The final publication is available at link.springer.com
Published at Int'l Conference on Advanced Information Systems Engineering, pp. 594-609 (2013)
http://link.springer.com/chapter/10.1007/978-3-642-38709-8_38

Experience Breeding in Process-Aware Information Systems

Sonja Kabicher-Fuchs, Jürgen Mangler, and Stefanie Rinderle-Ma

University of Vienna,
Faculty of Computer Science, Austria
{sonja.kabicher-fuchs,juergen.mangler,stefanie.rinderle-ma}@univie.ac.at

Abstract. Process-Aware Information Systems (PAIS), such as workflow systems, support organizations in optimizing their processes by increasing efficiency and structure. In such systems, the inclusion of humans beyond the typical concept of roles has not yet been paid much attention to. However, a tighter integration of human resources can be beneficial for both, employees and employers. Our contribution is the formal integration of experiences into PAIS. This integration a) enables employees to track which experiences they gain while working on process tasks, b) allows employees to express experience development goals, and c) allows employers to, based on the employees' experiences and goals, improve task allocation to employees. We introduce experience breeding, which describes how to measure experience variances that occur when employees work on certain tasks. We present a simulation design, discuss preliminary results and the potential improvements to overall task allocation effectiveness compared to standard algorithms.

Keywords: Human-Centric Process-Aware Information System (HC-PAIS), process experience, experience breeding, resource management

1 Introduction

The advantage of Process-Aware Information Systems (PAIS), such as workflow systems, is an overall increase of efficiency and structure. However, a problem of such systems is their potential to support 'chain production in the office' [1][2]. Skepticism of users address the rigidity and monotony of work, and the limitations of flexibility and development. Such negative perceptions can have decreasing effects on the users' satisfaction, motivation, and their performance.

Human orientation in PAIS is particularly relevant in industries where processes require human knowledge, skills, competencies, experience, judgments and decisions. In these industries, such as service markets, human capital embodies the most valuable capital of a company. In such a context, human orientation in Information Systems and the consequent user acceptance of such systems is a critical issue for high performance and business success. Human orientation in the context of PAIS may refer to both, the inclusion of humans (by considering human behavior and demands) and the integration of humans (by assimilating humans attributes such as experiences, qualifications and other capabilities) into the system. A PAIS that includes and integrates humans in such a way for us means a Human-Centric Process-Aware Information System (HC-PAIS) [3].

In this work we aim at integrating experiences into HC-PAIS to use them as a critical factor for task allocation which supports experience breeding. By experience breeding we understand the progression, maintenance and negligence of experience levels. Experience breeding is guided by experience breeding goals expressed by users (task performers) in natural language within the HC-PAIS. To the best of our knowledge, this allocation approach is novel and has not been considered so far in PAIS solutions and research. Although PAIS offer tremendous potentials to measure experience values in a reliable way and to keep these values up-to-date, the concept of experience has been a mainly unexploited research area in PAIS. Our contribution includes:

1. The integration of experiences with tasks and users for which we propose an experience breeding meta model (see Section 2).
2. Algorithms for fine-tuning typical role-based task allocation which prioritize tasks that will support the users in reaching goals they select themselves.
3. The implementation of experience breeding (see Sections 3 and 4).
4. The discussion of a simulation design, preliminary results, and the effects of experience breeding on allocating tasks to users (see Section 6).

The research methodology of this work includes: (a) the conceptual design of experience breeding based on previous work [4] and on the theoretical backbone presented in Section 2.2, and (b) the evaluation of the design by means of prototyping and simulation. In our previous work [4] we extracted experience measurements from job offers and literature addressing PAIS and psychology that can be effectively supported by PAIS. These measurements we use in this work to elaborate an experience breeding rule that measures experience variances (Section 4). Furthermore, we present our approach by means of a fictive company GARDEN which is specialized on designing and creating gardens (Section 5). The application scenario is used to illustrate our concept and to yield synthetic data for our simulation. In addition to our contributions presented in the Sections 2, 3, 4, 5 and 6 as listed above, Section 7 provides related work, and Section 8 concludes our work and provides an outlook on future work.

2 Integration of Experiences with Tasks and Users

In this section we present our conceptual meta model for experience breeding and provide theoretical background on which our concept is based on.

2.1 Conceptual Model

The Experience Breeding Meta Model (EBreMM) for HC-PAIS is represented as Entity-Relationship Diagram [5] and depicted in Figure 1. In essence, the EBreMM extends user-role-task relationships as typically employed by PAIS by the concept of *Experiences*, *Goals*, and *Levels* as well as the relationships between them (highlighted in gray). *Experiences* can be assigned to *Users* and activated by certain *Tasks*. The *Tasks* can be used throughout several *Processes*. *Experiences* can be expressed at different *Levels* and serve as vehicle to achieve certain *Goals*. The EBreMM defines the data structure required for experience breeding at design time. We explain the EBreMM by means of an application scenario which is presented in Section 5.

