  4 *Required by Chapter:*
 - *4.1.2.1*

- Communication

  As the term "socialization" implies, communication is a key to tacit knowledge transfer. The information system should therefore support a variety of channels through which users can communicate. These include links to directly contact the author of a content item, comment threads on content as well as forum discussions.

  Requirement #5
  Communication

  5 *Required by Chapter:*
  - *4.1.2.1*

  These communication functions could be used as part of organic interaction within the proposed information system, or could be facilitated and guided to emulate knowledge
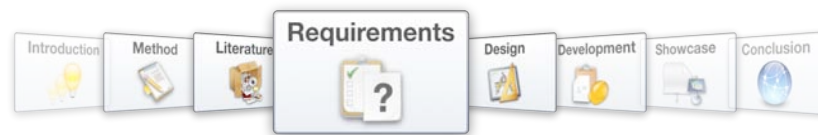
workshops and brainstorms. Knowledge is being transferred through these communication channels and is in effect being externalized, and thus any amount of integration with the network knowledge base is extremely valuable.

Synchronous communication (e.g. live chatting) enhances tacit knowledge exchange even further, as it takes a step closer to emulating face-to-face contact than is done through asynchronous communication (e.g. forums).

The level of media richness that can be used within the communication channels of the platform enhances the level to which users can express themselves in tacit knowledge exchange. A modern online approach to media presentation (images, audio, video, etc.) should therefore be implemented.

- User Profiles

Although project-driven interaction is the prime vehicle for tacit knowledge exchange, other social interaction within the platform will also contribute to socialization as a knowledge work process. Incorporating social networking functions adds powerful and subtle functionality to the system design.

> **Requirement #6**
> **User Profiles**
>
> 6   *Required by Chapter:*
> - *4.1.2.1*

Each user should have the ability to describe

his particulars and interests in a self-maintained biography. This forms an important first step on the way to capturing a basic tacit knowledge profile of a user. This biography should contain links to content that the user has contributed to the platform, thereby profiling his or her knowledge contribution.

The integration of these user profiles in the network knowledge base will enable the handling of users as knowledge objects. This integration is essential to ensure that the knowledge network is enriched.

