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# A Competence-based View on the Global Software Development Process

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**Abstract:** The adoption of Global Software Development (GSD) models by software development companies is growing continuously. A variety of challenges such as temporal, geographical and socio-cultural distance are hindering global organizations to achieve potential benefits. As a result, organizations need support in how to overcome the challenges. The emphasis in the literature to date has typically focused on overcoming the challenges by providing tool support, management guidelines and processes. This follows the assumption that a well-established and validated process results in high quality output, not taking the actors within the process into account. While recognized as an important factor for successful GSD, actors and their competences have been addressed from an organizational perspective focusing on organizational and team capabilities rather than from an individual perspective. In this article, we present the results of a literature review on competence-related challenges and competency related research for GSD. We extend existing GSD process models with functions of competence management. The resulting competence-based view allows the management of individual competences throughout the entire GSD process.

**Keywords:** Competence Management, Competence Based View, Global Software Development, Human Resource Development
**Categories:** D.2.0, K.6.1, K.6.3, K.7.2

## 1 Introduction

In today's global and competitive economy, software development companies are searching for a competitive advantage based on costs, quality, flexibility, and increased productivity and risk reduction [Sengupta et al. 2006]. To achieve competitive advantages, organizations often search for external solutions, which leads to globally distributed settings [Prikladnicki et al. 2006]. In globally distributed settings, organizations and individuals are confronted with temporal distance, geographical distance and socio-cultural distance [Ågerfalk et al. 2005] which lead to a wide variety of challenges including aspects of collaboration, coordination, communication and culture [Noll et al. 2010]. [Richardson et al. 2012] state that these challenges can prevent organizations from achieving a competitive advantage. To overcome these challenges, [Beecham et al. 2005] identified the importance of defined and established software development processes. However, [Ramasubbu et al. 2005] identified that key process areas in terms of managing distributed software

development teams are not addressed in traditional software development processes such as the waterfall model and agile methods. Following this, GSD process models with focus on a managerial perspective [Prikladnicki et al. 2006], global teaming [Richardson et al. 2012] and collaboration models [Rocha et al. 2011] were developed. While the majority of these developed GSD process models recognize the personnel as an important factor, competences are mainly considered from an organizational and managerial perspective rather than from an individual perspective [Richardson et al. 2012]. However, individual competencies are a key aspect for organizational business performance [Harvey et al. 2000].

In the software industry, [Lanubile et al. 2010] found that the personnel is crucial as the collaboration between people leads to the development of better software. Additionally, [Rivera-Ibarra et al. 2010] identified that the quality of software strongly depends on the competences applied by software developers throughout the software development process. This shows that, especially in software development, a more human-centric approach than the resource-based view seems appropriate. While development processes are being extended to fit globalization requirements [Prikladnicki et al. 2006], competence requirements and competence management, in particular for non-technical competences, are not researched to the same extent [Colomo-Palacios et al. 2013].

Therefore, a balanced orchestration of team members' competences is needed for successful GSD processes. Therefore, we have developed a competence-based view on the GSD process based on existing GSD process models and an in-depth literature review on competence-related challenges for GSD and potential solutions.

## 2 Theoretical Foundation

In this section, we first introduce and define the concepts of competency, competence and competence management.

### 2.1 Competency and Competency Management

The concept of competency is used ambiguously in the IS and computer science domain. On the one hand, competency describes the main abilities of an organization; on the other hand, it also refers to traits, skills and knowledge of individuals. The usage of the term competency as organizational capabilities has its origin in the resource-based view [Peppard and Ward 2004].

From an **organizational perspective**, it is important to differentiate between competences and the related concept of capabilities. Capabilities describe skills or processes [Wade and Hulland 2004] to transform inputs into outputs of a greater worth [Sanchez et al. 1996]. [Sanchez et al. 1996] differentiate between competences and capabilities by looking at the market position of the company. In contrast, capabilities can also be understood as the strategic application of competencies [Kangas 1999]. This means that competencies can be seen as potential of a company and by using this potential strategically they become capabilities.

In the domain of IS, [Peppard and Ward 2004] have analyzed the relation between IS capabilities and IS competencies [Figure 1].

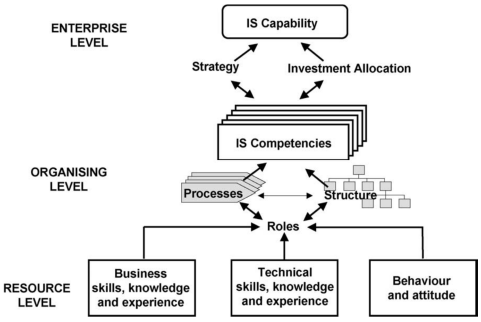


*Figure 1: A model of IS capability [Peppard and Ward 2004]*

The model shows in accordance with [Kangas 1999] that in the field of IS, capabilities are seen as strategically applied competencies. It also states that competencies are seen on the organizational level connected via processes and roles to resources and individual skills and knowledge. Humans are resources of the company and possess specific skills, knowledge, behaviors and attitudes. The skills, knowledge, behaviors and attitudes represent the **individual or human perspective**. But similar to the organizational level, it remains an unresolved issue what human competencies exactly are [Ley and Albert 2003]. Therefore, many contradicting definitions of individual competency exist [Westera 2001; Winterton 2009]. [Pawlowski and Holtkamp 2012] state that the definition is strongly depending on the research community and a different understanding of concepts, such as competence and learning outcome.

The terms competence and competency lead to some misunderstandings and conceptual problems. From an educational perspective, [Winterton 2009] defines competency as "characteristics of an individual that are associated with superior performance in a job". Competence "describes what a person needs to know and be able to do in order to undertake the tasks associated with a particular occupation". Thus, competency refers to the total set of skills, abilities and attitudes of an individual while competence refers to a specific skill, knowledge item or attitude.

Several authors have criticized current competency definitions. The **contextualization of competencies** is lacking in most of the common research [Sandberg 2000]. Additionally, studies have shown that practitioners are not familiar with concepts such as competency or competence and rather think in problems and possible solutions [Pawlowski et al. 2008].

Within the **human resource management** domain, competence is seen as "an underlying characteristic of a person, which results in effective and/or superior performance in a job" [Boyatzis 1982]. Explaining the relation between organizational and individual competences as well as their management has been one key focus point in HRM [Nordhaug 1998].