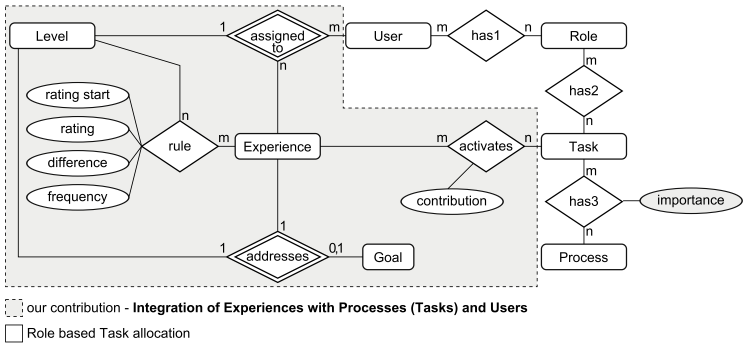

Fig. 1. Integration of Experiences with Tasks and Users - ER Diagram (Chen Notation)

2.2 Theoretical Background

In the following we provide the theoretical background to the entities of the EBreMM that are essential for experience breeding, such as Goal, Experience, Level, Task, and Role. We understand a process as a collection of tasks and a user as an employee (human) performing the task (task performer).

Goal. In motivational theory (e.g. [6][7][8]), goals have appeared in various forms. According to the goal-setting theory of [6], goals can be subdivided into *goals set by others*, such as a company, and *self-set goals* (individual goals). In management literature [9][10], various types of organizational goals have been brought up, such as strategic and assigned goals, and which can be interpreted as 'goals set by others'. Self-set goals include, e.g., performance goals and learning goals [7], whereas *self-defining goals* refer to a person's self-definition, e.g. becoming a competent computer scientist [11][7]. There are strong indications that if a task is perceived as relevant for achieving a self-set/self-defining goal, this task will be preferred and better performed. We assume that such goals support motivation. We therefore suggest patterns for self-set/self-defining goals (Section 3) that users can enter into the HC-PAIS. We further assume that typically goals set by the organization and self-set/self-defining goals are partially congruent. An analysis of how goal relationships may affect strategic/tactic planning of organizations is beyond the scope of this paper will be discussed in future work.

Experience. In psychological literature (e.g. [12][13]) *work experience* has been understood as multidimensional and multilevel construct (compare also with [4]). Work experience is collected by a person during the performance of some job in a work setting [13][14][12]. We understand experiences as being formed in daily real-world work settings whereas we consider competencies as being formed in particularly designed training units (e.g. [15] [16] [17]). Requirements to capture information about work experience include: (a) a definition of the domain of interest (e.g. individual employee, groups, organization), (b) the level of experience measurement specificity (e.g. task, job, organization, industry), and (c) experience measurements and functions to define the movement between levels. Task experience has been identified as an important contribution to job knowledge [18] and experience with similar tasks can increase an employee's performance [18][12]. In our work we assume that a process task requires and activates particular experiences and that these experiences can be possessed and increased by a user through performing that task. We also believe that experience can be tiered into levels, and scaled by means of rules.

Level. Levels are used to incorporate goal-based motivation, similar to levels as used in, e.g., role-playing games [19]. Levels are based on a particular measurement concept (rules) and are usually distinguished based on their labeling. There are innumerable ways of labeling experience levels, for example *Basic specialist*, *Senior specialist*, *Expert specialist*, *Very expert specialist*, and *Discipline advisor* [20], *Novice*, *Moderate*, and *Expert* [21], and *Novice*, *Expert*, and *Guru* [22]. As there seems to be no common labeling particularly for experience levels, we used the three levels *Noob* (default level for new users or an experience at a low level), *Valuable* (an experience at a mean level), and *Specialist* (experience at a high level). However, the labels and the number of levels can be individually adjusted by a company. In previous work [4] a collection of experiences measurements was provided that can be supported by a PAIS. We use these measurements for an experience breeding rule which is presented in Section 4.

Task. A task is *'a description of a piece of work that forms one logical step within a process. [...] [It]requires human and/or machine resources(s) to support process execution; where human resource is required an [task] is allocated to a [process performer (user)]'* [23, p. 13]. In [24] tasks are further categorized into different kinds of tasks such as automated tasks, service tasks, and user tasks. In this work we are particularly interested in user tasks which are understood as being performed by a human with the support of a software application [24]. Each task is assigned at least to one role. A task activates at least one experience. If a task has more than one experiences, then it needs to be defined how much percent of the task is occupied by which experience (contribution, see Figure 1). Importance is a value that is composed of a manually set value by a company during design time and a calculation of the critical path during run time. Related to task importance is task priority as presented in [24, p. 167].

