Dynamic Coupling of Learning with Operational Processes

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ABSTRACT

Volatile environments, such as today's digital eco systems, require dynamically adaptable infrastructures and technologies. In order to keep up with ongoing developments, stakeholder operation can benefit from enriching processes with features for effective capacity building. Consequently, learning technologies need to be coupled with workflow components when required. We propose a corresponding architecture and development approach. Design and execution are message-driven, and enable dynamic coupling of interoperable interaction and workflow components. We demonstrate the intertwining, and exemplify essential benefits, including aligned cognitive and social capacity building. Stakeholders can continue social media interaction they are familiar to, while learning to advance in managing their business processes.

CCS CONCEPTS

• **Software and its engineering-Software creation and management;** • **Software and its engineering-Designing software;** • **Human-centered computing-Human computer interaction (HCI);**

KEYWORDS

Learning Support, Capacity Building, Business Process Management, Organizational Learning

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1 INTRODUCTION

Business process environments become increasingly volatile with knowledge needed to proceed at speedy pace, which challenge the absorptive capacities of organizations and individuals [1]. [2]. Absorptive capacities are the company's abilities to "recognize the

value of new information, assimilate it, and apply it to commercial ends" [3]. Organizational learning processes behind absorptive capacities are inherently dynamic and linked to the company's environment [2]. In a volatile business and societal environment as we experience now, continuous adaptations are required to preserve and extend existing absorptive capacities. Due to this high dynamicity, handling and managing the business operation and the processing of knowledge becomes a tedious job for organizations, resulting into degrading the overall effectivity and productivity of the system. The need of flexible, but still effective architectures arises, which can increase the performance of disseminating knowledge in organizations to support the company's absorptive capacities. Effective operational support needs to provide relevant information to the right people at right time with respect to task accomplishment and individual/ organizational learning [4]–[6]. Recently, system development has been put into context considering current requirements, in order to accustom business organizations to continuous development [7].

Continuous business development requires continuous interdependency between business and dynamic operation development. We propose continuous process design through integrated organizational learning. The goal of this work is to provide a methodological and technological foundation recognizing the need for dynamic enrichment of operational business processes with learning features to support organizational development. We ground our work on a need-driven and integrated life cycle for enriching processes dynamically with learning support features (see fig. 1). An architecture enabling dynamic business operations requires structured procedures. With respect to knowledge deployment, we follow Nissen et al.'s [8] proposal of a lifecycle model, including creating, organizing, formalizing, distributing, applying, and evolving knowledge. Figure 1 reveals the phases (P1 – P4) an organization needs to follow when developing its knowledge base on business processes or stakeholder needs. We use it as an operational frame for coupling learning support features to workflows on demand.

The lifecycle, coupling operational workflows with learning processes, starts with the identification of needs (P1). Then, the demand is specified (P2) and represented as model which is stored in a dedicated repository aligned to process-organizing mechanisms. Implementing (P3) and operating (P4) process models subsequently, provides specific support for business operations and allows for introducing monitoring measures. When adaptation is required, process models can be utilized by accessing the process repository. Finally, the coupling is applied, and further evolved into new demands. It also leads to further knowledge creation and completing the lifecycle. For representing systems we use an actor-specific

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Figure 1: Adaption life cycle - managing change.

behavior abstraction: subject-orientation. It seeks to assist system development by encapsulating behavior-relevant information in a way analogous to natural systems' behavior, namely existing in parallel, and exchanging messages in an asynchronous way. Such behavior encapsulations are termed subjects. They represent human actors as well as technical systems, as they are abstraction from the actual organizational and technical implementation in a specific organizational setting or technical environment.

Besides representing functional tasks they are performing in business environments, such as preparing a report, their communication and exchange of data or business objects is captured explicitly in subject-oriented representation schemes [9]. Such a bipartite approach comes close to the reality as perceived by stakeholders, and thus allows them engaging more effectively in adapting technology to their needs [10], [11], including the automated execution of models. The latter allows stakeholders to experience operational behavior in a transparent way (cf. [12]).

When coupling learning processes to business operation, individual stakeholders should be able to identify their learning needs. Their workflows need to be enriched with learning features according to their individual capacity building requirements. This allows the stakeholders to individualize the workflows based on their needs providing more flexibility compared to a standardized workflow. Hereby, subject-oriented modeling and automated model execution enable dynamic adaptation, as the interaction with other actors remains untouched with respect to operational tasks. Learning-management functions can be established the same way, thus, facilitating self-organized adaptation of workflows with learning support features.

The paper is organized as follows. Section 2 provides existing research related to develop learning support in changing work environments and adaptive workflow management. We approach the situation from both sides, the stakeholder and the technology perspective. Consequently, section 2 also discusses the various approaches implementing multi-actor systems for dynamic adaptation based on stakeholder needs. Section 3 introduces an exemplary organizational development scenario and workflow-related learning needs. The introduced architecture of our approach is instantiated in section 4, including an effective user interface design for social and cognitive support when a learning process occurs along a specific workflow. In Section 5, we conclude with the distinct features of our approach, and sketching future research.

2 RELATED WORK

Few studies on the active design of dynamically coupling of business and education processes exist and thus, the embodiment of learning management systems into operational workflows still needs research. In Subsection 2.1, we review learning support with respect to identifying needs and specifying changes of work processes, revealing the organizational, social and cognitive aspects of capacity building. In Subsection 2.2, we review related work with respect to adapt workflows to stakeholder needs, and couple workflow systems with learning support features.