[Baladi 1999] identified the most important steps for **competence management** [Figure 2]. Hereby, the competence requirements are based on the strategy and previous experience of the organization. This follows the findings of

[Bergenhenegouwen et al. 1996] who state that an alignment of strategic orientation and HR practices is important. [Green 1999] gives a suggestion how to connect individual competencies with the organizational core objectives and capabilities. With a gap analysis the competence requirements are compared to the results of an analysis of the present situation, which is based on development discussions and competence profiles. Based on the results of the gap analysis several methods for sourcing of competences can be used.

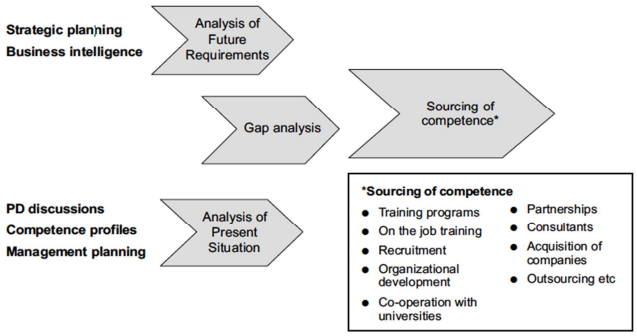


*Figure 2: Competence management process according to [Baladi 1999]*

Within the GSD domain, the predominant concepts used are skill and knowledge. However, as competence gives a more holistic view we will use competency and competence in this paper. We define competency as a collection of skills, abilities, and attitudes to solve a problem in a given context and competence as an instance of competency.

## 2.2 Global Software Development Process

The aim of this section is the creation of a structured GSD process to enable the matching of competence-based challenges to the different process phases.

Software development companies are facing a very competitive market. They are searching for a competitive advantage based on costs, quality, flexibility, and increased productivity and risk reduction [Sengupta et al. 2006] leading to distributed settings [Prikladnicki et al. 2006]. [Beecham et al. 2005] identified the importance of GSD processes. [Prikladnicki et al. 2006] argue that the software development process has to be adapted to the global setting. Based on a case study approach, [Prikladnicki et al. 2006] developed a reference model for GSD differentiating three major phases: strategic planning, including project selection and allocation; tactical and operational planning, including the project development; and learning, including evaluation and feedback. A similar structure for GSD projects has been proposed by [Ramasubbu and Krishna Balan 2008] who identified the phases project planning, project execution and project reflection.

Based on the general three-phase structure identified by [Ramasubbu and Krishna Balan 2008], we analyzed processes for GSD identified in our literature review. In the first step, the identified functions were assigned to the three main phases project

planning, project execution and project reflection. Following, the functions from different sources were clustered based on the included tasks and activities. This led to ten distinctive tasks within the project. In the final step, a process flow was identified [Figure 3]. This process should be understood as a sample representation of potential processes as not always all functions are necessary.

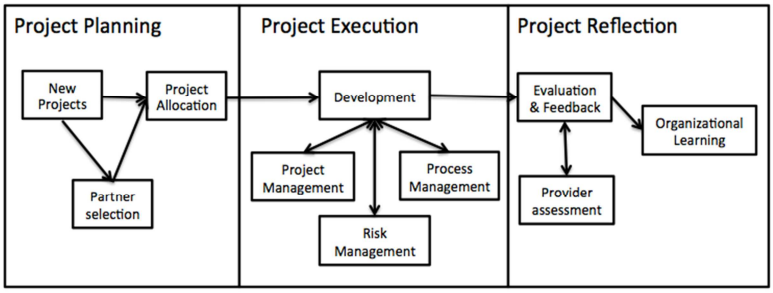


*Figure 3: Global Software Development Process*

The main goal of the **project planning phase** is the identification of potential new projects both from internal needs and customer requests [Prikladnicki et al. 2006], the evaluation of cost, time and personnel for the project [Ramasubbu and Krishna Balan 2008]) and the selection of potential project partners [Yalaho and Nahar 2009]. The selection of subcontractors is another important step in the planning phase. [Yalaho and Nahar 2009] described a process particular for offshore outsourcing. The team building is another important task within the project planning phase. The **project execution phase** aims at the development of a high quality product. The development is commonly separated into the elicitation of requirements, design of the software, implementation, testing and deployment [Rocha et al. 2011]. The **project reflection phase** deals with the evaluation of all activities [Prikladnicki et al. 2006] and the understanding and recording of potential learning points for the future [Collier et al. 1996]. For this purpose, strategies, the development process, the product [Prikladnicki et al. 2006] and external partners [Yalaho and Nahar 2009] have to be assessed and evaluated. The lessons learned can then be included in the knowledge base of the organization [Prikladnicki et al. 2006] and by that included in the organizational capabilities towards a learning organization [Ramasubbu and Krishna Balan 2008].

Summarized, the main focus of the analyzed literature is on the project execution and in particular the development and the project planning. The functions of the GSD process are used as a classification schema for the literature review.

## 3 Methodology

This paper follows a design science research approach [Hevner et al. 2004]. Design research usually involves the analysis of current practices and their performance with the aim to understand, explain and improve the analyzed artifact [Hevner et al. 2004].

To analyze the current practices and performance, a systematic literature review [Fink 2005] was conducted.

The main sources for the literature review were IEEE Xplore bibliographic database, ACM Digital Library as well as journals based on the ranking of the Association of Information Systems (AIS). The selected journals were The Management Information System Quarterly, Journal of Management Information Systems, Information Systems Research and European Journal of Information Systems. The journals were scanned in the time period 2000-2011 and all relevant papers were analyzed. To search in the databases Boolean search terms consisting of combinations of the strings such as “competency”, “competence”, “capability”, “skill”, “Information Systems development”, “global software development”, "challenges", “barriers” and “solutions” were used. One example for a search term is “competence” OR “competency” OR “competencies” OR “skill” AND “global software development”. All together a total sum of 378 research papers was taken into account for the analysis. The citations of the articles were scanned based on the before mentioned keywords to identify further important sources for the subject [Webster and Watson 2002]. The analysis of the paper used the following steps:

1. Identification of problems, challenges and barriers for GSD addressed by analyzing the papers for reasons of disturbance.
2. Analysis of the problem, challenge or barrier based on the occurrence as an organizational or individual challenge by mapping the challenges to the GSD process.
3. Analysis of competences, skills or knowledge items connected to the challenges by mapping the challenges to identified competency categories.
4. Identification of proposed solutions or interventions to overcome the challenges by analyzing the papers for identified possibilities to overcome challenges.