4.1.2.2. Externalization

The externalization process involves transforming implicit knowledge to explicit knowledge (refer to Figure 30). It is a process that can be supported by online technologies and media-rich environments, as it immediately offers a way to capture knowledge and to store or transmit it.
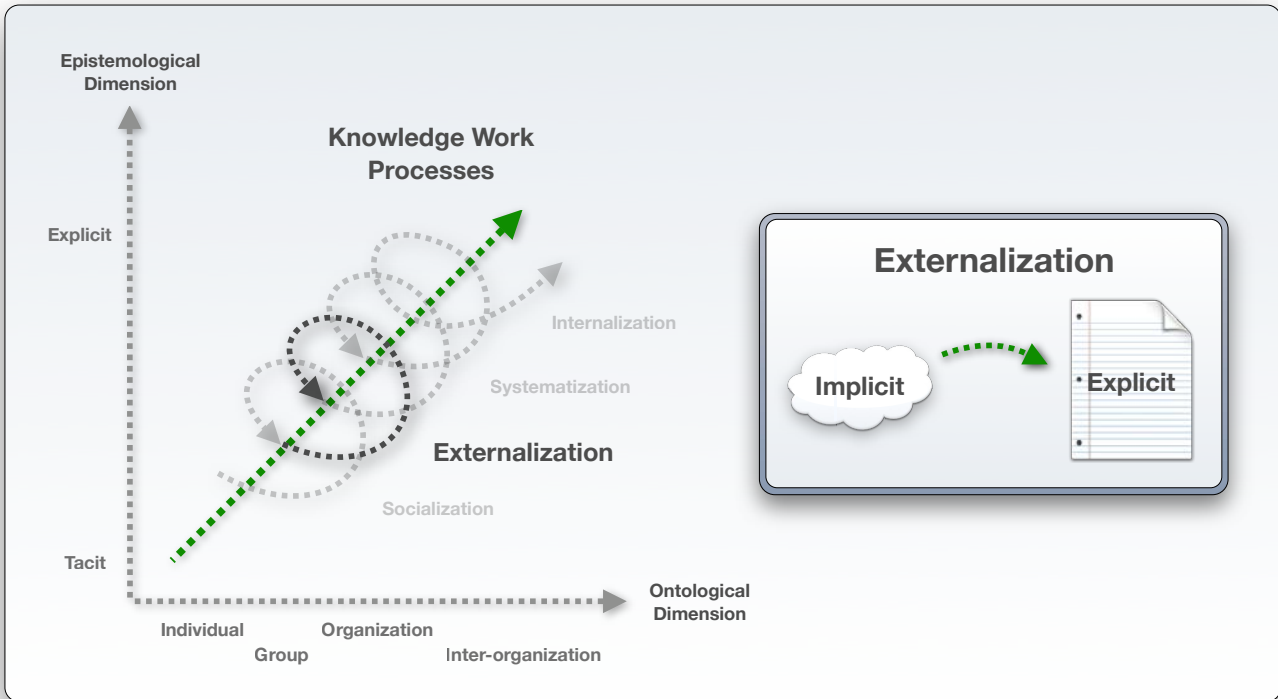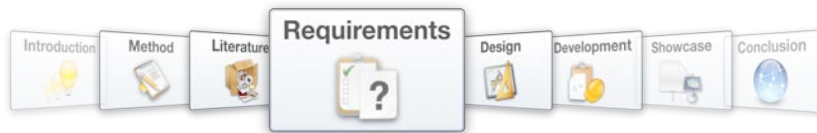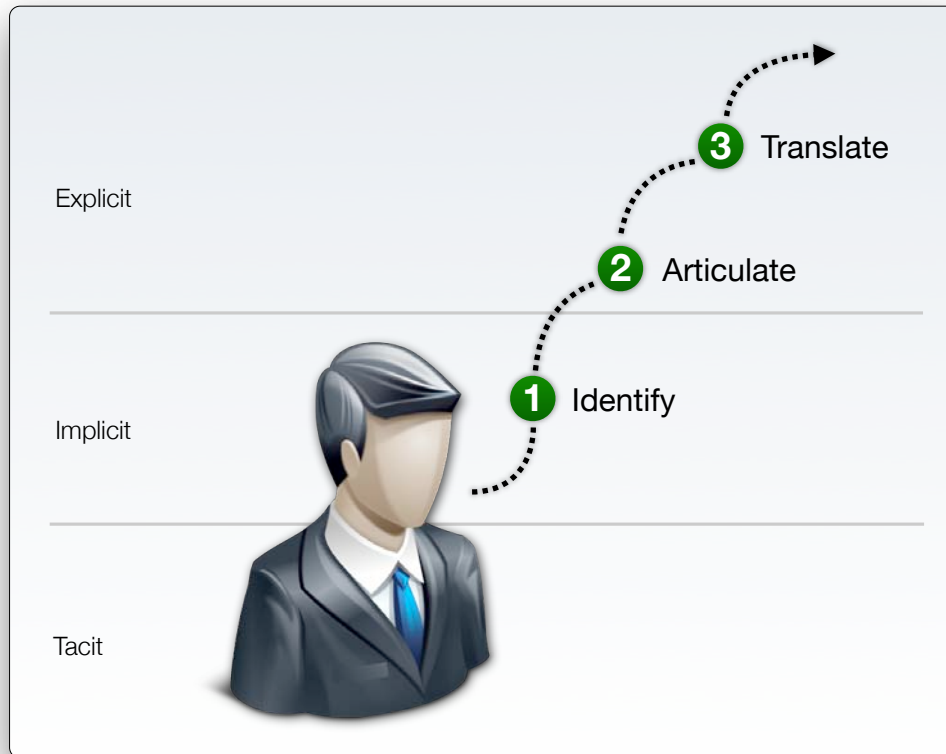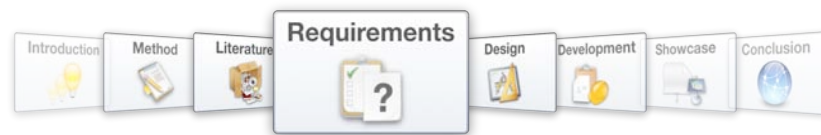
Figure 30 - Externalization: Transform implicit knowledge to explicit knowledge

A necessary condition for successful externalization is the existence of a knowledge culture of trust and openness with respects to users' implicit knowledge. This culture is often best cultivated through personal relationships and social interaction. The social networking features necessary to facilitate this will be discussed in the upcoming section on socialization.

The externalization process may be divided into the following basic phases (refer to Figure 31):

Figure 31 - The phases of externalization
(transforming implicit knowledge to explicit knowledge, as indicated by the knowledge zones)

1. **Identify**

   As was discussed in the section on socialization, there are a number of ways to build a knowledge profile so that it may be determined what a user may or may not know. This feature is useful in identifying users that may have certain implicit knowledge that could be externalized to fill gaps in the current knowledge base. Clear role definitions will ensure that specified users will monitor the network knowledge base in an effort to identify and fill as many gaps as possible. A network configuration that handles knowledge objects will also be instrumental in this process, as searches and navigation on certain topics will highlight users that are located in close vicinity in the network.