2.1 Learning in Dynamic Work Settings

Stakeholders have to elaborate on their work processes [13], [14], rather than being qualified to adapt [15]. The more stakeholders are informed about their organization of work, the more they become connected personally to their performance, and finally, willing to change [16]. It has been observed that people react to situations based on context rather than fixed behavior patterns, such as process specifications they need to follow [17]. Hence, even roles as functional or social entities evolve over time [18]. Stakeholders may change roles dynamically, driven by their personal identities triggering their behavior [19]. Such observations manifest individuals as self-regulated subjects. As such, they decide according to the construction of their reality on goals and the arrangement of activities. Based on their conscious reflection they learn to select from a variety of options to act, and finally, to solve problems [20].

Capturing work processes nevertheless is considered crucial to organizations in that respective artifacts (e.g., process models) not only serve documentation and communication purposes, but also are important to (continuous) improvement processes as well as adaptations and therefore organizational learning [21]. The representation of work processes in which persons occupy active parts (e.g., perform tasks which cannot be automated by a machine or software), however, requires considering actors and roles not only in the model but also during modeling and elicitation [20]. This particularly is relevant in the context of socio-technical systems and allows transferring human experiences as well as ideas into future process models [21].

Capturing stakeholder work knowledge and change encoded work patterns requires a context-sensitive approach to organizational learning and change processes (cf. [22], [23]). Hereby, modeling in a natural and intuitive way should potentially have greater accuracy than what could traditionally be achieved with common acquisition and analysis techniques [24]. Reducing the requirement of involving external people enables a wider scope of application, as more stakeholders could participate in organizational change and development. In contrast to explicit elicitation techniques, such as interviews, stakeholders need not rely on information provided by analysts. In settings involving external people, such as for interviewing, it cannot be assumed that analysts are familiar with the field [25]. Moreover, stakeholders, in particular experts, forget tasks to mention they assume to be widely known, or have difficulties explaining what they do without actually doing it [26], as knowledge is inseparable from doing [27]. The acquisition of work-relevant needs might include leveraging tacit or implicit knowledge [28]. Explicit knowledge is already documented information whereas

implicit knowledge is not available in documented form. It resides in people, and can be elicited to explain the rationale of behaviors or processes. Even if the elicitation of implicit knowledge is considered and supported by respective modeling methods, future conditions oftentimes are not predictable and therefore cannot be represented explicitly in the model [29]. According to [29], this may be a result of the situatedness of information which inherently cannot be represented *ex ante* to the actual occurrence (i.e., process instance).

While process management systems particularly focus on workflow execution (i.e., following a strictly prescribed sequence of tasks), learning management systems (LMS) offer high flexibility through demand-based orchestration of features [30]. Although two distinct approaches, both system types pursue similar objectives in the context of organizational development (e.g., improving cycle times in production processes or aligning business operations according to market needs). However, few studies exist investigating potential benefits when following an integrative perspective considering both, workflow execution, and organizational learning. Most studies on intertwining organizational and technical system design focus on the adoption of IT systems [31] rather than on organizational design involving human-centered work models and semantic process analysis [32]. However, recent studies, e.g., [33], have revealed the dynamics of organizational development and learning. Whatever triggers or initiates changes in a work organization seems to have an impact on the way people learn and acquire skills. Hence, besides the way work is organized and supported by technology, the dynamic assignment of learning features seems to depend on the trigger of learning processes (*ibid.*).

These triggers are dominated either by the skill space or the organizational space, depending on how an organization actually designs its work processes. According to [34] workers could either be forced to adapt to certain ways to accomplish tasks, in case an organization defines jobs according to its own criteria and process designs. In this case, the organizational space triggers learning, e.g., a person needs to be educated in a way fitting to pre-defined organizational structure, i.e., according to job profiles. An organization could also (re-)define itself based on existing qualifications and capabilities of its workforce at hand. In this case, the skill space determines learning needs and space. Overall, digital learning support requires a set of distinct features [35] referring to the way of learning, content or learning material, social interaction, and technology:

Authentic Learning Tasks: In order to get employees actively involved in knowledge construction, learning activities should focus on realistic, intrinsically motivating problems, e.g., being situated in the actual work environment of the employee. It represents the proper context for concrete application of acquired knowledge.

- **Support of Construction:** As employees are qualified for informed task accomplishment, they should be able to construct knowledge actively (rather than consume information) through their interactions with the environment, based on their prior knowledge and work experience.
- **Reference to Cognitive Skills:** In order to be useful for problem solving, knowledge and learning processes need to be related to cognitive work skills employees need to acquire,

e.g., reasoning on the basis of market data/developments, building analogies for product development.

- **Collaboration:** As work processes are part of an organization, and thus community, leaning occurs in social settings. Besides discussions, Q&A, and traditional information sharing, social media have become integral part of learning processes. Both, the interaction with peers, facilitators, and, experts can be enabled by digital support environments.
- **Information Technology:** Learning environments need to capture material for learning, content management, social media, and process support, including self-management and individualization, e.g., through specifying learning contracts, learning project negotiations, annotations, or Community of Practice (CoP) support where people in a shared domain gather in groups and engage in collective learning processes.

Consequently, knowledge generation has to be understood as individual(ized) construction process occurring in a social setting enabling constructive interaction with peers and facilitators ([36], [37]). This interaction needs to be context-aware as various stakeholders need to be kept aware or informed of the process or certain objects [38]. The process of maintaining awareness has to be grounded on a systematic, while dynamic basis [39].

2.2 Informed Adaptation of Work Processes

Once digital process support tools not only provide a notation for modeling work, but rather link modeling with execution, dynamic adaptation of processes is enabled. Approaches, such as FRODO [40], interleave modeling and execution of knowledge-intense processes. In addition, approaches featuring emergence allow dynamic development of semantic process representations. For instance, [41] use (business) artifacts to combine data and process as basic building blocks of modeling. Artifacts are key business entities (business-relevant objects) which evolve when passing through a business's operation. Various stakeholders can create, modify, and store them. As a result, business operations can be decomposed along various levels of abstraction. Artifacts are typed using both, an information model for data about the business objects during their lifetime, and a lifecycle model, describing the possible ways and timings that tasks can be invoked on these objects.