In a next step, the results of the literature reviews regarding competence-based challenges and competency related research in GSD were used to combine GSD processes and competence management. Hereby, the occurrence of a competence-based challenge in a specific process function indicates the need for an intervention to overcome the challenge. We address this need by adapting the specific process function with activities of competence management.

## 4 Results of the Literature Review

In this section we present the results of the literature review focusing on competence-related barriers and interventions for GSD and research addressing competencies and competences for GSD on an individual level.

### 4.1 Competence-based Challenges of GSD

This section addresses the questions, which challenges for GSD can be accounted for by a lack of competences and in which phases of the GSD process these challenges commonly occur.

Geographical, socio-cultural and temporal distances are usually seen as the **reason for challenges** in GSD [Ågerfalk et al. 2005]. [Ralyté et al. 2008] additionally address organization distance, technological distance and knowledge distance as a

cause for challenges in GSD. The identified distances can lead to weak ties between team members, which again lead to a lack of team awareness [Pallot et al. 2010] and a lack of trust among team members [Battin et al. 2001]. In particular the socio-cultural distance and organizational distance can cause different values, norms and practices [Huang and Trauth 2006]. The different values, norms and practices can lead to incompatible views of problems and misunderstandings [Sclater et al. 2001].

The challenges are rarely addressed from a **competence perspective** but it is evident that in particular aspects regarding intercultural competences, communication competences, collaboration competences and coordination competences are tightly connected to the challenges. [Ralyté et al. 2008] found that most of the challenges identified are related to communication, coordination and control activities. To overcome challenges, often a process and managerial perspective is taken [Richardson et al. 2012]. In spite of this, [Wright et al. 2001] state that it is crucial to examine the "people who engage in the process, the skills they individually and collectively must possess, and the behavior they must engage in (individually and interactively) to implement the process".

[Richardson et al. 2012] have developed a global teaming framework, taking a **managerial perspective** on the GSD process. They suggested process improvements in terms of Global Task Management, Knowledge and Skills management, Global Project Management, Operating procedures and Collaboration between locations. This includes aspects of competence management, in particular competence requirement in terms of business competences, cultural requirements and communication skills and training.

Table 1 shows a selection of example challenges, their mapping to processes and competence categories as well as possible interventions.

The results of the literature review on challenges, which can be accounted by a lack of competences, has shown that the challenges identified can be matched to most functions throughout the entire GSD process. However, the **matching of process and categorization** based on the given descriptions has shown that in particular in the project planning and project execution phase the majority of challenges occurred. Within the project planning phase, challenges could mainly be matched to the partner selection and project allocation. In the project execution phase, the majority of challenges referred to challenges either in the development or project management. In terms of competency categories cultural competences and communication competences seem to be the major underlying cause of the challenges. Hereby it has to be stated that the competency categories are strongly correlated to each other. This means that communication problems could also have a cultural background.

For each of the identified challenges, a suitable **intervention or solution** could be found in the literature. The majority of interventions addresses challenges by suggesting clearly defined and common processes, strategies and plans. However, the interventions also show that these strategies and common processes should not be imposed by one side but rather be collaboratively developed. However, none of the identified interventions directly address the competences of the individual team members.

| Challenge | Description | Process function | Competency category | Source | Intervention |
|---|---|---|---|---|---|
| Coordination breakdown | Differences in laws, traditions and regulations require extra effort to enforce work standards and processes | Project Management Process Management Development | Project Management Coordination | [Ågerfalk et al. 2005] [Pallot et al. 2010] [Carmel 1999] [Battin et al. 2001] | Collaboratively establish processes; Identify and communicate cultural differences [Richardson et al. 2012] Don't impose a process; Incremental Integration [Battin et al. 2001] |
| Different conceptual under-standing | Concepts and terms are understood differently based on various cultural backgrounds | Partner selection Project allocation Development | Culture | [Pallot et al. 2010] | Identify cultural requirements [Richardson et al. 2012] |
| Different tools or tool usage | The selection of tools strongly depends on organizational and cultural influence factors | Development | Tools / ICT | [Pallot et al. 2010] | Common tools [Battin et al. 2001] |
| Asyn-chronous collaboration | Synchronization of work between different geographical locations within different time zones | Development | Coordination Collabo-ration Communi-cation | [Ågerfalk et al. 2005] [Pallot et al. 2010] [Noll et al. 2010] [Huang and Trauth 2008] [Sarker and Sahay 2004] | Liaison team members [Battin et al. 2001] Clear communication strategy, cooperation and coordination procedures [Richardson et al. 2012] |
| Missing interpersonal awareness | Weak ties and degree of familiarity among team members can cause several problems such as the lack of team awareness and uncertainty about right contacts | Development | Culture | [Ågerfalk et al. 2005] [Pallot et al. 2010] [Sclater et al. 2001] [Battin et al. 2001] | Liaison team members; Face-to-face meetings [Battin et al. 2001] Meeting strategy [Richardson et al. 2012] |
| Lack of trust | Uncertainty about working behaviors and competences of team members lead to a lack of trust | Development | Culture | [Pyysiäi-nen 2003] [Pallot et al. 2010] [Noll et al. 2010] | Face-to-face meetings [Battin et al. 2001] Cultural profiles for each team [Richardson et al. 2012] |
| Communi-cation breakdown | Intercultural and virtual communication requires extra effort to avoid a lack of | Development | Communi-cation | [Ågerfalk et al. 2005] [Herbsleb and Moitra 2003] | Establish communication strategy and interface points; Identify communication skills for GSE |

| Challenge | Description | Process function | Competency category | Source | Intervention |
|---|---|---|---|---|---|
| | informal communication, loss of communication richness and misunderstandings | | | [Carmel 1999] [Sclater et al. 2001] [Riege 2005] | [Richardson et al. 2012] Continuous communication [Battin et al. 2001] |
| Language | Language differences can cause misunderstandings, delays and errors | Development | Communi-cation | [Pallot et al. 2010] [Imsland and Sahay 2005] | Clear Communication strategy [Richardson et al. 2012] |
| Different backgrounds | Different backgrounds of team members lead to incompatible views of problems and misunderstandings | Partner selection Project allocation Development | Culture | [Pallot et al. 2010] [Sclater et al. 2001] [Curtis et al. 1988] [Clausen and Worm 2010] | Identify cultural requirements; Ensure awareness of cultural profiles; Clear conflict management [Richardson et al. 2012] |
| Differences in negotiations and accepting work | Cultural backgrounds can influence the perceived outcome of negotiations and task distributions | Partner selection Development | Culture | [Ebert and De Neve 2001] | Task allocation strategy [Richardson et al. 2012] Rational task management [Battin et al. 2001] |
| Values, norms and practices | The cultural background has a strong impact on individual values, norms and practices | Development | Culture | [Huang and Trauth 2006] [Riege 2005] [Pallot et al. 2010] | Identify cultural requirements; Ensure awareness of cultural profiles [Richardson et al. 2012] |
| Time perception and time-based behavior | Team members from various backgrounds can have a different perception of time and deadlines | Development Project management | Culture | [Huang and Trauth 2006] [Huang and Trauth 2008] [Saunders et al. 2004] | Collaboratively establish work plan [Richardson et al. 2012] |