2. **Articulate**

   Articulation lies with the externalizer and involves the actual transformation of implicit knowledge to explicit knowledge. This could typically start with initial expression of thoughts or concepts in the form of simple notes or mind-maps. The new explicit knowledge will however not yet be clear, understandable and easy to transfer.
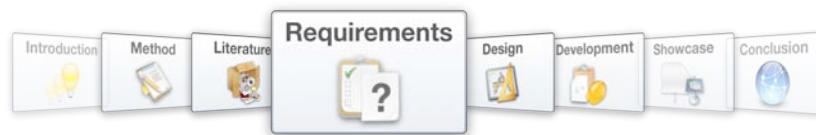
3. **Translate**

The eventual goal of externalization is to create explicit knowledge that is easy to understand and transfer. Translation of articulated fuzzy knowledge concepts to more defined formats is therefore very important. Defining context for the knowledge object and integrating it in the knowledge base may prove valuable in this sense, as it helps to position the object within the network. A high-level of media-richness capability in the platform supporting the knowledge network will help to offer a number of ways to present explicit knowledge. For instance, screencasts and audio podcasts may sometimes be the easiest ways of accurately expressing your knowledge in an understandable and transferable fashion.

The proposed Information System Architecture should include the following features to enable support for externalization:

- **Adding of Content**

Users should have the option to add content in a number of different ways – in terms of the way in which their content is filed and the type of media that can be used. Text-based content will be the most common form of explicit knowledge added, although some users will undoubtedly feel the need to employ images, video, etc. to externalize. It is

> **Requirement #7**
> **Adding of Content**
>
> **7** *Required by Chapter:*
> - *4.1.2.2*

a priority to remove as many barriers to entry for the externalization process as possible to encourage users to share their knowledge. Placing links to content-adding interfaces and presenting these interfaces in a user-friendly fashion will improve ease of use and thus contribute towards this goal.
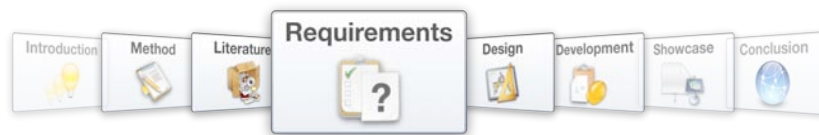
Collecting all the content indicated to be personal contributions from an individual author can form a blog. This view on content will inspire a sense of ownership in personal contributions, thereby adding to a culture of knowledge sharing within the platform. The blog-content must however also be tagged with the necessary metadata to enable integration within the knowledge base. It may also be worthwhile to approach certain experts to make regular contributions to the knowledge base, thereby championing the cause of externalization and stimulating discussion and further contributions from other members.

Capturing comprehensive metadata that gives context to the externalized knowledge often serves as a form of externalization without the author necessarily intending for it to do so. This metadata could include a time, date and location for the author, along with a link to his or her profile within the platform. Any clear links to other related pieces of content (inside or outside the platform) are also useful as it exposes links between knowledge objects. In the case of such links not being evident to the author, classifying the new content in terms of topics or keywords enables the system to connect the new content to objects the author might not have been aware of.

These links will be made solely on the basis of metadata similarities and will remain appropriate as long as the metadata associated with items are complete and accurate. In the case of the author not agreeing with the metadata links, network users may be alerted to discrepancies in the interpretation and application of metadata. The ability to influence the interpretation or application of metadata and to link certain pieces of content to form knowledge threads allows users to externalize further subtle metadata.

The way in which content is filed plays an important role in extracting the maximum amount of value from it. Users should have the option to select any one of a number of content types according to what they deem necessary to capture the content that they want to externalize. Sometimes a simple piece of text will be sufficient, whereas in some other cases the author might want to harness the collaborative power of a wiki. Collaboration is a powerful form of externalization and should be supported, and in this context progress trackers on knowledge objects will prove to be valuable in adding workflow management capabilities to the process. Sufficient communication systems should support this collaborative form of externalization.

- **Commenting and Forums**

The ability for users to instantly voice their opinion on content that has been added to the knowledge base is another powerful externalization tool. Users may often not necessarily see some of their implicit knowledge as relevant, but an article or blog posting might lead them to realize that they can contribute. Clear links to a user-friendly

Requirement #8
Commenting and Forums

8   *Required by Chapter:*
- *4.1.2.2*

commenting interface are necessary to facilitate this process. Comments on content may
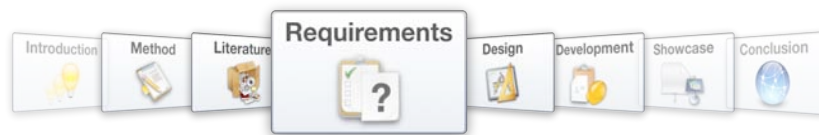
stimulate further comments leading to a chain of discussion based on content and will eventually externalize more knowledge than that of the content author alone.

Discussion does however not need to be based on a piece of content alone. A user may want to pose a question or statement as the seed of a forum topic upon which other users can elaborate and add their opinions. These forum discussions may lead to the externalization of valuable knowledge and also needs to be classified in such a way that they can add maximum value to the knowledge base.