Role. In typical PAIS, the concept of roles is used to link users with tasks [25]. There are two approaches for designing roles: From a technology-driven view, roles are a mechanism that associates users to tasks [23][26]. From an enterprise-driven perspective, roles are a mechanism to group users with a specific set of capabilities [23][25]. Our experience breeding concept uses the concept of roles as foundation. Tasks are basically assigned to users by means of roles. However, and to the best of our knowledge, our contribution goes beyond state of the art by considering experience breeding on top of the selection of users according to roles. Consequently, experience breeding can be understood as an extension that fine-tunes role-based allocation of users to tasks.

3 Goals - The Basis for Experience Breeding

In this section we present experience breeding goals which express the users' wishes how to shape their experiences as employees of a company. Allowing the users to actively shape their participation in day-to-day business acts as a strong motivational system. We assume that (a) users' motivation will increase when users can enter goals set by themselves into the system, (b) tasks that are perceived as relevant for the goals will be preferred and better performed by the users, and (c) when the provided tasks are perceived as relevant for the goals, then the satisfaction with experience breeding will increase. The basis for experience breeding is to make users experience breeding goals available for the system. The goals could be, for example, discussed and formulated in annual staff appraisals. In order to simplify the translation between verbalized and machine readable goals, we elaborated a set of goal patterns. These goal patterns are intended to cover a set of wishes, that users may formulate regarding their participation in a PAIS, or more general, in a company. Users should be able to address in their goals:

- Levels of experiences,
- Experiences,
- Experiences in a particular task,
- Experiences in tasks of a particular process,
- Experiences in tasks assigned to a particular role.

Furthermore, users should be able to state in which direction they want to shape their experiences. Hence, the experience breeding goals should support the collection, maintenance and neglection of experiences and their levels. 'Collection' means to breed the particular experience to the next higher level. 'Maintenance' means to keep the current level of the particular experience. 'Neglection' implies to breed the particular experience to the next lower level. To neglect experiences in HC-PAIS means that for the particular user, tasks will be prioritized that do not, or only to a small percentage, include the particular experience. In the case of an experience neglection goal, we assume, that the user's satisfaction with the system using experience breeding will increase, if the tasks that include the particular experience will be provided less often to him.

The five experience goal patterns are presented in the Figures 2, 3, 4, 5, and 6. The theoretical foundation on which the goal patterns are based on is presented in Section 2.2.

Become OR Remain [LEVEL] at [EXPERIENCE] *(optional [UNTIL]).*

Fig. 2. Experience Breeding Goal Pattern 1: Breed Level for Experience

Pattern 1: Breed Level for Experience. The user can formulate an experience breeding goal that directly addresses the desired level of the experience. For example, *'Become SPECIALIST at DEALING WITH CUSTOMERS until 29th June 2014'.* We propose the conversion of the following experience breeding goals into Pattern 1. The advantages of the transformation include an easy identification of contradictions between different goals. Furthermore, if Pattern 1 is explicitly used to formulate a goal, this goal receives the highest priority compared to goals based on the Patterns 2-5. Hence, the patterns allow us to rank the priority of the goals set by a user.

Collect OR Maintain OR Neglect experience with [EXPERIENCE]
(optional [LEVEL] [UNTIL]).

Fig. 3. Experience Breeding Goal Pattern 2: Breed Experience

Pattern 2: Breed Experience. The user can also formulate an experience breeding goal that addresses the experience without explicitly mentioning the desired level but by using the keywords *collect*, *maintain*, and *neglect*. For example, *'Neglect experience with DEALING WITH CUSTOMERS'.*

Collect OR Maintain OR Neglect experiences for task [TASK] *(optional [UNTIL]).*

Fig. 4. Experience Breeding Goal Pattern 3: Breed Experiences for a Task

Pattern 3: Breed experience for a task. As a task is described by means of experiences and contributions representing the percent of the task that the experience occupies (see Section 2), experience breeding goals may also address tasks. For example, *'Collect experiences for task PREPARE QUOTATION'.* The task PREPARE QUOTATION is described by the experiences *Calculating offers*, and *Describing offer details*, which both of them occupy 50% of the task. Hence, the user's current levels of the two experiences will be breeded towards the next higher level.

Pattern 4: Breed experience for a process. An experience breeding goal can also address a process and consequently refer to the experiences of all tasks of a particular process. For example, *Maintain experiences for process SMALL CUSTOMER GARDEN.* Consequently, the user's current levels of all the experiences by which the tasks of the process SMALL CUSTOMER GARDEN are described will be maintained.

Collect OR Maintain OR Neglect experiences for process [PROCESS] *(optional [UNTIL])*.

Fig. 5. Experience Breeding Goal Pattern 4: Breed Experiences for Tasks of a Process

Collect OR Maintain OR Neglect experiences for role [ROLE] *(optional [UNTIL])*.