*Table 1: Challenges, processes, competencies of GSD*

Summarized, the results show that a wide variety of challenges caused by a lack of competences. However, discussed interventions rarely take a human-centric or competence perspective. The focus of the intervention is instead on organizational resources such as processes, strategies and management practices. But as the challenges mainly occur on an individual level, competence-based interventions promise a suitable method to avoid and overcome problems of GSD.

### 4.2 Competency Research in GSD

The lack of competence-based interventions raised the question regarding the state of the art of research concerning competencies for GSD. Therefore, we analyzed the selected literature additionally for tools that could be used for competence-based interventions. In this case, we understand tools as specific competences, which could be used as learning outcomes for activities connected to interventions. The competences were clustered based on the same categories used for the competency categories in the previous section.

The results of the literature review have shown that competences are researched rather on a category level and that rarely concrete competences were addressed in the studies.

The results also show that the majority of identified studies focus on technical competences. However, in the last decade, a stronger focus on soft skills can be identified. Intercultural competences hereby receive the least attention. The majority of the competency related research addresses problems in a very narrow context. While aspects of competence management are related to GSD tasks, they are not an integral part of the GSD process. [Wright and Haggerty 2005] identified a long temporal lag between the functions situated in the operative side and human resource management. Additionally, [Foss 1993] states that the combination of competences with processes, learning and innovation play a crucial role in the firm's performance. Therefore, an integration of competence-based interventions and the GSD process based on identified challenges can lead to more flexibility and improved productivity. Table 2 presents a summary of the findings

| Addressed competencies | Source |
|---|---|
| Technical competences | Development of a body of knowledge for Information Systems with the core areas of IS application knowledge and IS development process knowledge [Iivari et al. 2004]<br>IT curricula of business schools focusing on learning outcomes / course offerings [McAfee 2007]<br>Identification of relevant knowledge areas for the field of information systems [Bacon and Fitzgerald 2001]<br>Influence of webmaster's competences on the job performance including technical, management, communication and collaboration competences [Wade and Parent 2001]<br>Importance of IT managers skills and activities on different managerial levels [Wu et al. 2007]<br>Qualitative analysis of relevant IS competences with a special focus on collaborative software development and modeling [Magenheim et al. 2010] |
| Application domain (business) competences | Introduction of application domain knowledge as an important factor for the body of knowledge for Information Systems [Iivari et al. 2004]<br>IT curricula of business schools focusing on learning outcomes and course offerings including management courses [McAfee 2007]<br>Development of a model and study on the importance of business competences for IT professionals [Bassellier and Benbasat 2004] |
| Coordination / project management competences | Identification of management skills for computing professionals [Fernandez-Sanz 2009]<br>Identification of relevant knowledge areas for the field of information systems [Bacon and Fitzgerald 2001]<br>Influence of webmaster's competences on the job performance including technical, management, communication and collaboration competences [Wade and Parent 2001]<br>Team knowledge and coordination in distributed software development teams with a focus on relevant skills [Espinosa et al. 2007] |

| Addressed competencies | Source |
|---|---|
| | Importance of IT managers skills and activities on different managerial levels [Wu et al. 2007] |
| Communi-cation competences | Communication skill teaching in the field of IT management [Sixsmith and Litchfield 2010]<br>Identification of communication skills for computing professionals [Fernandez-Sanz 2009]<br>Influence of webmaster's competences on the job performance including technical, management, communication and collaboration competences [Wade and Parent 2001]<br>Pedagogics for developing cross-cultural communication competencies in virtual collaborations [Paretti et al. 2006]<br>Development of a technical communication competency model [Isohella 2010] |
| Collaboration competences | Collaboration skill teaching in the field of IT management [Sixsmith and Litchfield 2010]<br>Identification of collaboration skills for computing professionals [Fernandez-Sanz 2009]<br>Collaborative behaviors and activities in multiparty software development [Levina 2005]<br>Influence of webmaster's competences on the job performance including technical, management, communication and collaboration competences [Wade and Parent 2001]<br>Qualitative analysis of relevant IS competences with a special focus on collaborative software development and modeling [Magenheim et al. 2010] |
| Intercultural competences | Introduction and study on the importance of cultural intelligence as a part of intercultural competency in technology work [Koh et al. 2009]<br>Collaborative behaviors and activities in intercultural software development [Levina 2005]<br>Pedagogics for developing cross-cultural communication competencies in virtual collaborations [Paretti et al. 2006] |

*Table 2: Competency research in GSD structured by competency categories*

## 5 A Competence-based GSD Process

Based on the results of our literature review, we have identified challenges and interventions related to competences. We merge these towards a guideline for GSD processes outlining the competence-related activities, which must be taken into account.

As the lack of competences can be accounted for a wide variety of challenges, competence management provides suitable interventions to help employees to overcome problems in their work. The inclusion of competence management functions into GSD processes constitutes a competence-based GSD process (Figure 4).

The analysis has also shown that competence-based challenges are present at most stages of the GSD process. Therefore, we propose competence management as an integral part of all GSD processes instead of an additional function. In the following table, we describe the problems and suggested changes for each of the identified GSD process functions.