- Rating of Content

Often a user's opinion on content might not necessarily be in the form of a comment. It is however still valuable to externalize users' opinion on knowledge items in the form of rating. This will serve as way for the entire user community to express their collective opinion and to validate certain items as trusted or popular pieces of knowledge. This

> **Requirement #9**
> **Rating of Content**
>
> **9**   *Required by Chapter:*
>   - *4.1.2.2*

kind of metadata also needs to be captured to extract more value from the knowledge base.
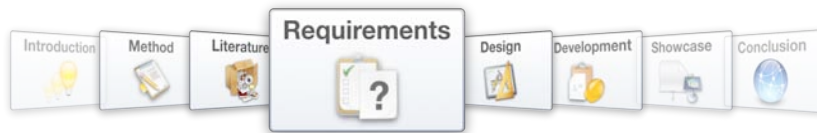
4.1.2.3. Systematization

The goal of the systematization process is to create new explicit knowledge by giving structure to existing explicit knowledge (refer to Figure 32), thereby enhancing its efficient reuse.
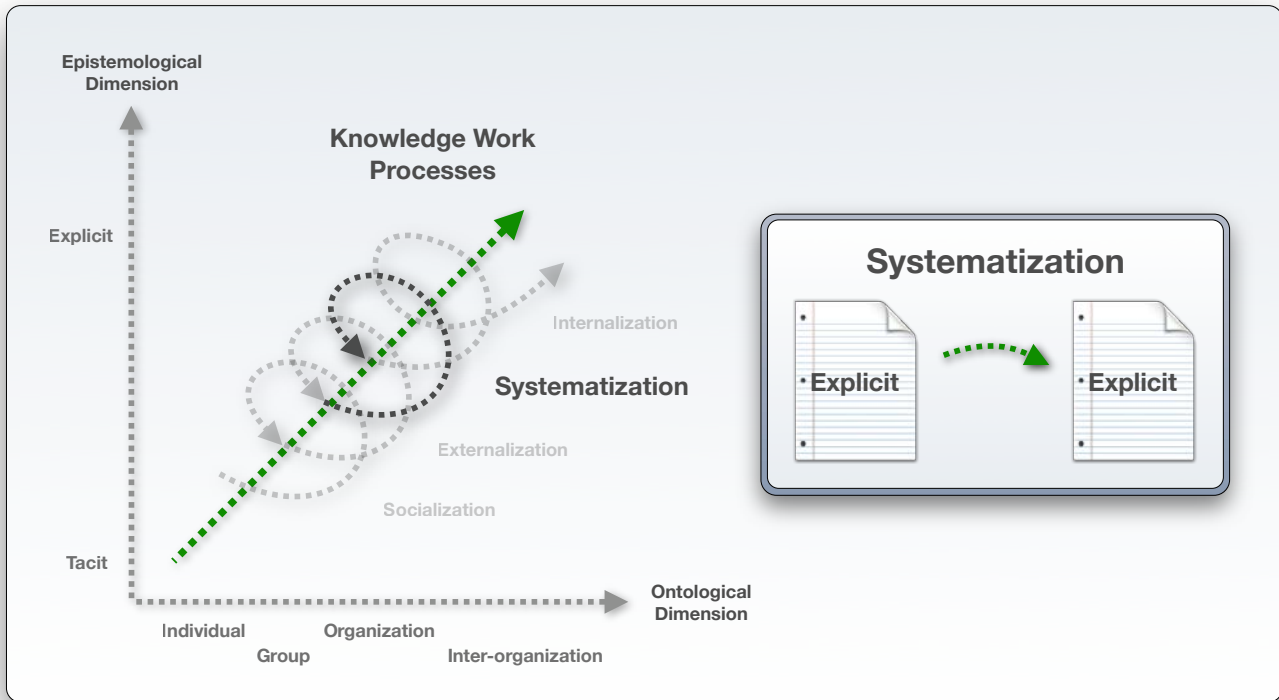