[42] developed a scalable, distributed and dynamic workflow system for digitization processes, whereby the workflow system leverages a message-routing framework to create dynamic workflow paths. This approach ensures a loose coupling of the application's integral parts while focusing on modularity and extensibility. The workflow system is entirely coded in Java and comprises a client- and a server-application. They communicate in a solely event-driven, asynchronous fashion. Events are passed using a simple text-message format, in order to comply with the JMS 7 standard. The authors use the Apache Camel framework (supporting most of the Enterprise Integration Patterns), in order to abstract from the message layer. This abstraction enables creating complex, dynamic message routing between different parts of the application. Such an architecture guarantees application responsiveness, stability, and a loose coupling of all integral parts. Workflow adaptation is based on the analysis on incoming documents, representing business objects. The workflow system features a variety of analysis

modules, capable of checking the digitization project for errors, extracting / augmenting information or processing the image data. Each module is a valid endpoint for the message-based communication within the workflow. This procedure allows creating dynamic processing chains involving a specific subset of analysis modules routes on-the-fly.

Actor-oriented approaches have been introduced in context-aware workflow management, relating to virtual enterprise design. [4] adopted Multi-Agent Systems (MAS) to capture the coordination and workflows of different entities accomplishing work tasks. Thereby, an agent is considered as autonomous, co-operative, and intelligent entity collaborating with other agents to process work tasks. The loosely coupled structure of agents enable manufacturing systems to be adapted when required while caring about the efficient use of available resources. Design requirements for those systems are:

- Context awareness, taking into account individual competencies, mobility and preferences of each worker, along with the competency requirements associated with each assembly activity, with respect to both the current master assembly schedule and the line balancing for each product.
- Runtime adaptation, i.e., a solution that increases system integration, openness, flexibility, and extensibility, all without having to restart a running distributed system, ensuring smart and dynamic composition of the services on the factory floor.

As the objective of these systems is to effectively support workflow management when operating a business, such that the cost can be minimized, and the time constraint for completing a task can be satisfied, so far, dynamic coupling workflows with learning support features or components in a stakeholder-centered way, to the best of our knowledge, has not been addressed explicitly. However, several approaches to that direction exist, as reported in the following.

[4] designed a networked organization able to handle (order) requests and deliver the relevant information to the right people in the organization at the right time. The networked organization is formed dynamically based on the capabilities and the workflows of individual participants in the organization. Each participant has a certain functional role to deliver information in the networked organization accurately. The context-aware application development environment for virtual organizations was based on JADE (Java Agent Development Environment) and supported two stages for accurate information provision: negotiation and user interface generation.

In the negotiation stage, the set of agents in virtual organizations apply a multi-level contract net protocol to form a networked organization. Negotiation relies on an infrastructure for individual agents to publish and discover their services. An agent searches the yellow page for the desired services provided by the upstream agents and then negotiates with the discovered agents by applying the contract net protocol to form a networked organization. After finishing the negotiation stage, the user interface generation stage dynamically generates the context-aware user interface based on the networked organization formed and the state visited. The list of actions for a user is generated based on the system state. Finally,

a context-aware user interface generation program is developed to generate the user interface based on the list of actions.

[43] address the modification of business processes, involving the operational environment, variability of resources, and stakeholder needs. In order to implement this type of multiple context awareness and thus, dynamically adapt to changes for workflow management they propose holonic multi-agent systems. These systems provide a flexible and reconfigurable architecture allowing to dynamically compose relevant services and adapt to changes as needed. The authors propose an interaction mechanism based on the contract net protocol (CNP) to compose the services based on holonic multi-agent systems. The interaction mechanism relies on a service publication and discovery scheme to find a set of so-called task agents and a set of so-called actor agents to compose the required services in the holonic multi-agent system. The changes in workflow and in the capabilities of actors are realized by a self-adaptation scheme and a corresponding architecture to reconfigure the agents and the composed services based on cooperation of agents in holonic multi-agent systems.

In the area of the Internet of Things [44] also addressed dynamic service composition, since such applications comprise physical and virtual objects. Cyber-physical systems enable the connection of such objects for further use in an Internet-like structure. When services are dynamically identified and composed in these systems, they may possess different requirements. It can become challenging to determine suitable services to be a part of a workflow. Compliance of such requirements, reflecting trust-based decision of a service to join a workflow, plays a significant role in the success of service interoperation. The authors have developed a compliance checking algorithms for service workflow specification and a service-workflow net to support trust-based decision for service workflow participation. A prototype has been implemented to evaluate the performance of the proposed algorithms. Hence, requirements can be fully and automatically verified by a running / implemented workflow.

The service workflow net is used for workflow modeling and requirements. The latter are expressed by service workflow specifications. The authors propose three categories for workflow specification: composite, path, and direction. As the service workflow net can be transformed into a finite state machine, it can be verified against path and direction operators. The conducted experiments to evaluate the performance of these algorithms showed that when a large number of services are involved, the proposed algorithms, on average, can operate with an acceptable execution time.