Fig. 6. Experience Breeding Goal Pattern 5: Breed Experiences for Tasks of a Role

Pattern 5: Breed experience for a role. Although the experience breeding task allocation to users is basically guided by roles, the fine-tuning by considering experience breeding can take place by addressing experiences of roles as well: Roles have dedicated tasks, and tasks are described by means of experiences. Consequently, a goal addressing experiences for a role refers to the experiences of all tasks that are assigned to a particular role. Such an experience breeding goal is relevant for users who, for example, consider to apply for a different role they are currently performing in. For example, *Collect experiences for role MANAGER*. The user will still receive tasks that are assigned to his current role, e.g. the role LANDSCAPE DESIGNER, however, tasks will be prioritized that include experiences of tasks that are dedicated to the desired role MANAGER.

4 Experience Measurement

Central for experience breeding is the measurement of experiences. There have been several experience measurements mentioned in job offers and literature referring to PAIS and psychology research which were collected in our previous work [4]. In this work we want to provide an experience measurement rule that combines quantitative and qualitative experience measurements and that defines when an experience ascends to the next level, maintains at the same level, or descend to the next lower level. We considered four experience measurements:

- *Count* (How often has an experience been collected?),
- *Duration* (How long has an experience been collected?),
- *Importance* (How important was the task performed?), and
- *Quality* (How good was a task performed?).

Figure 7 illustrates the proposed generic experience breeding rule to measure experiences with HC-PAIS. This rule is a mathematical function and supports us to achieve one value for an experience. The above listed four experience measurements are considered as inherent parts of the rule. The weights of each measurement and the operators (such as plus (+) or times (x)) that combine the components of the function can be assigned by the company for each experience. *Count* represents a value which illustrates how often an experience was collected. Each time a task was performed that activates the particular experience, the value is incremented. *Duration* represents values that illustrate how long an experience has been collected. The actual duration of the task performed is used as basis which is multiplied by the percent of the experience to which it is activated in the particular task. *Importance* is a qualitative measurement of experience, it illustrates the type of a task (e.g. [13] [12]). *Quality* represents values that show how good a task was performed. We understand measurements that address the quality of task performance as highly task-related and consequently as highly context sensitive. Quality measurements can be very specific and need to be defined in a department, company or a branch. For example, for the task *writing a research paper* task-result quality measurements could include the type of paper written (journal article, conference article, book chapter), the reputation or impact factor of the outlets, and feedback of the reviewer [4].

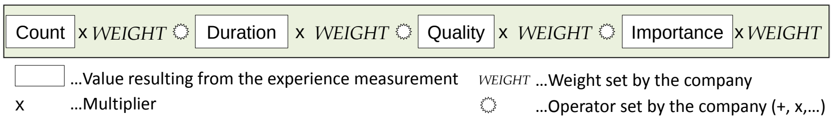

Fig. 7. Generic Experience Breeding Rule for HC-PAIS

In regard to the experience measurement *importance* we suggest the composition of the value of different importance values: the process importance value (e.g. with the weight of 60%), the task instance value (e.g. with the weight of 20%) which need to be manually determined by a company, and an importance value derived from the critical path (e.g. with a weight of 20%). In the case of the example values stated in the round brackets above the process importance value has a stronger influance on the resulting importance value than the task instance value or the value derived from the critical path. As the determination of experience breeding rules may emerge as a sophisticated challenge for companies, we will address this issue in more detail and provide experience breeding rule patterns, simulation methods and evaluation mechanisms in future work.

5 Application Scenario

In this section we illustrate our experience breeding approach by means of processes of a fictive company GARDEN which is specialized on designing and creating gardens for big and small customers.

GARDEN uses a Human-Centric Process-Aware Information System (HC-PAIS) that is based on experience breeding to manage its processes and to support the employees' motivation and satisfaction. GARDEN has one process (with tasks such as T1: Examine location, T2: Check regulations with local authorities) which is illustrated in Figure 8. The company garden has different processes for big and small customers, which share many tasks. Martin, who is employed by GARDEN, performs tasks that belong to both. Overall, GARDEN has nine experiences activated by the tasks of the GARDEN process, as represented top right in Figure 8, such as E1: Calculating offers and E2: Describing offer details.