Figure 32 - Systematization: Transform explicit knowledge to explicit knowledge

Systematization can be divided into three basic steps (refer to Figure 33), which combine to form a knowledge work process. Firstly explicit knowledge must be captured and integrated into the network knowledge base and therefore systematization feeds directly from the externalization process's output. Secondly, the explicit knowledge must be disseminated throughout the knowledge network. This part of the process is heavily supported by information systems functions that transform the explicit knowledge into readily transferable formats. Lastly, the disseminated knowledge must be edited or processed to make it even more usable, which links systematization to internalization.
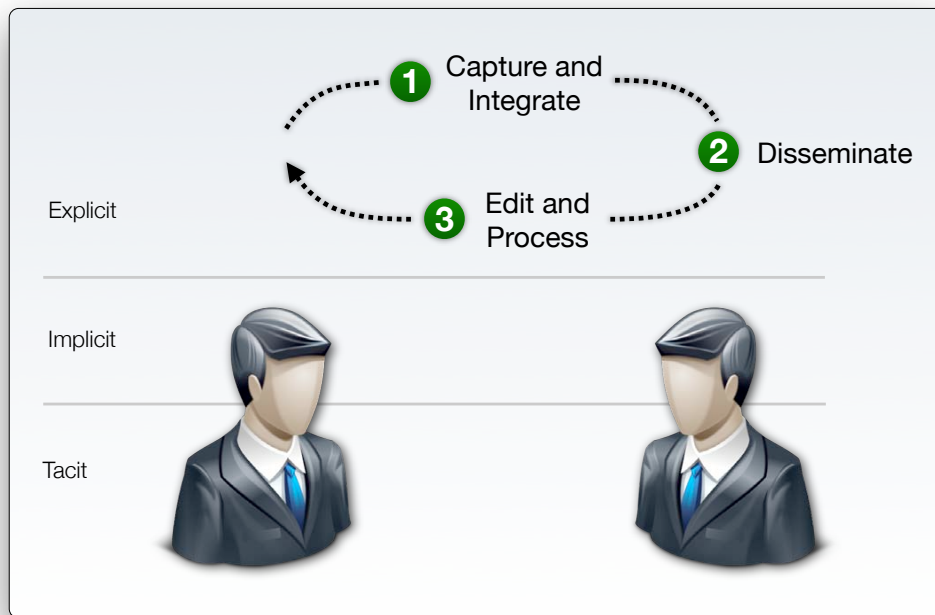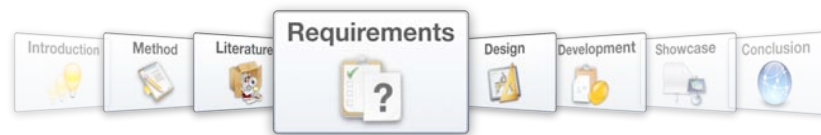
Figure 33 - Phases of systematization
(transforming explicit knowledge to new explicit knowledge, as indicated by the knowledge zones)

The proposed Information System Architecture should include the following features to enable support for systematization:

- Taxonomy

Using a taxonomy scheme to classify and tag knowledge objects within the knowledge base is a good way of systematizing explicit knowledge in such a way that will aid users in the internalization process. This taxonomy scheme could typically comprise several categories that combine to form the network knowledge base. To further distinguish

Requirement #10

Taxonomy

Required by Chapter:
- **4.1.2.3**

10

between knowledge objects and to allow users the ability to extend the predefined set of categories, free keyword tagging could be used to describe the knowledge that is housed within the object. The way in which objects are classified could be used to determine levels of relevance between them, creating metadata links that form knowledge paths through the knowledge base. These knowledge paths may often combine different fields of knowledge
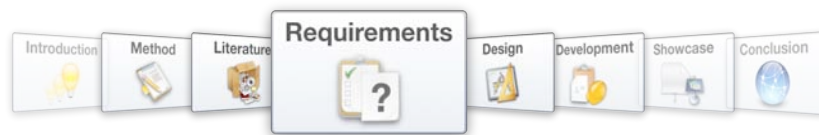
that were not previous thought to be related and can be the inspiration for the creation of new knowledge.

As was discussed in the network model requirements, it is important for the information system architecture to have the ability to handle content as knowledge objects and not just pieces of content. This implies that it should not only be possible to classify articles, but that the taxonomy would be able to house users, forum discussions, documents, etc.

The information system architecture should furthermore be able to produce custom views of the knowledge base based upon queries made by the user. These views could include listings of objects within a certain category, or any objects that were tagged with a specific keyword. Presentation of the query results could also vary from title listings to blog-style views of the introductory paragraph.

The wide array of tasks that are involved with the successful implementation of taxonomy necessitates the introduction of different formalized roles for users responsible for its success.

- Navigation

A clear and accessible navigation structure should accompany the systematization process, and thus the taxonomy, thereby opening the doors to exploration of the network knowledge base. This navigation structure will mainly consist of links that provide custom views of the knowledge categories within the knowledge base. It is

> **Requirement #11**
> **Navigation**
>
> **11**   *Required by Chapter:*
> - *4.1.2.3*

important for this navigation to be constructed in a way that is consistent with the layout of the knowledge base, as the creation of the user's constant mental model of the knowledge base and the information system as a whole is imperative.

Handy features that will enhance the user experience as well as efficient navigation of the knowledge network include links to related content, new postings and top rated items. Placement and configuration of these features should also be considered to ensure maximum effectiveness. For instance, links to related knowledge objects will for instance be most effective when placed in a prominent part of the page layout and is only visible when reading a content item. Links to latest postings will however be most useful on the first platform page that the user visits. This page could be the main platform homepage and/or a user's personal

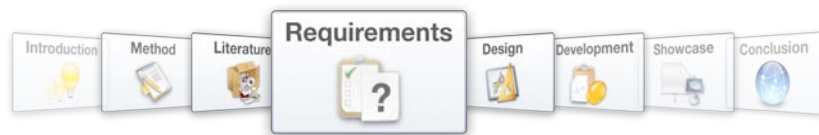platform homepage. In both these examples, the link module could be configured to show items in rating order, or for maximum relevance based on keyword similarities.

- Search

A searching function that is integrated with the taxonomy will add further value to the platform. As the taxonomy is designed to handle all content within the knowledge base as knowledge objects, a search for a specific topic or keyword will therefore be able to direct the searcher to users, discussions, document or content items. The location of the search function along with the presentation of the navigation structure will combine to make the platform more user-friendly.