[45] took a step closer to stakeholder behavior. When operationalizing care delivery through an interdisciplinary healthcare team they elicited knowledge about the overall structure of the team and the behavioral rules that ‘control’ the dynamics of this structure. Focusing on the behavioral aspects of the team associated with its dynamics, the authors proposed an extended Team and Workflow Management Framework. It contains a set of rules to operationalize team behavior, namely in terms of clinical leadership, coordination of workflow execution over multiple days as part of continuity of care, and management of tasks, including urgent ones that hinder execution of the planned workflow. The authors provide a proof-of-concept implementation supporting cooperative execution of clinical workflows by an interdisciplinary healthcare

team. The system is built on top of an existing business workflow execution engine, and employs behavioral rules to control the interdisciplinary health team behavior. In the course of the study, [45] found out that the crucial element of stakeholder support in workflow design is a defined structure together with a set of behaviors that actually describe how the stakeholders, in their case members of the interdisciplinary healthcare team, operate. Behavior specifications need to go beyond generic design patterns to represent work situations in a semantically correct way, and to detail the step of task allocation to various stakeholders, in particular for flexible task assignments in critical workflows. When care delivery may take several days and consequently, work tasks and/or management responsibility may need to be transferred to different team members. The authors of the study related their research to manage urgent tasks that may occur dynamically and cause issues in routine workflow execution rather than educational or skill needs. In their work, they were striving towards continuity of care. However, when developing their team description, they found out that a specification language needs to go beyond business process modeling, and allow context-relevant characteristics of (healthcare team) work to be represented. Concluding,

- A Stakeholder-centered perspective is required on both, work and learning processes, otherwise stakeholders will not be able to identify the entry point for learning support in operational workflows.
- Dynamic coupling goes beyond organizational charts and functional role descriptions. It can be realized using behavior encapsulation rather than structural change.
- Continuous improvement processes and adaptations are not yet fully aligned with educational and development needs. So far dynamic adaptations are realized only on an implementation level using dynamic service composition and requirements validation.
- Methodological and technological foundations need to be defined for dynamic coupling of workflows with learning support features from a stakeholder perspective.

Although dynamic adaptation is well established in BPM research, an integrated approach addressing the dynamic and stakeholder-specific coupling of learning support and workflow execution has not been presented.

In the following we propose a concept and system facilitating situation-specific work and learning support by combining structured workflow execution and the flexible orchestration of learning features for specific stakeholder groups. Volatile work environments and learning contexts can be combined ad-hoc.

3 DYNAMIC COUPLING

First, we provide an example illustrating our concept. It stems from the communication provision industry. Following, we deal with the identification of needs and the intertwining concept on social media integration. Finally, we demonstrate the intertwined workflow in the context of the learning management system “Ueber Learn”.

3.1 A Case

In today’s highly contested markets involving the customers through feedback and suggestion, management has become an

Figure 2: Social Media based feedback management.

essential aspect of the product and service development life cycle. Social media platforms enable both the customer and the service or product provider a straightforward possibility to give or receive feedback. The company described in this use case scenario made the transition from an entirely internal innovation process to a customer feedback improvement and innovation strategy. The company relies on its Facebook page as the main source for customer feedback. For managing the social media customer feedback a dedicated position, the social media Feedback Manager, has been created in the organization responsible for screening posts and selecting relevant feedback for further consideration. Once a suggestion (in the form of a post) has been identified as relevant the suggestion is passed on to the internal Innovation Board. This step maps to the need identification phase of the adaption life cycles. The Innovation Board is not a static team but is assembled by the Feedback Manager based on the content of the suggestion and the mentioned product or service. This dynamic team composition allows addressing each suggestion in an informed and targeted manner. After a suggestion has been passed to the Innovation Team, the team discusses whether to pursue the idea and start an internal project addressing the necessary developments to improve the product or service accordingly. Although the innovation process based on the customer suggestion itself is completely internal, the company tries to keep the customers updated with plans, ideas, and results of the innovation process. For this information flow from the company to the customer, the social media platform is used in compliance with the company’s information sharing policies.

An exemplary instance of this innovation process could be triggered by a post on the company’s Facebook page complaining about slow response times of the technical help center. The Feedback Manager identifies this complaint as relevant for being addressed in the innovation and improvement process and notifies the relevant employees in order to form the Innovation Board for this case. In the Innovation Board the following role carriers are present: head of the service and helpdesk department, lead technician who is contacted when the helpdesk is contacted with more complicated problems, and the process owners of the corresponding processes. The Innovation Board decides, after discussing the relevant aspects and dimensions of the issue, on planning and starting a larger-scale process redesign project to improve the service processes. The Feedback Manager notifies the customer of this new project and keeps all stakeholders updated on the project status via the Facebook page.

Figure 3: Project-based learning.

For the project itself, a separate team is assembled. Furthermore, all relevant customer inputs and results of the Innovation Board are documented and made accessible for the project team. Based on this simplified scenario the proposed coupling of learning support systems with workflow execution will be shown.

3.2 Handling Learner Needs

Following the integrated adaptation lifecycle introduced in Section 1, the company requires appropriate feedback management supporting the identification of learning needs during business operation. In the context of the given usage scenario, social media channels (i.e., Facebook) need to be integrated seamlessly into the respective feedback management workflows allowing for further processing headed by a dedicated social media Feedback Manager. The Feedback Manager, however, might not be qualified in all respects to decide whether a particular posting (complaint or suggestion) needs to be considered as business critical in terms of a specific product or service. For this purpose, the Feedback Manager needs to be supported in decision making processes aside the official communication channel, i.e., the Facebook page. A task force may be created for this purpose to collaboratively come to a decision, either defining appropriate follow-up procedures or assessing the issue as irrelevant for being pursued immediately (cf. Figure 2).

In order to keep customers up to date during decision making processes, the Feedback Manager needs to be able to respond to original postings by leaving the task forces' internal interaction spaces. Specifically, this means that bidirectional communication via social media is required allowing the creation of postings on Facebook based on internal content and discussion contributions. Once the task force has decided to continue working on a specific complaint or suggestion, a dedicated workspace providing a more powerful set of (learning / collaboration) features needs to be created. This marks the transition from the first step in the integrated adaptation lifecycle (need identification) to the specification of respective learnings, e.g., reflected in adapted business processes or improved products. Workspaces are the central starting point for learning and collaboration activities. Therefore, it not only needs to support static content provision, but is required to facilitate and foster individualized and collaborative knowledge creation while drawing on existing learning artifacts developed and organized during previous projects.