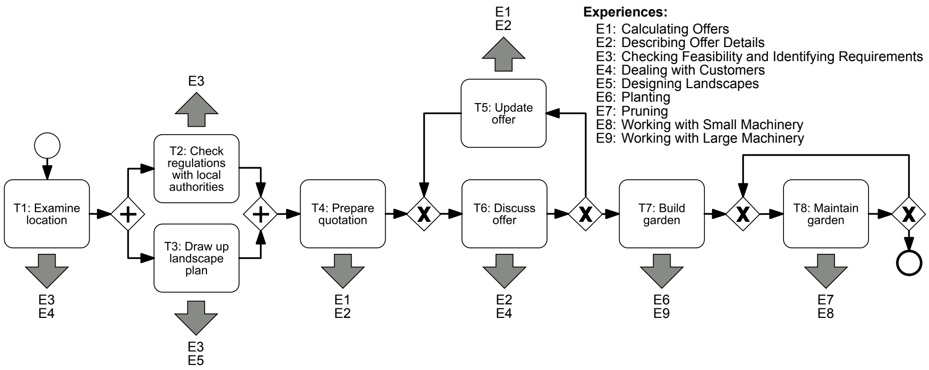

Fig. 8. Abstract process: Design a Garden for a Big Customer

Each experience is integrated with tasks, which is illustrated by means of the gray arrows reaching out of the tasks and pointing at the experiences in Figure 8. The task description is explained in more detail by means of the task *'Draw Up Landscape Plan'* in Figure 9. The task *'Draw Up Landscape Plan'* is described by: (1) The process the task belongs to and a value that indicates the importance of the task (read more about the importance value in Section 4). (2) The role to which the task is assigned to, in this case the task can only be performed by users acting in the role *'Landscape Designer'*. (3) The experiences that are activated by the task. The task *'Draw Up Landscape Plan'*, includes the experiences E3: Checking Feasibility and Identifying Requirements and E5: Designing Landscapes.

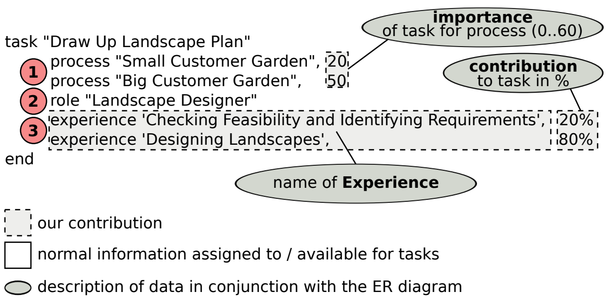

Fig. 9. Integration with Tasks

As illustrated in Figure 10 Martin is *Landscape Designer* (1). There are two further roles defined to perform tasks in GARDEN, the *Manager* and the *Gardener*. Martin has also experiences at particular levels (2), for example he has the level *'Valuable'* at *'Designing Landscapes'*. In GARDEN there are three soaring levels used: *Noob*, the lowest level, *Valuable*, the mean level, and *Specialist*, the top level. Martin has also goals which he has formulated by himself and which he made available to the system (3): For example, he wants to become *Specialist* at the experience *Designing Landscapes*.

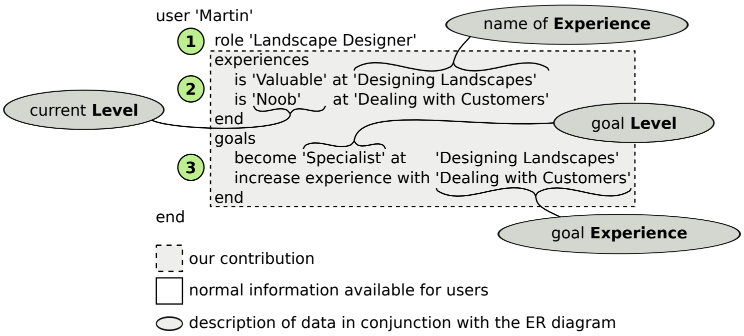

Fig. 10. Integration with Users

For each experience particular measurements, such as count, duration, importance and quality are used and combined to rules that define changes between experience levels (read more in Section 4). Martin performs in his role *Landspace Designer* the task *Draw Up Landscape Plan*. The task activates the experience *Check Feasibility and Identifying Requirements* (see Figure 9). So far, no level for this experience is known for Martin. Therefore, the rule for the default level *Noob* is used, which is illustrated in Figure 11. The rule is composed of the attributes *frequency*, *rating start*, *rating*, and *difference* (1), (see Figure 1). The rule is performed every six months (frequency), and considers the values from six months ago to now (rating start). The rating is composed of the experience measurements described above: Each time a task is performed that activates the experience will increase the value of count (2). The average duration (compare with Figure 11(3)) is calculated for the minimum of the values count, or the last ten invokes of the experience at the most, which will then be subtracted from 30, the value that represents twice the typical duration (60 hours) minus the medium duration (30 hours). Quality is considered by summing up the last ten quality values (4), and the average of the importance of the last 10 tasks is calculated (5). The measurement values are further weighted (e.g. importance is weighted by the factor 0.2) and summed up. While rating represents the current standing of a user given a certain level, *difference* is used to determine if a user can ascend to the next level, or descend a level. The difference in Figure 11 defines an ascend of the level in the case of a value equal or greater 40. Otherwise, the level Noob will maintain, as there is no lower level.

