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## **ENTERPRISE SYSTEMS FOR COMPETENCE DEVELOPMENT: APPROACH, METHOD AND CHALLENGES**

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### **Abstract**

*Due to a shortage of key competencies in organisations and the rising challenge to find the right person to do a job, organisations are under pressure to assess, monitor and continuously develop their workers' competencies. At the same time, enterprise systems offer data that provide a basis for strategic decisions in the area of competence development. This domain was investigated with two case studies in two medium-sized organisations and a set of parameters describing workers, tasks, competencies, and learning measures, was derived that can be used to solve the decision problem of allocating workers to learning measures. The resulting model was reviewed in a first evaluation cycle on a micro, meso, and macro level, involving 203 employees, 16 focus group participants and six human resource experts, respectively. The feedback from the evaluation informed a revision of the model, adding factors that describe competencies of promoted team members. The preliminary results comprise an updated optimisation model as well as a set of challenges for competence development derived from the first evaluation cycle.*

*Keywords: competence development approach, decision support system evaluation, enterprise systems, human resource management, workforce planning.*

## 1 Introduction

Strategic human resource development (HRD) has become the focus of research that supports the development of human resources (HR), offering capabilities that can be turned into competitive advantage of an organisation (Dulebohn and Johnson, 2013). One goal of strategic HRD is to service formal HR processes with data gathered in enterprise systems in order to drive strategic objectives of the organisation (Garavan et al., 1995). Enterprise systems make available a variety of data that feed into decision support systems (DSS) and improve managerial decision making (Arnott and Pervan, 2012), also in the domain of HRD (Vaiman et al., 2012).

An organisation's performance can be enhanced by the use of information technology to manage and develop competencies (Lertwongsatien, 2005). A meta-analysis of 69 studies (Tharenou et al., 2007) reports positive effects of HRD on organisational performance, but identifies a huge gap in the integration of individual and organisational HRD models and theories. HRD can be achieved via different pathways, such as trainings or team building, and can be addressed on different organisational levels, i.e., on a micro level by focusing on individual worker's competencies, on a meso level, by focusing on competencies of teams, and on a macro level by focussing on strategic organisational competencies (Kozlowski and Klein, 2000). Greater integration between the individual, team, and organisational level bridges the micro-meso-macro gap in the organisation according to competence research (Tharenou et al., 2007). The research-in-progress reported in this paper aims at addressing this gap with a DSS that taps into the potential of data taken from enterprise systems and from individual employees. This is intended to support HR managers and team leaders in their decision on what worker should perform what learning measure to gain a certain competence that is required for a project task. Hence, the research question addressed in this research is: *How can individual and team data available in enterprise systems be employed to support HR managers and team leaders in deciding what learning measures should be assigned to knowledge workers to develop competencies needed for a task and what challenges arise when addressing this question?*

## 2 Procedure and results

To capture the real-world problems in HRD and to address them with a well-structured DSS, several modelling cycles of abstraction, evaluation, and refinement are necessary. Schneeweiss (2003) suggests that the first cycle should capture the conceptual frame by describing those aspects of the real world that should be modelled and by defining the goals and boundaries of the model. The result of this abstraction process is a *master model*. In design science terminology, the master model can be referred to as an artifact, in particular, a conceptual *model* (Hevner et al., 2004). This model then needs to be empirically evaluated and refined. Once in a stable state, the master model needs to be formalised. This process is known as relaxation, and results in the *formal model* (Schneeweiss, 2003), which in design science is referred to as a *method* (algorithm), which is evaluated in what Schneeweiss calls a decision evaluation. Both types of models require different problem structuring and evaluation methods. This section will give a glimpse into the master model, describe its empirical evaluation, and develop the formal model.

### 2.1 Master model and evaluation

The master model was developed based on a real-world problem studied in two medium-sized organisations. Both organisations can be categorised as knowledge-intensive (Eurostat, 2009), whereas one provides IT development and consulting services in the healthcare sector (here referred to as HC) and the second organisation is a telecommunication provider (COM). The results of the case study (Maier et al., 2011) were analysed in richly described work practices using the scenario technique (Rosson and Carroll, 2002). Constructs were derived from the developed HRD work practice. The constructs were used by HR developers and team leaders to decide which worker to assign to what competence development measure. The four main concepts in this decision process are *knowledge*

workers, learning measures, tasks, and competencies with constraints comprising time, cost, competence levels, values, and worker preferences. The decision process was modelled and described in a textual, graphical, and formal way.