Since projects are set up based on specific complaints or suggestions, the authenticity of learning tasks is given on the basis of these circumstances, representing the context for concrete applications. Figure 3 shows the direct link between a project's workspace and its starting point, which is represented by the original interaction thread. Both, content authoring and collaboration feature need to be consolidated in the context of a workspace, allowing for the active construction of knowledge rather than passively consuming information.

3.3 Adaptive Learning Support

The proposed framework follows a service-oriented design approach, where each service runs autonomously being able to provide its functionality to other services registered on the framework. From a technological perspective, a Scala-based implementation of the Actor Model (Akka) is used to provide the required capacities in terms of encapsulating and distributing feature sets. The linking among services is based on messages, which are dispatched by a dedicated routing mechanism. By this means, request patterns involving multiple services can be resolved automatically.

Behavior encapsulation is enabled through the proposed architecture. Specific implementation details of services are encapsulated and made available only on an abstract level (i.e., messages). Specific wrapper classes can be used to make the service accessible by means of specific technologies or protocols, such as HTTP. As illustrated in Section 2.1, digital learning support requires a set of distinct features, referring to the support of specific learning styles, the management of content and learning materials, as well as social interaction and collaboration. Based on these categories, a specific service arrangement (i.e., a set of autonomous services) is proposed using the framework presented above. Particularly, services dedicated to the management of content and learning materials (resources and documents), interactions, and projects are defined.

- **Resources.** The resource service allows the management of static resources. This includes uploading new resources from the local file system as well as managing, both, basic properties (e.g., name of the resource) and different versions. Resources in particular support the individual construction of knowledge and provide the basis for future collaboration.
- **Documents.** The document service allows managing interactive documents. It not only supports the individual construction of knowledge, but also provides a powerful set of features in terms of collaboration (e.g., annotation management, linking other document parts or discussion contributions). Resources which are used in documents, such as images, are automatically extracted in order to be manageable by the resource service.
- **Interactions.** The interaction service supports managing interactions each of which may involve multiple users discussing particular topics, questions, or issues. Interaction spaces can be flexibly configured (e.g., discussion groups, etc.) to serve the needs of a specific subject for discussion. Since interactions use the document service to represent content, the respective contributions become automatically available to other interactions as well as documents, the

Figure 4: Deployment scenario for dynamic coupling workflows.

latter allowing for the composition or enrichment of documents. Resources used in the context of a specific interaction (e.g., as part of a posting) are automatically extracted in order to be manageable by the sources service.

- **Projects.** The project service represents the most sophisticated service as it combines the other services for the purpose of project management support. It not only allows managing projects, but supports project work by means of documents, resources, and interactions. Specifically, projects allow managing documents, resources, and interactions in the course of project work. Interactions, for instance, may be used as means to structure discussions among users. Resources used throughout a specific discussion, however, are not isolated from its original context but can be made available to users associated with the project or even to users associated with other projects. The same holds true for documents and resources as well. Projects therefore provide a unified structure which not only support cognitive skill development and knowledge construction, but also collaboration aligned with learning objectives in the context of authentic tasks.

Since the proposed framework focuses on defining and providing functional units (i.e., services), the accessibility in terms of graphical user interfaces needs to be provided by separate applications. Although requiring additional development effort, user experience increases as being able to develop and operate multiple applications aligned to specific usage scenarios. Figure 4 shows the deployment scenario used for dynamically coupling learning support features with workflows. The proposed framework is represented by the integrative repository and interoperability platform which particularly is used for interconnecting the available services (e.g., interaction and document service).

3.4 Dynamic Execution

For the specification of executable structured procedures, a workflow model is required. As stated, people tend to react on a certain situation based on its context rather than according to a predefined procedure. In a company’s organization of work standardized procedures are nonetheless a requirement. The approach introduced in this paper tries to enable flexibility in terms of ad hoc coupling between learning support systems and supporting workflows while still offering structured workflows.

Relying on the service-based architecture, the workflow engine interpreting workflow specifications has been implemented as a separate service providing the workflow functionalities to other services registered at the Aeolion middleware. The workflow engine is not only responsible for executing the workflow specifications. It also offers additional functions related to the workflow models. UeberFlow can display the current state of each running instance in real-time and visualize which activities of the process model have already been finished. Accordingly, an important part of the meta-model and the engine implementation is the functionality to coordinate the interplay of Aeolion services and features. This requires that certain constraints can be set to limit the access of certain features or services for some users based on their roles or the current instance data. UeberFlow supports both approaches to limit the use of services and features from the workflow perspective.

For interacting with the Aeolion platform and external systems and including web service into the workflow a dedicated element in the meta-model used for describing the workflow models has been created (a detailed description of the meta-model can be found in [46]). This allows leaving the defined workflow sequence of the process specification and triggering an external Rest API. The workflow engine allows halting the execution of the process or a process path right after the call and waiting for a result or for continuing execution and waiting for the result at a different point of the workflow sequence. The result can be provided to the workflow instance again as a REST call. The expected data structure is defined as JSON. Being able to define “exit” points which allow exiting the workflow execution and “re-enter” it on defined points in the workflow sequence facilitates a higher flexibility in process execution. Only the minimal requirements of task sequences and data exchange are specified in the workflow. Segments of the workflow, in particular where flexibility regarding the creation of results or data sets is required, can be realized using the described mechanism. The only statically defined aspects are the exit point of the workflow and the re-entry point in combination with the expected data. How the required data was created, and which users, systems, and services are used, can entirely be decided on an instance-by-instance basis.