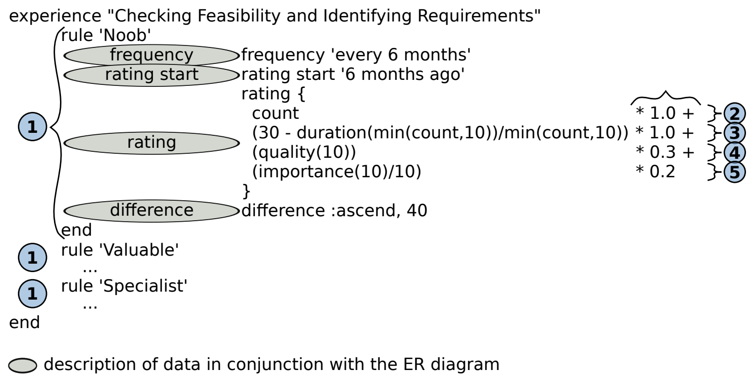

Fig. 11. Experience Measurement Rule

6 Simulation Design and Preliminary Results

In this section, we present a simulation design to evaluate the results of the effects of experience breeding on task allocation to human resources by using synthetic data derived from our fictive company GARDEN application scenario. The scenario of GARDEN has already been described in Section 5. The goal of the simulation is to verify the effectiveness of the concepts introduced in this paper in comparison to more traditional role-based task allocation algorithms.

6.1 Simulation Design

For a simplified simulation of the concepts presented in this paper, we can select the following parameters, and make the following assumptions [1]:

- We allocate tasks to a set of 5 users (see bottom of [1]). All start of with varying experience levels (ranging from Noob to Specialist) as a simulation starting point.
- As shown in Figure 11, the attribute *frequency* typically determines how often *rating* and *difference* are used to determine the level of a user. For this paper we determine the level after each task execution to make the simulation results more comprehensible.
- For the sake of simplicity we assume that all users have the same role. Thus we selected the tasks "Examine Location" and "Draw Up Landscape Plan" from the GARDEN scenario. These tasks contain the experiences E3, E4 and E5 as specified in Figure 8.

[1] for detailed parameters and the full GARDEN scenario see http://cpee.org/EB

- We randomly created 5000 task instances, belonging to either SMALL CUSTOMER GARDEN or BIG CUSTOMER GARDEN (including different importances for both processes). To furthermore express that various instances (customers) of each task have a different importance for the company, an additional value between 0 and 20 was added to 'importance'.

We can furthermore assume the following impact on *duration* and *quality* (see Section 2): (a) a Valuable user is between 10% and 20% better than a Noob user, (b) a Specialist user is between 5% and 10% better than a Valuable user. Please note, that these values have to be tested and evaluated by companies for the real world examples, and may thus differ for different scenarios and experiences. For harnessing the advantages of experiences we used a simple Experience Breeding (EB) algorithm with the following properties:

- If the importance of a task is higher than 60, a Specialist is selected.
- If the importance of a task is between 50 and 60, a Valuable user is selected.
- If the importance of a task is below 50, a Noob user is selected.
- Balance the duration each user is working on tasks (this will lead to slightly more task assignments for Valuable and Specialist users).
- When multiple users of the same level exist, select one with a goal that matches the experiences trained in this task. Equally share the tasks between all users with the same goal.

A good candidate to comparing the above algorithm to is a simple Round Robin (RR) assignment of tasks to users. Please note that for the RR algorithm we also have consider that users move between levels, in order to give a fair comparison. Thus, after running the simulation for EB and RR, it is possible to compare (a) the efficiency of task allocation regarding the duration/quality of tasks execution, and (b) the experience changes compared to the goals of the users.

6.2 Conditions, Preliminary Results, and Lessons learned

The simulation was conducted based on a full implementation of the concepts/data structures presented within this paper.

Conditions of the simulation: Multiple users were able to perform a task and could be rated according to the experience measurement and the goal accomplishment. The simulation was not conducted based on the execution of processes (there is no connection to a workflow engine yet). Tasks were selected randomly out of the set of available tasks. Thus tasks might occur not exactly according to the proportions in the above described GARDEN scenario. In non-simulated scenarios a task's quality/duration could be influenced by preceding tasks in the process. Such effects were not considered by the simulation.

Preliminary results: The preliminary result of the simulation was that Experience Breeding (EB) performed better than Round Robin (RR) due to some predictable reasons. In more detail the simulation showed that:

– EB supported the achievement of the users' experience breeding goals. Thus, EB led to a much more distinguished workforce compared to RR.
– There was a much higher count of Specialists after EB, also due to the consideration of users' experience goals.
– RR supported the cyclic assignment of tasks to users. Hence, Noob users got a higher number of tasks and a longer duration (time of collecting an experience). More Noob users became Valuable users compared to EB.
– The workforce consisted mostly of users with the level 'Valuable' for the experiences after RR. This result can also be explained with the RR's purpose to assign the same number of task instances to each user.

Lessons learned: To represent the motivational effects on the simulation, it can be beneficial to introduce a special factor with impact on quality and duration. This factor is not yet included in the simulation design above, but will be explored in future work to further improve the realism of the design. Also not yet included is the impact of users that work in a process: although each task may be allocated by a single user, the results (quality, duration) can alter properties of subsequent tasks. While some of these effects may be hard to quantify (e.g. higher duration, lower quality due to the results of previous tasks), it will be very well possible to factor in effects of task duration on a critical path, and increase/decrease the importance of a task accordingly.