The decision model was empirically evaluated in the two case study organisations on micro, meso, and macro levels using a mixed method approach (Johnson and Onwuegbuzie, 2004). This approach was chosen because the combination of different methods allows investigating various perspectives on the HRD situation and constitutes a recognized approach for exploiting the full richness of the real world (Mingers, 2001). A first quantitative survey with 203 participants was used to study teamwork and competence factors of individual workers (micro-level) and to select participants for the qualitative study with eight focus group interviews involving 16 participants (meso-level), followed by an expert survey with six HR experts (macro-level) (Seeber et al., 2013). Focus groups and expert evaluation are a recommended technique for the evaluation of personal DSSs, in particular to establish the utility of the artifact and improve it before engaging in a more effort- and resource-intensive evaluation (Arnott and Pervan, 2012; Tremblay et al., 2010). Table 1 summarises the evaluation levels.

Org. level	Sample size	Data collection method	Data analysis method
Micro	203 employees (90 from HC and 113 from COM)	Survey	Exploratory factor analyses, one-way ANOVAs and 2x2 factorial ANOVAs
Meso	16 employees, 4 different groups	Focus group interviews	Description, categorisation, and interpretation of focus group outputs
Macro	6 HR experts	Survey	Coding and interpretation

*Table 1: Overview of evaluation levels*

Based on reliability results, one-way ANOVAs, and 2x2 factorial ANOVAs of the quantitative survey, 16 focus group participants representing the team perspective were selected using the following criteria: 1) those that were with the organisation for at least one year, and 2) those who perceived themselves to perform particularly well in their teams. Criterion 1) was chosen to ensure sufficient knowledge of the organisational context and criterion 2) to learn from successful practices. Eight people from each organisation were selected. Participants in the first COM group worked in primary and secondary customer support, participants in the second COM group worked in monitoring, R&D trouble shooting, and field operations. Participants in the first HC group worked in software development, and participants in the second HC group worked in strategic planning, marketing, and advertising. The groups were interviewed on two consecutive days in two one-hour sessions each. The interviews were designed using thinkLets (Briggs et al., 2001) in order to facilitate suitable, transferable, predictable, and repeatable interviews and analysed by describing, categorising, and interpreting focus group output.

Two case study internal HR experts, one from HC and one from COM, and four external HR experts participated in the expert evaluation. The external experts were selected by convenience sampling by the research team. Table 2 presents demographic data of the experts. Experts were provided with 1) an executive summary describing the model and the context, 2) a power point presentation that visualised the key aspects of the model, and 3) a feedback questionnaire. The survey questions were adapted from an expert evaluation study (Parboteeah and Jackson, 2011) in order to meet the research context and focus: e.g., a question on crucial aspects influencing the adoption of the model was added, while questions on the definition of terms were left out. Experts were offered support in terms of a personal introduction to the model and support when filling out the questionnaire. Three experts (E 1, 3, 4) accepted this offer. Data was analysed using a coding technique, where the parameters of the model presented the basic coding categories. Additional parameters were added as new codes which were stated to be important by the experts in the suggested HRD decision making process with an inductive approach. In a second step the indicators were interpreted with respect to whether they do or do not support the parameter in the context of the decision problem.

Expert ID	Profession	Description of HR experiences and focus	Years in HR
E1	HR manager	HRM with focus on recruitment, HRD, team formation at COM.	5
E2	HR manager	HRM with focus on recruitment, HRM technologies, and HRM administration at HC.	10
E3	Full Professor	Specialised in the implementation of HRM practices, with focus on organisations' inefficiency & dysfunctional effects.	15
E4	HR consultant	Focus on competence management, HRD, and inter-organisational process design.	7
E5	Project coordinator & HRM consultant	Focus on HRD, HR processes and training, specialised in technology-enhanced learning, competence modelling	5
E6	Head of HR division	Head of HR and responsible for management of sub-divisions at a large software company.	10

Table 2. Demographics of HR experts

## 2.2 Formal model development

This section presents the formal model supporting the decision process of what worker to develop with which learning measure. The constructs are formally defined and justified with original voice from the focus groups and quotas from the expert survey. Statements annotated in italics refer to the experts E1-6 (table 2) and the focus groups COM1, i.e. organisation COM – focus group 1, COM2, HC1, HC2.