In this context, Ueber Learn represents the learning support platform using Ueber Flow as workflow engine for process execution. Ueber Learn is a Web-based application supporting project-based learning with the aid of workflows. It has been developed in the context of the given case using the Aeolion framework.

Following a project-based learning approach, each user can access available projects from the dashboard view (cf. Figure 5). The Feedback Manager and all potential members of the work force or the Innovation Board, e.g., can access the project which is used to

Figure 5: General dashboard view: List of available projects.

Figure 6: A project's interactions view including Facebook integration.

organize and manage the Social Media feedback channel (i.e., Facebook). All other users, such as potential project members associated with other departments within the company, may only have access to designated projects in which their specific expertise is required.

Once a user accesses a specific project, detailed project information (i.e., dashboard, materials and documents, interactions, and settings) is available and accessible by means of the main menu on the top of the application. Navigating to the interactions view (team symbol), the user can access all interactions in which he or she is involved as a participant (cf. Figure 6). Discussion threads available on Facebook are integrated and are available by the menu on the left hand side as well. For instance, the Feedback Manager, may access the respective Facebook discussion thread in order to monitor and assess postings with respect to their relevance for being further pursued in the course of an internal project. Using the functions provided for each post, the Feedback Manager can then share the complaint or suggestion with the Innovation Board by either creating a new interaction space or using an existing one.

During project work, the materials view can be used to structure and organize all content relevant to the project (cf. Figure 7). Both,

interactive documents and static resources can be used for learning and may be imported from other projects or created in the course of the project by the involved users. The collected content part finally allows managing a list of postings which are considered relevant aside the original context, specifically, the interaction in which it has been posted originally.

3.5 Taking a System(ic) Perspective

Combining the scenario described in Section 3 with the introduced enabling technology allows describing the use case from a system perspective. Such a perspective allows illustrating the interplay of the different components and how they are used to meet the requirements stemming from the use case. Figure 8 provides an overview of how the components interact based on an exemplary workflow. The workflow is encapsulated according to the subject-oriented modeling approach [9-11]. In this context, the involved components exchange messages to specify the discussed workflow.

The post is processed by the Facebook service and made available in Ueber Learn via the coupling mechanism provided by the Aeolion middleware. The Ueber Learn platform is the central point

Figure 7: A project's content view: Materials and documents.

of interaction for the Feedback Manager. Here, all communications, internal as well as external via Facebook, are bundled and presented in a consistent manner. By identifying a customer suggestion as relevant for the internal organization development, the underlying innovation processes encoded in the workflow engine is triggered. The event triggering/starting the workflow execution is routed via the Aeolion middleware.

Now the workflow engine uses the features currently available in the platform to create the working environment for the Innovation Board as defined and prompts the Feedback Manager to assemble the Innovation Team. After having selected the required employees for handling this specific request, the workflow engine again takes care of the information and invitation process of the selected employees. By agreeing to join the Innovation Board, the newly assigned members are automatically granted access to the interaction area where the suggestion and ideas can be discussed. After entering a decision for creating an innovation project based on this idea, the workflow engine again is triggered to take care of the structured project setup as defined by the organization's guidelines.

Referring to Figure 2, the phase of interaction and discussion is an example for an underspecified task which cannot be handled in a strictly predefined way. How decisions are made, which documents and results are created in this process and even which collaboration tools are used cannot be predefined since it will differ from case to case. Therefore, at this point in the workflow only a "re-entry" point using the functionality has been created, stating that a decision (with a given set of required information) must be made in order to proceed in the innovation process. At no point in the workflow specification it is specified how this decision has to be made.

4 CONCLUSION

Today's business operations require embodying learning capabilities into workflows, in both, an effective and efficient way. Effectiveness of enriching workflows with learning support features is given, once the position of learning intervention, i.e., the task context, can be clearly identified. Then, learning support is provided for the right stakeholder at the right time. Efficiency is given, in case the

intervention can be set with minimal cognitive and implementation effort. This requirement implies (i) to provide an intelligible and easy to handle specification of the workflow from a stakeholder perspective including triggering the inclusion of learning support, and (ii) a technological infrastructure that implements dynamic process adaption in a straightforward way, e.g., based on executable process specifications.

We have tackled the situation-sensitive availability and handling of information and continuous improvement processes by adapting workflows to stakeholder learning needs. While providing structured workflows, unstructured courses of action are explicitly supported to enable case-based use and combination of available features. Leveraging stakeholder capabilities is driven by individual knowledge needs identification and collective interaction with work-relevant knowledge, before connecting to social media, learning material or domain content, and process specifications. Hence, from a socio-technical design perspective, a lifecycle frame of reference facilitates the adaptation process for stakeholders. Comparing our achievements with existing results and findings reveals the following:

The workflow-contextual information with respect to learning in this paper is not considered by works in adaptive WFMS or agent-based architectures, where the main types of contextual information consists of operational environments, variability of resources, and stakeholder needs in general.

- This paper is different from Multi-Agent-Systems work, as the proposed contextual approach is based on user-defined behavior encapsulations, as proposed by [45], rather than intelligent agents.
- This paper is differentiated from the work of [4] and similar work, e.g., [44], in that it concentrates on the design methodology in the development of context-aware workflow systems rather than implementation issues, e.g., composing services, verifying requirements. The method proposed in this paper directs intertwining through user needs based on the learning support features.
- The advantages of the proposed design methodology include the specification of workflows and automated execution to

Figure 8: Coupling mechanisms combining workflow and feature usage.

minimize the cost involved in needs analysis and design, and efficient generation of context-aware educational procedures along workflows based on the subject-oriented specification of workflows.