Requirement #12
Search Function

Required by Chapter:
- *4.1.2.3*

12
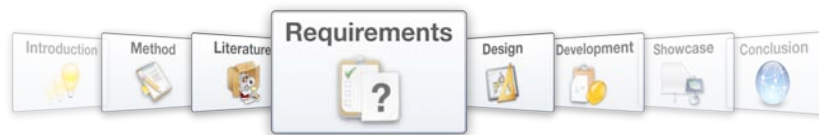
4.1.2.4. Internalization

The internalization process involves transforming explicit knowledge to implicit knowledge (refer to Figure 34).
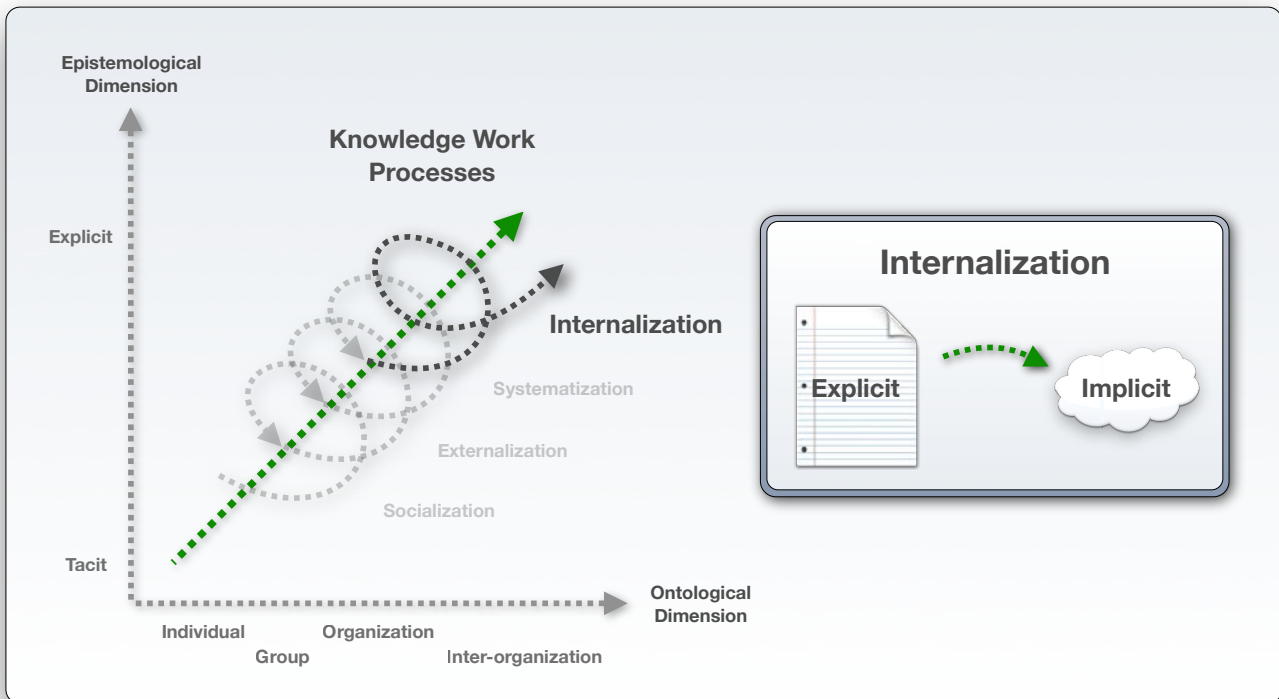

