IT-Support for Self-Regulated Learning and Reflection on the Learning Process

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ABSTRACT
In the last years, knowledge management and technology enhanced learning are confronting a lot of new challenges due to rapid changes in business environment and technological progress. In a fast changing business environment, where jobs and roles never stand still, the slow processes of creating formal learning materials and delivering vocational training across the whole organisation can create barriers to the adoption and use of learning technologies. In work-intensive environments, a formal way of knowledge acquisition and learning (from a classroom to classic eLearning) is often insufficient, especially for small and medium-sized enterprises. Furthermore, mobile devices are becoming more and more powerful. They are increasingly used in parallel to PC or notebooks especially by people who spend a lot of time on business trips. They are becoming more important for knowledge acquisition and technology-enhanced learning. Therefore, knowledge management and eLearning tools should be available not only as web application integrated in widely-used Internet platforms, but also for mobile devices.

To close these gaps, the EU projects “ROLE – Responsive Open Learning Environments” and “MIRROR – Reflective Learning at Work” aim to support self-regulated and reflective learning-on-the-job methodologically and technically.

Based on a self-regulated learning process model and reflective learning artefacts, a multi-platform prototype for self-regulated learning including reflection on the learning progress is being developed. The prototype contains integrated tools for self-regulated vocabulary training and activity tracking tools supporting reflection on the learning process. The tools are available as both web applications and mobile apps. Their application is demonstrated by a showcase scenario of mentored self-training including reflection on the learning process.

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General Terms
Design, Human Factors

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Reflection, Self-Regulated Learning, Personal Learning Environments, Multi-platform Development

1. INTRODUCTION
Several studies show that only about 25 percent of knowledge is acquired by formal learning in working environment. [11] In fast changing business and technical environments, formal way of knowledge acquisition and learning (from a classroom to classic eLearning) is often insufficient. Both employees and self-employed often must learn and refine their important skills informally. [22] Therefore, a new generation of tools supporting self-regulated informal learning is needed as an alternative to classic knowledge management and eLearning platforms.

The growing popularity of becoming more and more powerful smartphones opens up new opportunities for informal self-regulated eLearning. Research and consulting firms such as Brandon Hall, Bersin & Associates and Gartner forecast a mobile learning “boom” in the next years. [20] “More than a quarter of the world’s population now uses a mobile device and frequent mobile Internet use has almost doubled in the past year, according to the study. The research report of Bersin & Associates also notes that the informal uses for mobile learning vastly outnumber the formal, and that these new applications increasingly empower today’s workers to access the information they need on demand.” [15] Thus, tools supporting self-regulated learning have to be developed for mobile platforms as well.

Towards these challenges and trends, concept models and technical frameworks for self-regulated and reflective learning are being developed within the European projects ROLE and MIRROR.

The EU project ROLE offers adaptivity and personalization of technology-enhanced learning environments in terms of content and navigation. The ROLE infrastructure provides a learner-centred personal learning environment (PLE) for learners and teachers and aims to empower the user for true lifelong learning across institutional boundaries. The integration of learning with other parts of the learner’s social life is being considerably facilitated, thus increases motivation for and effectiveness of learning. [17]

The integrated EU project MIRROR aims to support and motivate employees, teams and organisations to learn by reflection on experiences in daily working routine. It covers different learning areas of reflective learning such as collaborative knowledge construction, creative problem solving, organisation learning etc. The overall objective of the MIRROR project is to empower and
engage employees to reflect on past work performances and personal learning experiences. [14]

In this paper, we introduce a showcase scenario that integrates ROLE and MIRROR approaches and focuses on reflection in self-regulated learning. Before the question, how reflection in self-regulated learning can be supported technically, can be answered, in the next section, we discuss a process of self-regulated learning and point out the role of reflection in it.

2. REFLECTION IN THE SELF-REGULATED LEARNING

The process model of the self-regulated learning defined in ROLE includes four learner-centred phases: learner profile information is defined or revised, learner finds and selects learning resources, a learner works on selected learning resources, learner reflects and reacts on strategies, achievements and usefulness. These phases are summarized as “plan-learn-reflect-plan” loop (Figure 1). [10]

![Figure 1. Self-regulated learning process model](image)

The ROLE learning process model is based on the concept of the self-regulated learning approach of Zimmerman, who emphasizes self-awareness and self-motivation as indispensable components of the self-regulation of learning and structures the process of self-regulation as shown in the Figure 2.