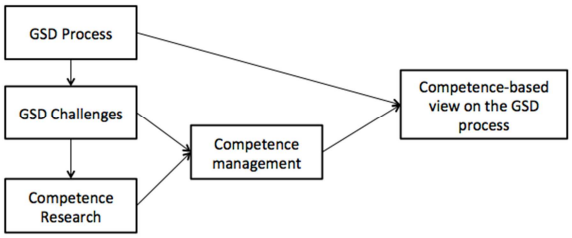


*Figure 4: Relation of sub-fields of the Competence-Based View of GSD*

| Process Function | Problem | Competence-based intervention based on competence management |
|---|---|---|
| New projects | Decision which project to run | In terms of decisions regarding new projects, for each potential project the analysis of the competence management project should be part of the decision process. The knowledge of the competencies of employees allows for a flexible assembling of project teams [Lucas and Weber 2000]. Based on an analysis of required competences and existing competence profiles [Ley and Albert 2003; Reinhardt and North 2003], a gap analysis should be conducted [Baladi 1999]. A plan run of competence sourcing can then establish possibilities to overcome the identified gaps. If external partners should close the gaps, it is necessary to identify if suitable partners are already available or if a new partner has to be found. |
| Partner selection | Decision which external partners to include in the project | The selection of partners should follow the target of closing competence gaps. This means that the strategic competence analysis [Yalaho and Nazar 2009] should focus rather on individual competences than on organizational capabilities. Ideal would be the provision of competence profiles for each team member of the potential partner. The aim of the partner selection should be to find a best match of complementing competences and price. |
| Project allocation | Decision which parts of the project to be executed by which partner | The project allocation has the aim to find the best fitting partner. While the partner selection tries to find suitable partners taking all projects into account, the project allocation looks at one particular project. A special focus should be on competences of all potential team members in partner organizations. To analyze the competences of potential team members, different methods are available [Reinhardt and North 2003]. |
| Project planning | Planning of projects risks and personnel | The project planning aims at planning costs, risks and personnel for the particular project. It should take the global teaming framework by [Richardson et al. 2012] into consideration. In particular, Global Task Management, Knowledge and Skills Management, Operating procedures and Collaboration between locations should be planned and established in this phase. For personnel planning, it is important to build a team fitting the established competence requirements. |
| Project management | Monitoring of project progress and task allocation | The project management function should be extended to global project management [Richardson et al. 2012]. Monitoring and control of the development work should take competencies into account to analyze if the assumptions regarding competency requirements and competence profiles of the team members are adequate. In case new requirements surface, competence sourcing should take place. Additionally, competencies should be taken into account for task allocation to team members [Ley and Albert 2003] |

| Process Function | Problem | Competence-based intervention based on competence management |
|---|---|---|
| Process management | Control of all involved processes | Process management should take processes regarding competence management into account. It is important to monitor the effectiveness of the competence management process to ensure a high performance. The competence requirements of a project can change dramatically both between project planning and project execution and during the project execution [Hiermann and Höfferer 2003]. |
| Evaluation and Feedback | Evaluation of the project | It is important to evaluate strategies and decision regarding competences. Competence requirements should be evaluated to understand if the assumption behind the personnel planning and competence sourcing activities were adequate. Additionally each team member's competences should be evaluated based on the project experiences to update the individual competence profile. The update of the competence profile should also include new experiences and potential training. |
| Provider assessment | Decision if the partnership should be continued | Teams of external partners should be evaluated. Hereby, both the experienced organizational capabilities and individual competencies should be evaluated. In particular should be evaluated, if the experiences match the provided competence profiles of the team members. The results should be taken into account for upcoming decision regarding project allocation and partner selection. |
| Organizational learning | Learning from experience | Organizational learning should include a strong focus on individual learning. Based on the experience of the project and the results of the evaluation, individual development plans should be created. The development plans for the team members should therefore be created based on the experiences of previous projects and on requirements for upcoming projects. |

*Table 3: Integration of competence management and the GSD process*

However, to achieve an applicability of the competence-view on the GSD process in practice, substantial further research efforts in terms of competence-related GSD challenges, relevant competences and methods for competence management for GSD have to be undertaken. The following section provides a proposed research agenda on these topics.

## 6 Discussion

Based on our holistic analysis, we have created a **competence-based view for global software development**, creating a different perspective on causal relations between resources and organizational performance. Therefore, the competence-based view should be understood as an extension or specialization of the resource-based view. Fundamental in the resource-based view is a set of physical, human and organizational resources specific for a firm, which leads to a competitive advantage and a superior long-term performance [Barney 1991; Wernerfelt 1984]. [Dierickx and Cool 1989] state, that highly skilled employees with hard to copy or obtain competences are the best possibility to achieve a competitive advantage. This means that individual competences can explain the gap between resources and the performance [Dierickx and Cool 1989]. Our competence-based view addresses the gap between physical and organizational resources and the performance.

Especially in software development, the quality of products depends strongly on the competences applied by software developers throughout the software development

process [Rivera-Ibarra et al. 2010]. The physical resources such as hardware and the organizational resources such as development processes are tools used by the individual actors to apply their individual competences. The resource-based view hereby neglects the fact that many resources can't be used without the appropriate human resources and competences. This shows that a **human perspective** in GSD might rather lead to a competitive advantage as the product quality is strongly depending on the quality of employees assigned to the project. This is supported by [Foss 1993] who states in his work regarding a competence-based view of the firm that the combination of competences with processes play a crucial role in the firm's performance. If the highly skilled employees are not available for the project, the organization might not be able to achieve a similar product quality even when using the same process.

The competence-based view of the GSD process is also in line with the **competence-based view of the firm** including the continuous change and development of the firm and the included set of competences [Foss 1993]. This seems to be a crucial aspect in the global market with changing project partners and requirements. The competence-based view of the GSD process allows for a dynamic and flexible adaptation based on the changing environment and requirements.

For an operationalization of the competence-based view on the GSD process, a number of questions were either entirely or not sufficiently answered by the literature. In the following, we will shortly present and discuss these questions.

With the help of our literature review, we identified that the challenges discussed in the related literature are not related to the **project reflection phase**. However, it can be expected that both the partner assessment and the organizational learning are more complex in international settings and socio-cultural difference can play an important role. Therefore, it is important to analyze which challenges the globalization of software development raises in this particular phase of software development projects.

Another important aspect is the **relation between competences and challenges**. A wide variety of challenges have been identified [Ågerfalk et al. 2005; Noll et al. 2010; Pallot et al. 2010]. However, the challenges are usually not analyzed taking a competence perspective. It is necessary to emphasize more on the relation between challenges and competences and to validate the findings.

Further more, **team building** and the connected **orchestration of competences** among team members is an important issue. [Ramasubbu and Krishna Balan 2008] state that guidelines regarding the competence orchestration "will be one of the significant first steps towards achieving normative governance schemes for distributed software development projects". Therefore, the orchestration of competences among team members is an important rising topic. It is in particular important to analyze which competences are necessary for all team members and which are necessary for team members fulfilling a specific task. This could lead for example to the creation of new or updated job descriptions and requirements for partner selection and personnel management.