- This paper can be differentiated from the works of [42] in that it concentrates on the development of a context-aware learning support system triggered by messages rather than documents or business objects in workplace settings.
- This paper elaborates the results presented in [46], which is bound to workflow execution when implementing business processes in general.

Future research is needed to investigate the presented approach from two sides. On the one hand, adaptive workflow management support needs to be enriched with recommender functions, in order to profit from existing experiences. In organizations there may be bottlenecks with respect to certain work procedures, activities, or task-specific steps. In these cases, stakeholders may be offered learning support by workflow management systems based on adaptation rules created from previous interactions and lifecycle needs.

On the other hand, learning support systems need to follow a service-oriented approach, in order to provide features on a fine-grain level. They then provide more focused or dedicated support, e.g., like tagging functions to express the didactic function of content elements. In addition, learning support patterns could be provided based on didactic concepts, e.g., problem-based learning. Selecting a certain learning format could facilitate positioning learning support, as it would provide possible context of existing apps or system functions, such as ‘liking’ (from social media) using for ‘explanations’ (from learning content management). In this way, the intertwining of workflows with learning processes could be accelerated, due to the extending of the scope of existing features, using them as a metaphor for interaction.

REFERENCES

- [1] K. Božič, and V. Dimovski 2019. Business intelligence and analytics for value creation: The role of absorptive capacity. *International journal of information management*, 46, 93-103, 2019.
- [2] B. Zou, F. Guo, and J. Guo 2016. Absorptive capacity, technological innovation, and product life cycle: a system dynamics model, *Springerplus*, vol. 5, no. 1, p. 1662, Dec. 2016.
- [3] W. M. Cohen and D. A. Levinthal 1990. Absorptive Capacity: A New Perspective on Learning and Innovation, *Adm. Sci. Q.*, vol. 35, no. 1, pp. 128–152, 1990.
- [4] E. el Khaldi Ahanach, S. Koulouzis, and Z. Zhao, 2019. Contextual linking between workflow provenance and system performance logs. In *2019 15th International Conference on eScience (eScience)* (pp. 634-635). IEEE, Sep. 2019.
- [5] P. M. Senge 1990. *The Fifth Discipline, The Art and Practice of the Learning Organization*. Doubleday, New York, 1990.
- [6] J. P. Thompson and S. Cavaleri 2010. Dynamic Knowledge, Organizational Growth, and Sustainability, *Int. Stud. Manag. Organ.*, vol. 40, no. 3, pp. 50–60, Oct. 2010.
- [7] P. Forbrigg, Does Continuous Requirements Engineering need Continuous Software Engineering? 2017 in *Joint Proceedings of {REFSQ-2017} Workshops, 22nd International Conference on Requirements Engineering: Foundation for Software Quality {REFSQ} 2017*, Essen, Germany, Februar, 2017.
- [8] M. E. Nissen, M. N. Kamel, and K. C. Sengupta 2000. Toward integrating knowledge management, processes and systems: a position paper, in *Proceedings of the AAAI Symposium on Bringing Knowledge to Business Processes*, Stanford, CA, 2000.
- [9] A. Fleischmann, W. Schmidt, C. Sary, S. Obermeier, and E. Börger 2012. *Subject-Oriented Business Process Management*, Berlin Heidelberg, Germany: Springer Berlin Heidelberg, 2012.
- [10] A. Fleischmann, W. Schmidt, and C. Sary, Eds. 2015 *S-BPM in the Wild*. Cham: Springer International Publishing, 2015.
- [11] M. Neubauer and C. Sary, Eds. 2017. *S-BPM in the Production Industry*, 1st ed. Springer International Publishing, 2017.
- [12] T. Haldin-Herrgard 2000. Difficulties in diffusion of tacit knowledge in organizations, *J. Intellect. Cap.*, vol. 1, no. 4, pp. 357–365, Dec. 2000.
- [13] J.F. Martínez-Cerdá, J. Torrent-Sellens, J., and I. González-González, 2020. Socio-technical e-learning innovation and ways of learning in the ICT-space-time continuum to improve the employability skills of adults. *Computers in Human Behavior*, 107, 105753, 2020.
- [14] J. Li and A.M. Herd 2017. Shifting practices in digital workplace learning: An integrated approach to learning, knowledge management, and knowledge sharing, *Human Resource Development International*, 20(3), 185-193, 2017