Figure 34 - Internalization: Transform explicit knowledge to implicit knowledge

As with other knowledge work processes, internalization can be seen as a sequence of tasks (refer to Figure 35). The first of these involves identifying and understanding explicit knowledge within its correct context. If the explicit knowledge was captured in a comprehensive fashion with sufficient metadata, this phase can take place without relying on personal relationships with other users associated with the explicit knowledge item. Upon identifying and understanding the explicit knowledge in question, it must be embodied and transformed to form part of the learning user's implicit knowledge. This may be done with the help of tutorials, simulations, etc. and is often more reliant on personal relationships with other users than the initial identification phase. Both phases are supported by a knowledge culture that endorses learning by doing and informal communication.
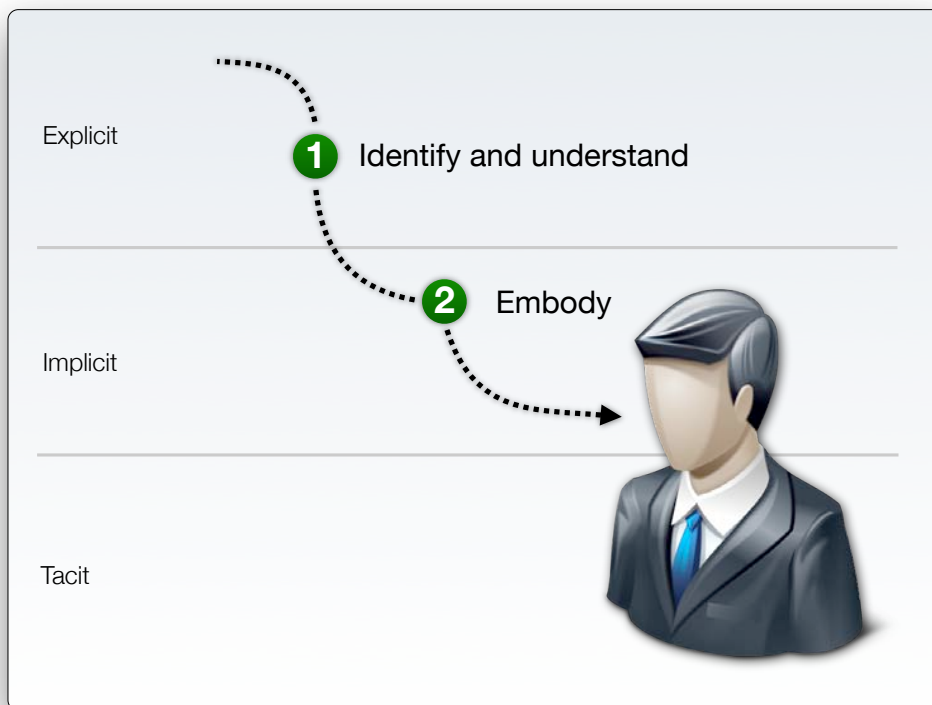
Figure 35 - Phases of internalization

(transforming explicit knowledge to implicit knowledge, as indicated by the knowledge zones)

Although internalization is largely a user-driven process, it can be facilitated and made more efficient through a number of platform features and design principles. Explicit knowledge should be delivered to the user in a structured format that assists in identifying knowledge that is relevant at a specific point of time based on the user's interests. Media-richness allows the presentation of this knowledge context and is also required to allow transfer of knowledge in a way that enhances internalization.

The proposed Information System Architecture should include the following features to enable support for internalization:
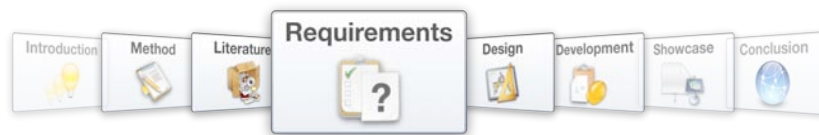
- Taxonomy

  Internalization relies on the user's ability to recognize personally relevant knowledge and to ultimately embody that knowledge as part of their implicit knowledge. The user should be helped to recognize the knowledge objects that would be personally relevant to

  Requirement #10
  Taxonomy

  Required by Chapter:
  - *4.1.2.3*
  - *4.1.2.4*

him through the classification structure previously proposed as a supporting feature for systematization (refer to Chapter 4.2.1.3). A degree of intelligence can also be built into the way that the taxonomy and navigation structure combine to make suggestions on knowledge objects that is particularly relevant to the one that is currently displayed on screen. These suggestions would ideally be placed in the side-columns of the eventual page design.

- Navigation

It is critical that the user's clear and consistent mental model of the information system and its knowledge base be maintained at all times. The user must be able to navigate the knowledge base with ease and should never be confused about which navigation options to follow.

> **Requirement #11**
> **Navigation**
>
> **11** *Required by Chapter:*
> - *4.1.2.3*
> - *4.1.2.4*

- Page Layout

Presenting a rich network knowledge base on screen will always lead to the possibility of producing pages that contain too much information. This will however detract from the user's ability to navigate the platform and identify relevant knowledge objects. The challenge is therefore to find a design principal that allows for comprehensive

> **Requirement #13**
> **Page Layout**
>
> **13** *Required by Chapter:*
> - *4.1.2.4*

representation of the knowledge base without leading to pages which try to convey too much information.

- Featured Content

In a platform that supports a lot of simultaneous knowledge flows, it would be easy for content to get lost. Drawing attention to newly contributed content by displaying it on the platform front page is one way of mitigating this problem. Content is then shifted down by one sport each time that a new item is posted, much in the way that modern blogging websites present content. Pagination must however be inserted to ensure that the pages do not get too long. The same concept should apply to the presentation of content items when browsing the knowledge base, with latest content being placed on top of the content stack.

Requirement #14
Featured Content

14

Required by Chapter:
- *4.1.2.4*

- Communication

All the necessary functions to facilitate informal communication within the platform must be readily available. Users must be assisted through communication functions when personal relationships need to be forged and maintained in order to help embody explicit knowledge. These communication channels include synchronous (e.g. live chatting) as well as non-synchronous functions (e.g. forum discussions).