A complex issue is the lack of coherent **standards for competence descriptions** [Reinhardt and North 2003; Ley and Albert 2003]. Different domains and even different organizations might use various ways to represent competences. [Paquette 2007] presents an overview of the definitions and underlying assumptions of the term

competency from different domains and gives a suggestion for a common understanding. However, up to date no standardized form can be found.

Another important issue is the notion of **context** within the competence description. As context is often seen as the crucial driver for competence requirements, we have to understand how this relation works. The understanding how changes of context influence the required competences is crucial for the creation of competence requirements for a specific project.

To enable organizational and individual learning in the competence-based GSD process, it is important to be able to assess individual competences continuously during the project runtime. For this purpose, specific **competence assessment** methods have to be developed as traditional tests or self-ratings might not reach the necessary accuracy. Based on the Competence Performance Theory (CPT), [Ley and Albert 2003] suggest using the repertory grid technique (RGT) for the knowledge elicitation. [Reinhardt and North 2003] state that different methods such as questionnaires and online polls can be used to ascertain the individual competences with a competence catalogue based on the organizational strategy and requirements. However, the suggested methods restrict the competencies to a prior set and do not allow for elicitation of all competencies of the employees. In case of changing requirements based on the nature of new projects, additional competences might emerge as important. Therefore, methods covering the entire competences of individuals seem relevant.

While [Baladi 1999] suggests a wide variety of methods for **competence sourcing**, we have no evidence of the effectiveness of the suggested methods. In particular when discussing intercultural competencies and knowledge sharing, [Casado-Lumbreras et al. 2011] have shown that mentoring might lead to better results than traditional training. [Dodero et al. 2007] suggest the usage of Competence Development Programs (CDPs), which are a collection of learning activities and units aimed at increasing the competences of the employees. However, which method for competence sourcing is best suited for the competences of different competency areas is crucial to plan the competence development.

## 7 Conclusion

Globally distributed software development is a complex and difficult task [Richardson et al. 2012] based on challenges coming from geographical, temporal and cultural distance [Ågerfalk et al. 2005]. In GSD projects development and management processes are important to handle the complex task. However, the human perspective of team members cannot be underestimated.

In this paper, we have developed a competence-based view on the GSD process. This view enables the direct integration of competence management tasks within the GSD process. The integration of competence management and the GSD process leads to a streamlining of competence activities and a reduction of temporal lag of human resource management. Therefore, the competence-based view has the potential to increase the productivity and guide new ways for achieving a competitive advantage. Additionally, the competence-based view of the GSD process can lead to overcoming or preventing a wide variety of common challenges for GSD by providing individuals with the suitable tools in terms of competences to overcome these challenges.

Competence-based interventions were suggested to close the gap between the required and the actual competence level of employees.

While the theoretical concept of the competence-based view promises a lot of benefits for organizations, the operationalization of the concept requires more research. Based on our literature review we have shown the state of the art of competency research related to GSD and have given suggestions for important research topics.

## References

[Ågerfalk et al. 2005] Ågerfalk, P.J., Fitzgerald, B., Homström, H., Lings, B., Lundell, B., Ó Conchúir, E.: "A Framework for considering opportunities and threats in distributed software development"; In International Workshop on Distributed Software Development, Austrian Computer Society, Paris (2005).

[Bacon and Fitzgerald 2001] Bacon, J., Fitzgerald, B.: "A systemic framework for the field of information systems"; Data Base, 32, 2 (2001), 46-67.

[Baladi 1999] Baladi, P.: "Knowledge and Competence Management: Ericsson Business Consulting", Business Strategy Review, 10, 4 (1999), 20-28.

[Barney 1991] Barney, J.B.: "Firm resources and sustained competitive advantage"; Journal of Management 17 (1991), 99–120.

[Bassellier and Benbasat 2004] Bassellier, G., Benbasat, I.: "Business Competence of Information Technology Professionals: Conceptual Development and Influence on IT-Business Partnerships"; MIS Quarterly, 28, 4 (2004), 673-694.

[Battin et al. 2001] Battin, R., Crocker, R., Kreidler, J., Subramanian, K.: "Leveraging resources in global software development"; IEEE Software, 18, 2 (2001), 70–77.

[Beecham et al. 2005] Beecham, S., Hall, T., Rainer, A.: "Defining a requirements process improvement model"; Software Quality Journal, 13, 3 (2005), 247–279.

[Bergenhenegouwen et al. 1996] Bergenhenegouwen, G.J.: "Competence development - a challenge for HRM professionals: core competences of organizations as guidelines for the development of employees"; Journal of European Industrial Training, 20, 9 (1996), 29-35.

[Boyatzis 1982] Boyatzis, R.E.: "The competent manager: a model for effective performance"; Wiley, London (1982).

[Carmel 1999] Carmel, E.: "Global Software Teams – Collaborating Across Borders and Time-Zones"; Prentice Hall, US (1999).

[Casado-Lumbreras et al. 2011] Casado-Lumbreras, C., Colomo-Palacios, R., Soto-Acosta, P., Misra, S.: "Culture dimensions in software development industry: The effects of mentoring," Scientific Research and Essays, 6, 11 (2011), 2403-2412.

[Clausen and Worm 2010] Clausen, E., Worm, V.: "Corporate Cross-cultural Collaboration the Contextual Challenges of Multi-cultural Teams in China and Japan"; In International Conference on Intelligent Computing, August 19–20, Copenhagen, Denmark (2010).

[Collier et al. 1996] Collier, B.; DeMarco, T., Fearey, P.: "A defined process for project post mortem review"; IEEE Software, 13 (1996), 65- 72.

[Colomo-Palacios et al. 2013] Colomo-Palacios, R.; Casado-Lumbreras, C.; Soto-Acosta, P.; García-Peñalvo, F.J., Tovar-Caro, E.: "Competence gaps in software personnel. A multi-organizational study"; Computers in Human Behavior, 29, 2 (2013), 456-461.

[Curtis et al. 1988] Curtis, B., Krasner, H., Iscoe, N.: 1988: "A field study of the software design process for large systems"; Communications of the ACM, 31, 11 (1988), 1268-1287.

[Dierickx and Cool 1989] Dierickx, I., Cool, K.: "Asset Stock Accumulation and Sustainability of Competitive Advantage"; Management Science, 35, 12 (1989), 1504–1511.

[Dodero et al. 2007] Dodero, J.M., Sánchez-Alonso, S., Frosch-Wilke, D.: "Generative Instructional Engineering of Competence Development Programmes"; Journal of Universal Computer Science, 13, 9 (2007), 1213-1233.