The Boolean decision variable is defined as  $X_{w,m} \in \{0,1\}$  with the dimensions **knowledge worker** W and **learning measure** M. Due to the fact that financial resources are limited in organisations, **costs**  $Cost_{w,m} \in R$  of learning measures need to be considered and E1 confirms this parameter: “*If it is too expensive to gain the knowledge required for a project we consider to not do the project.*” So “*we have to find a way to cut and [...] prioritise*” (HC1). On the other hand, **value**  $V_{c,l} \in R$  are gained depending on the use of a competence on a certain level in one or more **tasks in a project**  $Task_{c,l} \in R$ : “*To decide, if a training should be applied we usually also try to figure out if the knowledge that he will gain, can also be used somewhere else*” (E1). Workers have **preferences** for certain competencies on a certain competence level  $P_{w,c,l} \in R$ , that represents the worker's anticipated benefits from the performance of the measure. Experts reason that “*HR development is always a combination of what an employee wants and what the organisation wants*” (E3) and “*we [...] focus on the coverage of worker preference mainly to assure continuous motivation.*” (E2) Furthermore, **time required** by workers to perform a learning measure  $MTime_m \in R$ , the **time a worker is available** for a learning measure  $WTime_w \in R$ , and the **time until a competence is needed** in a task  $TTime_t \in R$ , have to be defined, and were generally confirmed as parameters for the this decision process by E1: “*factors that we consider [...] [are] money, time, and people*”. The last concept that was already considered in the master model was the level of **competence available from workers, required for and resulting from learning measures, and required for tasks**:  $W_{c,l}, MMin_{c,l}, MExp_{c,l}, Task_{c,l} \in \{0,1\}$ . E1 explains “*we define the level of knowledge, skill, and attitude within a specific and consistent scale.*” Additionally, experts suggest preferring employees who, 1) have “*promoted competencies, i.e., competencies of employees who got promoted*” (E3), 2) “*have the competence to share what they have learned [...] because they can teach their colleagues afterwards.*” (E1), and 3) detect “*synergies between competencies.*” (E1) These constructs are introduced as **weights**  $wei_{c,l}$  that can be set by the decision maker. Due to the three dimensions, measure, competence, and level, a decision cube with Boolean assignments is necessary  $Map_{m,c,l} \in \{0,1\}$ . We can now define the objective function

$$U = \sum_{w=1} \sum_{m=1} X_{w,m} * (\sum_{c=1} \sum_{l=1} Map_{m,c,l} (P_{w,c,l} + (V_{c,l} * wei_{c,l})) - Cost_{w,m}) \rightarrow \max \quad (1)$$

and the constraints:

$$\sum_{w=1} \sum_{m=1} X_{w,m} * MTime_m \leq WTime_w, \forall W \quad (2)$$

$$\sum_{w=1} \sum_{m=1} \sum_{t=1} X_{w,m} * MTime_m \leq TTime_t, \forall M \quad (3)$$

$$X_{w,m} * W_{c,l} = X_{w,m} * MMin_{c,l}, \forall W \quad (4)$$

$$Task_{c,l} \leq MExp_{c,l}, \forall M \quad (5)$$

Competence-centred approaches to assign workers to tasks have gained popularity in operations research where the “multi-skill project scheduling problem” (MSPSP) is a repeatedly addressed optimisation problem in the domain of portfolio management and workforce planning. Optimisation objectives are minimising staffing costs (Avramidis et al., 2010; Firat and Hurkens, 2011), minimising the make-span (Bellenguez and Néron, 2005; Pessan et al., 2007), minimising outsourcing costs (Wu and Sun, 2005), and maximising economic gains from projects and strategic gains from desirable competencies (Gutjahr et al., 2008). These MSPSP models focus primarily on tightly scheduled, non-knowledge intensive tasks of individual workers, but no approach could be detected that optimises required expenses in HRD and considers both, individual parameters (e.g., worker’s preferences), and team parameters (e.g., promoted competencies). Individual, team and organisational performance have been studied also, e.g., with respect to team diversity (Rupprecht et al., 2011) or team structure (Hopp and Zenk, 2012). Reviews of concepts, models, and case studies with respect to individual, team, and organisational competencies and competence management systems (Boucher et al., 2007; Draganidis and Mentzas, 2006) inform the software implementation of the model. Furthermore, Dulebohn and Johnson (2013) characterise HR decisions in a conceptual, two dimensional (management level and decision-making structure) HR decision framework and provide a basis for designing HR DSS.

### 3 Discussion

Focus group participants and experts generally supported the goal, constructs, dependencies, and constraints of the presented competence development decision support model. This section discusses the evaluation results along challenging topics for further investigation, includes original voice from focus groups and expert evaluation, references to literature, and concludes with limitations that should be considered when drawing on these results.