7 Related Work

We discuss related work to modeling organizational aspects in PAIS, allocation of tasks, and measurement of experience.

Modeling organizational aspects in PAIS. Typically, organizational models are used to define and integrate organizational structures into PAIS [23][26][25]. The description of users is typically based on the concept of roles. Roles are used to link users with tasks [25]. So far, users have been addressed by means of the term 'human resources' in PAIS [27][28][29][30] and have been described by using different terms, such as 'capabilities'[27][28], 'competencies'[31], 'features' [27][28], 'qualifications' [32][33]. According to our previous work we describe users by reference to previous work experience and process work experience [4]. In contrast to competencies, we understand work experience as being developed in real work settings whereas the former we understand as being developed in specially designed training settings.

Allocation of tasks. Existing allocation patterns [27][28], such as capability- and history-based resource allocation, consider work experience as one of the capabilities according to which the assignment of tasks to users can be guided. In the case of capability-based allocation, once such an work experience value has been entered into the system it often remains the same up to a manual update so far. Work experience as a factor for history-based allocation has been considered for identifying the most experienced users. In our work, we do not use the concept of experience exclusively to identify the most experienced user, we rather use integrate experiences into PAIS to support a human-centric task allocation based on individual experience breeding goals of the user.

Measurement of work experience. Experience as capability of users in PAIS has been expressed as simple quantity [27], e.g. least number of failures, or years working in a particular field, or a simple quantity comparison such as 'more executions = more experience' [25][4]). We understand work experience as a multidimensional and multilevel construct with different experience measurements (count, duration, quality, and importance) combined in a function. In [20] an experience index calculation is presented which is based on user (actor) evaluation made by a unit manager. The manager has to subjectively indicate, among others, if an user is able to perform a task or not. In our work we provide an experience measurement concept that considers qualitative and quantitative measurements to avoid subjective ratings. In [31] an ontology-based competency model is presented for integrating competencies into PAIS. Competencies were used to identify competency gaps that can immediately be addressed by specific training. In our work, we consider work experience as a work around of competencies. This means that work experience can only be possessed when a user actually performs a task rather than participates a training unit. We dynamically measure work experience by means of measurements and rules which consequently provide the current values of experience of users in a company. Experience gaps can be easily identified and addressed.

8 Conclusion

In this work we presented experience breeding for Process-Aware Information Systems (PAIS). Our contribution included the Experience Breeding Meta Model (EBreMM) that supports the integration of experiences with tasks and users, five experience breeding goal patterns that support the formulation of user goals within the system, and an abstract experience measurement function that supports companies to individually rule chances between experience levels. We presented our approach by means of an application scenario and provided a simulation design and its preliminary results. In conclusion, experience breeding is particularly fruitful in an organizational environment that fulfills the following requirements:

- The organization uses a Process-Aware Information System (PAIS).
- The organization has several processes.
- The processes include human tasks.
- Users are organized with several roles in the PAIS.
- There is more than one user assigned to a role.
- Tasks of various processes can be allocated to the users (in the broadest sense comparable to, e.g., job rotation).

- Experiences are preliminary identified for users and determined for tasks.
- The organization is willing to use experience breeding.

There are strong indications that experience breeding in PAIS will increase the users' motivation and satisfaction and thus qualify a PAIS towards a HC-PAIS. The main advantages for users working with such a HC-PAIS are: First, users can express their experience breeding goals in the HC-PAIS in natural language and thus influence the allocation of tasks. Second, users can track their progress and extract their individual track record, e.g. in the case of changing the job. Using a HC-PAIS with experience breeding enables enterprises to, e.g. identify and suggest available users for roles in a more objective way by taking into account user's experiences that are reliable and kept up-to-date in the HC-PAIS (e.g. supported by experience measurements and functions), to identify and counteract experience gaps in the pool of available users, and to select special users for special cases (e.g. specialist for escalations).

Our future work will address experience measurement functions, the detailed analysis of goals and mentoring with experience breeding.