[Ebert and De Neve 2001] Ebert, C., De Neve, P.: "Surviving global software development"; IEEE Software, 18, 2 (2001), 62-69.

[Espinosa et al. 2007] Espinosa, J.A., Slaughter, S.A., Kraut, R.E., Herbsleb, J.D.: "Familiarity, complexity, and team performance in geographically distributed software development"; Organization Science, 18, 4 (2007), 613-630.

[Fernandez-Sanz 2009] Fernandez-Sanz, L.: "Personal Skills for Computing Professionals"; Computer, 42, 10 (2009), 110-112.

[Fink 2005] Fink, A.: "Conducting research literature reviews: From the internet to paper (2nd ed.)"; Sage Publications, Thousand Oaks, CA (2005).

[Foss 1993] Foss, N.: "Theories of the Firm: Contractual and Competence Perspectives"; Journal of Evolutionary Economics, 3, 2 (1993), 127-144.

[Green 1999] Green, P.C.: "Building Robust Competencies: Linking Human Resource Systems to Organizational Strategies"; Jossey-Bass, San Francisco (1999).

[Harvey et al. 2000] Harvey, M.G., Novicevic, M.M., Speier, C.: "An Innovative Global Management Staffing System: A Competency-Based Perspective"; Human Resource Management, 39, 4 (2000), 381–394.

[Herbsleb and Mockus 2003] Herbsleb, J.D., Mockus, A.: "Formulation and preliminary test of an empirical theory of coordination in software engineering"; In Proceedings, European Software Engineering Conference and ACM SIGSOFT Symposium on the Foundations of Software Engineering, Helsinki, Finland (2003), 112-121.

[Hiermann and Höfferer 2003] Hiermann, W., Höfferer, M.: "A Practical Knowledge-based Approach to Skill Management and Personal Development"; Journal of Universal Computer Science, 9, 12 (2003), 1398-1409.

[Huang and Trauth 2006] Huang, H., Trauth, E.M.: "Cultural diversity challenges: issues for managing globally distributed knowledge workers in software development"; In Yoong, P., Huff, S. (eds) Managing IT professionals in the Internet Age, 254-276, Idea Group Publishing, Hershey, PA (2006).

[Huang and Trauth 2008] Huang, H., Trauth, E.M.: "Cultural Influences on Temporal Separation and Coordination in Globally Distributed Software Development"; In International Conference on Information Systems 2008 Proceedings, Paper 134 (2008).

[Iivari et al. 2004] Iivari, J.; Hirschheim, R.A., Klein H.-K.: "Towards a distinctive body of knowledge for Information Systems experts: coding ISD process knowledge in two IS journals"; Information Systems Journal, 14 (2004), 313-342.

[Imsland and Sahay 2005] Imsland, V., Sahay, S.: "Negotiating Knowledge: The Case of a Russian-Norwegian Software Outsourcing Project"; Scandinavian Journal of Information Systems, 17, 1 (2005), 101-129.

[Isohella 2010] Isohella S.: "What Working Life Requires: An Approach to a Technical Communication Competency Model"; In Professional Communication Conference (IPCC), IEEE International (201), 310-314.

[Kangas 1999] Kangas, K.: "Competency and Capabilities-Based Competition and the Role of Information Technology: The Case of Trading by a Finland based Firm to Russia"; Journal of Information Technology Cases and Applications, 1, 2 (1999), 4-22.

[Koh et al. 2009] Koh, C.; Joseph, D., Ang, S.: "Cultural Intelligence and Collaborative Work: Intercultural Competencies in Global Technology Work Teams"; In Proceedings of the 2009 international workshop on Intercultural collaboration, ACM, New York (2009), 261-264.

[Lanubile et al. 2010] Lanubile, F., Ebert, C., Prikladnicki, R., Vizcaino, A.: "Collaboration tools for global software engineering"; IEEE Software, 27, 2 (2010), 52 –55.

[Levina 2005] Levina, N.: "Collaborating on Multiparty Information Systems Development Projects: A Collective Reflection-in-Action View"; Information Systems Research, 16, 2 (2005), 109-130.

[Ley and Albert 2003] Ley, T., Albert, D.: "Identifying Employee Competencies in Dynamic Work Domains: Methodological Considerations and a Case Study"; Journal of Universal Computer Science, 9, 12 (2003), 1500-1518.

[Lucas and Weber 2000] Lucas R., Weber T., Skill-Management: Building Block for Project Management with Flexible Teams, 4th IEEE International Baltic Workshop on databases and information systems, Vilnius, Lithuania (2000).

[Magenheim et al. 2010] Magenheim, J., Nelles, W., Rhode, T., Schaper, N., Schubert, S., Stechert, P.: "Competencies for Informatics Systems and Modeling. Results of Qualitative Content Analysis of Expert Interviews"; In Global Engineering Education Conference (Educon), IEEE, Madrid (2010).

[McAfee 2007] McAfee, A.: "Those to Whom IT Matters Most: Perspectives of IT Faculty on Curricula, Courses, and Class Materials"; Information Systems Research, 18, 2 (2007) , 142-149.

[Noll et al. 2010] Noll, B.J.; Beecham, S., Richardson, I.: "Global Software Development and Collaboration: Barriers and Solutions"; ACM Inroads, 1, 3 (2010), 66-78.

[Nordhaug 1998] Nordhaug, O.: "Competence specificities in organizations"; International Studies of Management and Organization, 28, 1 (1997), 8–29.

[Pallot et al. 2010] Pallot, M., Martínez-Carreras, M.A., Prinz, W.: "Collaborative Distance"; International Journal of e-Collaboration, 6, 2 (2010), 1-32.

[Paquette 2007] Paquette, G.: "An Ontology and a Software Framework for Competency Modeling and Management"; Educational Technology & Society, 10, 3 (2007), 1-21.

[Paretti et al. 2006] Paretti, M.C., McNair, L.D., Burgoyne, C.B.: "Work in Progress: Pedagogies for Developing Cross-Cultural Communication Competencies in an Era of Virtual Collaboration"; In: ASEE/IEEE Frontiers in Education Conference. San Diego, CA (2006).

[Pawlowski et al. 2008] Pawlowski, J.M., Schrader, H., Khatami, P., Adelsberger, H.H.: "The Globalization Technology Competency Framework for the Knowledge Worker – an E-

Learning Program for Enterprise Resource Planning"; In European e-skills Conference, Thessaloniki, Greece (2008).

[Pawlowski and Holtkamp 2012] Pawlowski, J.M., Holtkamp, P.: "Towards the Internationalization of the Information Systems curriculum"; In Multikonferenz Wirtschaftsinformatik (MKWI) 2012, Braunschweig, Germany (2012).