**Long-term plans vs. ad-hoc task-assignment:** Organisations and workers are challenged with knowledge workers entering and leaving the organisation because *“a new person [...] can't learn everything in one month. It just takes time to get to know things in detail. Even if you have the best knowledge base, it's impossible. You have to [...] learn step by step.”*(COM1) Several workforce scheduling algorithms focus only on the current gaps and do not consider what in traditional HR management was called career plans. Career plans provide certain stability in a worker’s schedule and in the organisation’s long-term plans (Garavan et al., 1995). Partly, this challenge is addressed by understanding that *“the method can guide the daily as well as the long-term development of HR”* (E5) but due to e.g., the unstructured character of knowledge-intensive work, it is difficult to define tasks, and an optimal workforce-scheduling (Firat and Hurkens, 2011) would not be feasible in knowledge work due to its weakly structured character (Kelloway and Barling, 2000).

**Optimise personnel analysis:** The presented module provides suggestions and support for the use of enterprise system data. However, gathering employee data is said to require experienced HR developers who manage to capture the actual potential of employees (Garavan et al., 1995). *“You could look into potential analysis [...] and methods such as “similarity learning”* (E4) and *“personnel analysis can be [applied] to find out about career types [and] learner types”* (E3). Focus group participants emphasised the importance of knowing colleagues’ competencies because *“sometimes you have to have a solution within minutes and it's important that you are able to [...]ask the right person [...] and get help quickly”*(COM2).

**Integration with HRM processes:** *“This [HRM] is an overall complex system with various components - the system only makes sense if all components are applied.”* (E5) The competence development process cannot be supported with a sufficient DSS when isolated from competence gaps analysis, team formation, recruitment, and personnel reduction. To staff key roles in an organisation, an adjusted process of *“hiring, training, and supporting juniors [...] solves problems with recruiting [senior roles]”*. (HC2) The integration of HR methods and tools goes along with the goal to *“integrate preferences of a large number of employees into the organisational HR development”* (E3) which emphasises the micro-meso-macro approach (Kozłowski and Klein, 2000).

While these challenges already make explicit some limitations by the real-world settings, there are a few methodological limitations that constrain this work. They comprise typical formal modelling limitations resulting from the abstraction and the relaxation (Schneeweiss, 2003). While evaluation is supposed to counter these limitations, also evaluation has limitations, namely, the fairly small sample of experts chosen for the empirical evaluation which was compensated to a certain degree with the focus group interviews of teams. It is also problematic that parts of the evaluation were performed in the case study organisations where the work practices were first studied (Hevner et al., 2004). This limitation was addressed by involving external experts, and an additional evaluation cycle will follow.

## 4 Conclusion and next steps

This paper was motivated by the HRD decision problem of what worker to assign to what learning measure. The results presented in this paper discuss the relevance and feasibility of the method in the light of a cycle of evaluations consisting the micro, meso and macro levels of HRD in organizations and hence provide an important basis for the second evaluation cycle where it is planned to perform an experiment and follow an evaluation framework, such as (Forgionne, 1999; Phillips-Wren et al., 2004). The next goals will be finalising a prototype and evaluating the extent of decision support of the formal model, towards criteria such as personal productivity of stakeholders when establishing decision criteria, evaluating decision alternatives, and making final choices. Such an experiment in an organisational setting requires a tremendous effort, even if enterprise systems in use already provide large parts of the required data. Therefore it is of major interest for the evaluation organisation and the research team to assess the value and the limitations of the model *ex ante*, as shown in this article.

Finally, it is worth reflecting on the contribution of this research using the seven guidelines for design-science research articulated in (Hevner et al., 2004). The study produces two artifacts, the conceptual master model and the formal model (method) (Guideline 1 or G1). These artifacts provide methodical solutions to important and relevant organisational problems, namely to the HRD process, in particular the decision problem of assigning workers to learning measures (G2). The utility of the conceptual master model has been shown within the focus group and expert evaluation (G3). Furthermore, the evaluation raised additional parameters to be considered in the design of a HRD DSSs and hence provides a contribution in the area of methodology design (G4). All steps in model development and evaluation were performed and described based on a rigorous research approach (G5). The proposed artifacts utilise available parameters, i.e., means, to reach desirable competence development, i.e. ends, while satisfying constraints, i.e., laws in the problem environment (G6). This research addresses, technology-oriented (e.g., enterprise system developers) as well as management-oriented (e.g., HR managers) interests, and is intended to be communicated to both audiences (G7).

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