- [15] G. Pütz and R. Lüger 2003. Flucht in die Technik oder neue Qualität des betrieblichen Lernens?, in *Wissen und Lernen in virtuellen Organisationen*, Heidelberg: Physica-Verlag HD, 2003, pp. 199–215.
- [16] D. McGregor 1960. *The Human Side of Enterprise*, vol. 2, no. 11. McGraw-Hill, New York, 1960.
- [17] J. Meyrowitz 1986. No Sense of Place: The Impact of Electronic Media on Social Behavior. *Am. J. Sociol.*, vol. 92, no. 1, pp. 229–230, Jul. 1986.
- [18] M. Castells 2010. *End of Millennium: The Information Age: Economy, Society, and Culture*. 2010.
- [19] G. P. Montague 2012. Who am I? Who is she?: a naturalistic, holistic, somatic approach to personal identity. *Walter de Gruyter*, 2012.
- [20] W. Edelmann and S. Wittmann 2012. *Lernpsychologie*. Beltz Weinheim, 2012.
- [21] S. Oppl 2016. Articulation of work process models for organizational alignment and informed information system design, *Inf. Manag.*, vol. 53, no. 5, pp. 591–608, 2016.
- [22] A. Ates and U. Bititci 2011. Change process: a key enabler for building resilient SMEs, *Int. J. Prod. Res.*, vol. 49, no. 18, pp. 5601–5618, Sep. 2011.
- [23] A. R. Silva, R. Meziani, R. Magalhaes, D. Martinho, A. Aguiar, and N. Flores 2009. AGILOPO: Embedding social software features into business process tools, in *International Conference on Business Process Management*, 2009, pp. 219–230.
- [24] J. Harman, R. Brown, U. Kannengiesser, N. Meyer, and T. Rothschild, *Model as You Do: Engaging an S-BPM Vendor on Process Modelling in 3D Virtual Worlds*, in *S-BPM in the Wild*, Cham: Springer International Publishing, 2015, pp. 113–133.
- [25] K. Parsaye and M. Chignell 1988. *Expert Systems for Experts*. New York, NY, USA: John Wiley & Sons, Inc., 1988.
- [26] A. Grosskopf, J. Edelman, and M. Weske 2010. Tangible Business Process Modeling – Methodology and Experiment Design, in *Business Process Management Workshops: Revised Papers*, Springer Berlin Heidelberg, 2010, pp. 489–500.
- [27] P. Brey 2005. The Epistemology and Ontology of Human-Computer Interaction, *Minds Mach.*, vol. 15, no. 3–4, pp. 383–398, Nov. 2005.
- [28] I. Nonaka and G. Von Krogh 2009. Perspective-tacit knowledge and knowledge conversion: Controversy and advancement in organizational knowledge creation theory, *Organ. Sci.*, vol. 20, no. 3, pp. 635–652, 2009.
- [29] T. Herrmann and K.-U. Loser 1999. Vagueness in models of socio-technical systems, *Behav. Inf. Technol.*, vol. 18, no. 5, pp. 313–323, Jan. 1999.
- [30] G.-J. Hwang 2014. Definition, framework and research issues of smart learning environments - a context-aware ubiquitous learning perspective, *Smart Learn. Environ.*, vol. 1, no. 1, p. 4, Dec. 2014.
- [31] R. Adams 2004. Universal Access Through Client-Centred Cognitive Assessment and Personality Profiling, in *User-Centered Interaction Paradigms for Universal Access in the Information Society: 8th ERCIM Workshop on User Interfaces for All*, Vienna, Austria, June 28–29, 2004, Revised Selected Papers, C. Stary and C. Stephanidis, Eds. Berlin, Heidelberg: Springer Berlin Heidelberg, 2004, pp. 3–15.
- [32] M. Prilla, M. Schermann, T. Herrmann, and H. Krcmar 2011. Process Modeling with SeeMe: A Modeling Method for Service Processes, in *Implementing International Services*, Wiesbaden: Gabler Verlag, 2011, pp. 67–81.
- [33] P. Bélanger 2015. Taking steps: Formal adult education in private and organisational life. A comparative view, *Int. Rev. Educ.*, vol. 61, no. 2, pp. 261–263, Apr. 2015.
- [34] M. Maurice, F. Sellier, and J.-J. Silvestre, 1986. The social foundations of industrial power: a comparison of France and Germany. 1986.
- [35] S. Hadjerrouit 2005. Learner-Centered Web-Based Instruction in Software Engineering, *IEEE Trans. Educ.*, vol. 48, no. 1, pp. 99–104, Feb. 2005.
- [36] M. Resnick, A. Bruckman, and F. Martin 1996. *Pianos Not Stereos: Creating Computational Construction Kits*, interactions, vol. 3, no. 5, pp. 40–50, Sep. 1996.
- [37] M. Tam 2000. Constructivism, instructional design, and technology: Implications for transforming distance learning, *Educ. Technol. Soc.*, vol. 3, no. 2, pp. 50–60, 2000.
- [38] R. Bentley *et al.* 1992. Ethnographically-informed Systems Design for Air Traffic Control, in *Proceedings of the 1992 ACM Conference on Computer-supported Cooperative Work*, 1992, pp. 123–129.
- [39] I. Hawryszkiewicz 1997. *Designing Networked Enterprise*. Artech House Inc., Boston, USA, 1997.
- [40] L. van Elst, F.-R. Aschoff, A. Bernardi, and S. Schwarz 2003. Weakly-structured workflows for knowledge-intensive tasks: an experimental evaluation, in *WET ICE 2003. Proceedings. Twelfth IEEE International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises*, 2003, pp. 340–345.
- [41] D. Cohn and R. Hull 2009. Business artifacts: A data-centric approach to modeling business operations and processes, *Bull. IEEE Comput. Soc. Tech. Comm. Data Eng.*, vol. 32, no. 3, pp. 3–9, 2009.
- [42] H. Schöneberg, H.-G. Schmidt, and W. Höhn 2013. A Scalable, Distributed and Dynamic Workflow System for Digitization Processes, in *Proceedings of the 13th ACM/IEEE-CS Joint Conference on Digital Libraries*, 2013, pp. 359–362.
- [43] F.-S. Hsieh and J.-B. Lin 2016. A self-adaptation scheme for workflow management in multi-agent systems, *J. Intell. Manuf.*, vol. 27, no. 1, pp. 131–148, Feb. 2016.
- [44] W. Viriyasitavat, L. Da Xu, and W. Viriyasitavat 2014. Compliance Checking for Requirement-Oriented Service Workflow Interoperations, *IEEE Trans. Ind. Informatics*, vol. 10, no. 2, pp. 1469–1477, May 2014.
- [45] S. Wilk *et al.* 2016. Aligning Interdisciplinary Healthcare Team Behavior with Workflow Execution: An Example of a Radical Prostatectomy Workflow, in *2016 IEEE 29th International Symposium on Computer-Based Medical Systems (CBMS)*, 2016, pp. 112–117.
- [46] F. Krenn and C. Stary 2016. Dynamic switching of perspectives on business processes, in *CEUR Workshop Proceedings*, 2016, vol. 1684.