[Peppard and Ward 2004] Peppard, J., Ward, J. M.: "Beyond strategic information systems: towards an IS capability"; Journal of Strategic Information Systems, 13, 2 (2004), 167-194.

[Prikladnicki et al. 2006] Prikladnicki R., Audy, J.L.N., Evaristo, R.: "A Reference Model for Global Software Development: Findings from a Case Study"; In International Conference on Global Software Engineering, Florianopolis, Brazil (2006), 18-28.

[Pyysiäinen 2003] Pyysiäinen, J.: "Building trust in global inter-organizational software development projects: problems and practices"; In The International Workshop on Global Software Development, Portland, Oregon, USA (2003).

[Ralyté et al. 2008] Ralyté, J., Lamielle, X., Arni-Bloch, N., Léonard, M.: Distributed Information Systems Development: "A Framework for Understanding and Managing"; International Journal of Computer Science and Applications, 5, 3b (2008), 1-24.

[Ramasubbu and Krishna Balan 2008] Ramasubbu, N., Krishna Balan, R.: "Towards Governance Schemes for Distributed Software Development Projects"; In Proceedings of the 1st international workshop on Software development governance, ACM, New York , USA (2008), 11-14.

[Ramasubbu et al. 2005] Ramasubbu, N., Krishnan, M.S., Kompalli, P.: "Leveraging global resources: a process maturity framework for managing distributed development"; IEEE Software, 22, 3 (2005), 80–86.

[Reinhardt and North 2003] Reinhardt, K., North, K.: "Transparency and Transfer of Individual Competencies – A Concept of Integrative Competence Management"; Journal of Universal Computer Science, 9, 12 (2003). 1372-1380.

[Richardson et al. 2012] Richardson, I., Casey, V., McCaffery, F., Burton, J., Beecham, S.: "A Process Framework for Global Software Engineering Teams"; Information and Software Technology, 54 (2012), 1175-1191.

[Riege 2005] Riege, A.: "Three-dozen knowledge-sharing barriers managers must consider"; Journal of Knowledge Management, 9, 3 (2005), 18-35.

[Rivera-Ibarra et al. 2010] Rivera-Ibarra, J.G., Rodríguez-Jacobo, J., Serrano-Vargas, M.A.: "Competency framework for software engineers"; In Proceedings of the 23rd IEEE conference on software engineering education and training (CSEE&T), Pittsburgh, PA, USA (2010), 33-40.

[Rocha et al. 2011] Rocha, R.G.C., Costa, C., Rodrigues, C., de Azevedo, R.R., Junior, I.H., Meira, S., Prikladnicki, R.: "Collaboration Models in Distributed Software Development: a Systematic Review"; CLEI Electronic Journal, 14, 2 (2011).

[Sanchez et al. 1996] Sanchez, R., Heene, A., Thomas, H.: "Introduction: Towards the Theory and Practice of Competence-Based Competition"; Pergamon Press, Oxford (1996).

[Sandberg 2010] Sandberg, J.: "Understanding human competence at work: an interpretative approach"; Academy of Management Journal, 43, 1 (2010), 9-25.

[Sarker and Sahay 2004] Sarker, S., Sahay, S.: "Implications of space and time for distributed work: an interpretive study of US–Norwegian systems development teams"; European Journal of Information Systems, 13 (2004), 3–20.

[Saunders et al. 2004] Saunders, C., Van Slyke, C., Vogel, D.R.: "My time or yours? Managing time visions in global virtual teams"; Academy of Management Executive, 18, 1 (2004), 19-31.

[Sclater et al. 2001] Sclater, N., Grierson, H., Ion, W. J., MacGregor, S. P.: "Online collaborative design projects: overcoming barriers to communication"; International Journal of Engineering Education, 17, 2 (2001), 189–196.

[Sengupta et al. 2006] Sengupta, B., Chandra, S., Sinha, V.: "A Research Agenda for Distributed Software Development"; In Proceedings of the 28th international conference on Software engineering, Shanghai (2006), 731-740.

[Sixsmith and Litchfield 2010] Sixsmith, A.J., Litchfield, A.J.: "Improving the learning of Graduate Attributes in the Curriculum: a Case-Study in IT Management"; In: Proceedings of the Twelfth Australasian Computing Education Conference (ACE 2010), Australian Computer Society Inc., Sydney (2010), 155-164.

[Wade and Hulland 2004] Wade, M.,; Hulland, J.: "Review The Resource-Based Review: View and information systems and Suggestions Review, Extension, Suggestions for Future Research"; Management Information Systems, 28, 1 (2004), 107-142.

[Wade and Parent 2001] Wade, M.R., Parent, M.: "Relationships Between Job Skills and Performance: A Study of Webmasters"; Journal of Management Information Systems, 18, 3 (2001), 71-96.

[Webster and Watson 2002] Webster, J., Watson, R.T.: "Analyzing the Past to Prepare for the Future: Writing a Literature Review"; MIS Quarterly, 26, 2 (2002), xiii – xxiii.

[Wernerfelt 1984] Wernerfelt, B.: "A resource-based view of the firm"; Strategic Management Journal 5 (1984), 171–180.

[Westera 2001] Westera, W.: "Competences in education: a confusion of tongues"; Journal of Curriculum Studies, 33, 1 (2001), 75–88.

[Winterton 2009] Winterton, J.: "Competence across Europe: highest common factor or lowest common denominator"; Journal of European Industrial Training, 33, 8/9 (2009), 681-700.

[Wright et al. 2001] Wright, P.M., Dunford, B.B.,Snell, S.A.: "Human resources and the resource-based view of the firm"; Journal of Management, 27 (2001), 701-721.

[Wright and Haggerty 2005] Wright, P.M.; Haggerty, J.J.: "Missing Variables in Theories of Strategic Human Resource Management: Time, Cause, and Individuals,"; Management Revue, 16, 2 (2005), 164-172.

[Wu et al. 2007] Wu, J.H., Chen,Y.C., Chang, J.: "Critical IS professional activities and skills/knowledge: A perspective of IS managers"; Computers in Human Behavior, 23, 6 (2007), 2945-2965.

[Yalaho and Nahar 2009] Yalaho, A., Nahar, N.: "The ICT-Supported Unified Process Model of Offshore Outsourcing of Software Production: Exploratory Examination and Validation"; International Journal of Innovation and Technology Management, 6, 1 (2009), 59-96.