References

1. Vanderfeesten, I., Reijers, H.A.: A human-oriented tuning of workflow management systems. In: Proceedings of the 3rd international conference on Business Process Management, Springer (2005) 80–95
2. Kueng, P.: The effects of workflow systems on organizations: A qualitative study. In: Business Process Management. LNCS. Springer (2000)
3. Kabicher-Fuchs, S., Rinderle-Ma, S., Recker, J., Indulska, M., Charoy, F., Christiaanse, R., Dunkl, R., Grambow, G., Kolb, J., Leopold, H., Mendling, J.: Human-centric process-aware information systems (hc-pais). Research Report arXiv:1211.4986 [cs.HC], arXiv (2012)
4. Kabicher-Fuchs, S., Rinderle-Ma, S.: Work experience in pais - concepts, measurements and potentials. In: Advanced Information Systems Engineering. Volume 7328. Springer (2012) 678–694
5. Chen, P.P.S.: The entity-relationship model toward a unified view of data. ACM Trans. Database Syst. **1**(1) (1976) 9–36
6. Locke, E.A., Latham, G.P.: A theory of goal setting and task performance. Prentice-Hall, New York (1990)
7. Brunstein, J.C., Gollwitzer, P.M.: Effects of failure on subsequent performance: The importance of self-defining goals. J. of Personality and Social Psych. **70** (1996)
8. Urdan, T.C., Maehr, M.L.: Beyond a two-goal theory of motivation and achievement: A case for social goals. Review of Educational Research **65**(3) (1995) 213–243
9. Singh, S., Woo, C.: Investigating business-it alignment through multi-disciplinary goal concepts. Requirements Engineering **14** (2009) 177–207
10. Woo, C.: The role of conceptual modeling in managing and changing the business. In: Proceedings of the 30th int. conf. on Conceptual modeling, Springer (2011)
11. Wicklund, R., Gollwitzer, P.: A motivational factor in self-report validity. Psychological perspectives on the self **2** (1983) 67–92
12. Tesluk, E., Jacobs, R.R.: Toward an integrated model of work experience. Personnel Psychology **51**(2) (1998) 321–355

13. Quinones, M., Ford, J.K., Teachout, M.S.: The relationship between work experience and job performance: a conceptual and meta-analytic review. Personnel Psychology **48**(4) (1995) 887–910
14. Rowe, P.M.: The nature of work experience. Canadian Psychology **29**(1) (1988)
15. Tuning Management Committee: Tuning Educational Structures in Europe. (2006)
16. Bennett, N., Dunne, E., Carr, C.: Patterns of core and generic skill provision in higher education. Higher Education **37** (1999) 71–93
17. Commission of the European Communities: Implementing the Community Lisbon Program - Proposal for a Recomm. of the Europ. Parliament and of the Council on the Establishment of the European Qualification Framework for LLL. (2006)
18. Littlepage, G., Robison, W., Reddington, K.: Effects of task experience and group experience on group performance, member ability, and recognition of expertise. Organizational Behavior and Human Decision Processes **69**(2) (1997) 133–147
19. von Ahn, L., Dabbish, L.: Designing games with a purpose. Communications of the ACM **51**(8) (2008) 58–67
20. Corallo, A., Lazoi, M., Margherita, A., Scalvenzi, M.: Optimizing competence management processes: A case study in the aerospace industry. Business Process Management Journal **16**(2) (2007) 297–314
21. Maloor, P., Chai, J.: Dynamic user level and utility measurement for adaptive dialog in a help-desk system. In: Proceedings of the 1st SIGdial workshop on Discourse and dialogue, Association for Computational Linguistics (2000) 94–101
22. Papadopoulos, G., Fakas, G.: Component-based development of dynamic workflow systems using the coordination paradigm. In: Parallel Computing Technologies. Volume 2763. Springer (2003) 304–315
23. Workflow Management Coalition Specification, .: Workflow Management Coalition, Terminology and Glossary. Workflow Management Coalition Specification (1999)
24. OMG: Business process model and notation (BPMN) version 2.0. OMG Document formal/2011-01-03, OMG (2011)
25. Zur Muehlen, M.: Organizational management in workflow applications issues and perspectives. Inf. Technol. and Management **5** (2004) 271–291
26. Zur Muehlen, M.: Resource modeling in workflow applications. In: Workflow Management Conference. (1999) 137–153
27. Russel, N., ter Hofstede, A., Edmond, D., van der Aalst, W.: Workflow resource patterns. Technical report, Eindhoven University of Technology (2004)
28. Russell, N., Hofstede, A.H.M.T., Edmond, D.: Workflow resource patterns: Identification, representation and tool support. In: Advanced Information Systems Engineering. LNCS (2005) 216–232
29. Dumas, M., van der Aalst, W., ter Hofstede, A., eds.: Process-Aware Information Systems : Bridging People and Software through Process Technology. Wiley-Interscience (2005)
30. Ouyang, C., Wynn, M.T., Fidge, C., ter Hofstede, A.H., Kuhr, J.C.: Modelling complex resource requirements in business process management systems. In: 21st Australasian Conf. on Information Systems, ACIS (2010)
31. Macris, A., Papadimitriou, E., Vassilacopoulos, G.: An ontology-based competency model for workflow activity assignment policies. Journal of Knowledge Management **12**(6) (2008) 72–88
32. Russell, N.C.: Foundations of process-aware information systems. PhD thesis, Queensland University of Technology (2007)
33. Hall, J.: D2.1 visp workflow technologies - functional analysis and comparison. Technical report, Project no. FP6-027178 (2006)