Requirement #5
**Communication**

5

Required by Chapter:
- *4.1.2.1*
- *4.1.2.4*

- User Alerts

Users should have the option of subscribing to selected content and then be informed when a posting is made that matches the subscription criteria. These subscriptions could be made according to taxonomy category, author, etc. The option should also
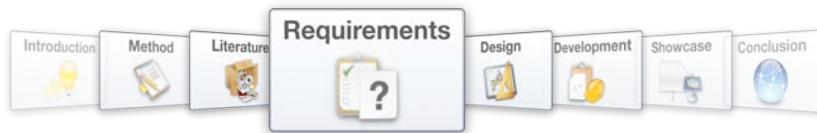
Requirement #15
User Alerts

15

Required by Chapter:
- *4.1.2.4*
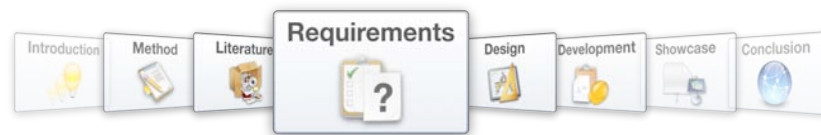
be available to alert a user when there has been a reply on a discussion thread that he has participated in or found interesting and subscribed to. Within the knowledge networking paradigm this equates to having the facility of being notified whenever a new network node is created in close proximity to other nodes that a user found interesting. The user is in fact clustering relevant knowledge objects around him, thereby enhancing internalization.

4.2. Innovation Support

The Innovation Process as described by the FUGLE model proposes a generic life cycle for innovation projects (refer to Figure 36). This generic model will be used to derive system architecture requirements that, if implemented correctly, will enable innovation support within the platform.
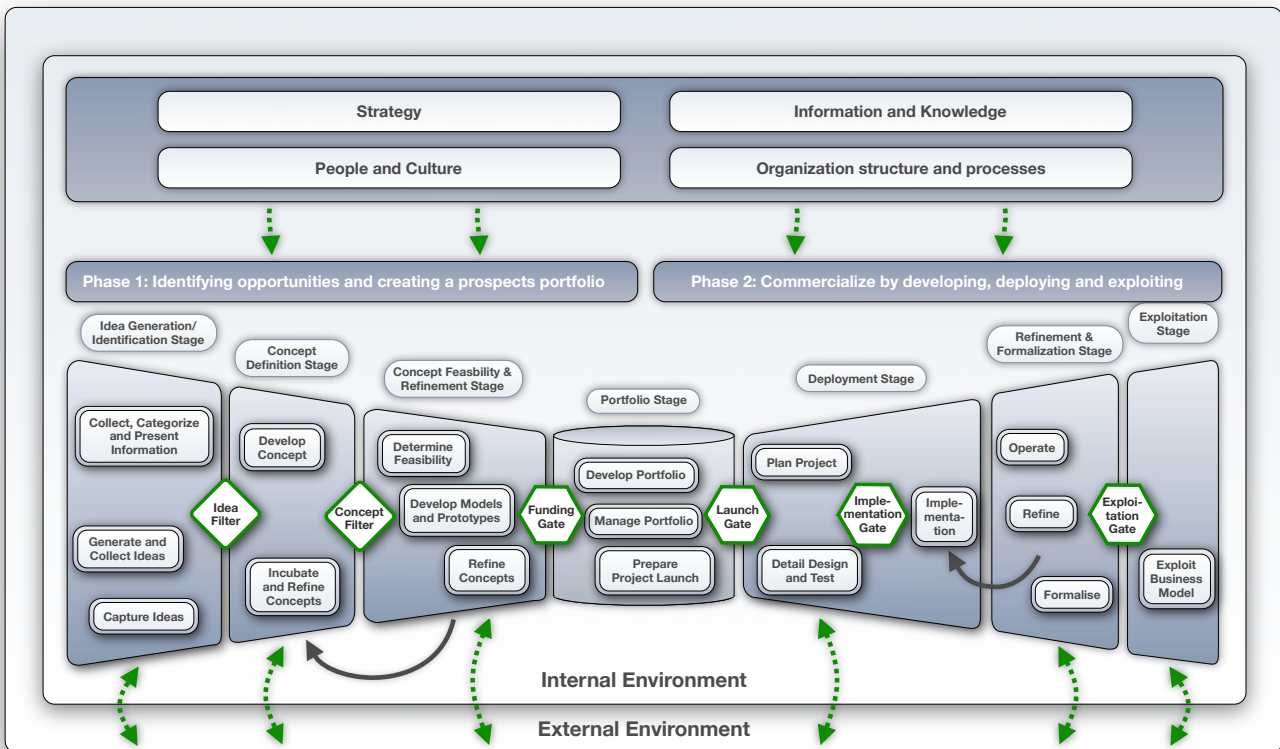

Figure 36 - The FUGLE Innovation Process Model

To simplify the task of equipping the proposed Information System Architecture with support for the entire Innovation Life Cycle, each stage of the innovation process as presented by the FUGLE model will be considered separately. The functional information system requirements of each stage will subsequently be determined. Combining these requirements will provide a requirement specification for support of the entire Innovation Life Cycle.