![Figure 2. Phases and Subprocesses of Self-Regulation](image)

The performance phase is the actual learning phase. It falls into two classes of processes: self-control, which refers to application of learning methods and strategies defined in the forethought phase, and self-observation. The latter includes self-recording of personal events and self-experimentation to find out the cause of these events. These meta-learning processes refer to the self-awareness and are essential as a base for continuous learning process improvement.

The self-reflection phase includes self-judgment and self-reaction processes. The self-judgment processes are cognitive. One form of self-judgment, self-evaluation, refers to comparisons of self-observed performances against some standard. Another form of self-judgment involves causal attribution, which refers to beliefs about the cause of one’s errors or successes. [22] A basis for the well-founded causal attribution is self-observation.

The self-reaction phase includes, on the one hand, emotional processes involving feelings of self-satisfaction and positive affect regarding the own performance, which influence motivation and efforts to learn, and on the other hand, active adaptive or defensive response involving change in behaviour. “Defensive reactions are efforts to protect one’s self-image by withdrawing or avoiding opportunities to learn and perform. In contrast, adaptive reactions refer to adjustments designed to increase the effectiveness of one’s learning method, such as discarding or modifying an ineffective learning strategy.” [22] The adaptive reaction is only possible if a learner has drawn correct conclusions about the causes of his failures and successes.

As the process of the self-regulated is cyclical, the self-reflection influences subsequent forethought processes. This process model was evaluated within several studies, which showed high correlations between learners’ use of the introduced process model and their performance and achievement of learning goals. [5, 6, 23]

Therefore, the two prerequisite for the successful self-regulated learning are emotional attitudes (motivation) and an effective learning strategy. They both can be positively influenced in the self-reflection phase, which is based on the self-evaluation and causal attribution. Attributing a poor achievement to limitations in fixed ability can be very damaging motivationally because it implies that efforts to improve it will not be effective. In contrast, attributing poor results to controllable processes, such as the use of the wrong solution strategy, will sustain motivation because it implies that a different strategy may lead to success. [22] Thus, reflection on the learning process is an essential prerequisite for planning and improving the learning strategy and learner’s motivation, and hence, for the success of self-regulated learning as a whole.

3. REFLECTION PROCESS ARTEFACTS

To analyse how reflection in self-regulated learning can be supported within personal learning environments, artefacts of the reflection process will be defined and specified based on the classical data-information-knowledge-wisdom (DIKW) hierarchy (Figure 3).

Data are simple, isolated, discrete, objective facts or observations, which are unorganized and unprocessed and therefore have no meaning or value because of lack of context and interpretation. [21] “Raw” data in reflective learning is either related to a situation being reflected or to feelings and behaviour of a reflecting person. In a learning environment, data about personal activities such as user activities on PC or mobile phone can be useful for retrieval information about person’s behaviour. Data capturing
refers to the self-recording sub-process of the Zimmerman’s model.

![Figure 3. DIKW: structure of learning process artefacts](adapted from [1])

Information emerges when such facts are put into a context and combined within a structure. Thus, information is organized or structured data, which has been processed in such a way that the information now has relevance for a specific purpose or context, and is therefore meaningful, valuable, useful and relevant. [21] Information in reflective learning provides context to a reflected situation and response of a person to this situation. In regard to a situation or an event, it describes what has happened, to whom, when, where and so on. “Raw” behaviour data such as logged user activities do not answer the question, what a person is doing it for. Only combined with related context, “raw” behaviour data becomes valuable for reflective learning. For reflection on the learning process, tools providing user interface for collecting context data have to be integrated in personal learning environments. For example, a task tracker tool can provide a context to activity logs, collecting information about tasks being accomplished by the user. Collecting context data refers to the self-recording sub-process of Zimmerman’s model as well.

Beside data and information related to the learning process and personal events, learning and working performance indicators are important for reflection on the learning process and for its self-regulation in general because they serve as an input for self-evaluation. Examples of such data are quantified learning results, time spent on a particular task compared to the average time spent on similar tasks by experienced colleagues and the like.

Knowledge is generally agreed to be a concept that is difficult to define. [19] To differentiate between knowledge and wisdom in the DIKW model, knowledge will be defined as information connected in relationships and given meaning by interpreting it [21]. Knowledge in reflective learning results from meaningful interrelations between information about a reflected situation and its environment as well as information about feelings and behaviour of a reflecting subject (a person or a group). Knowledge is created by composition information puzzles to a completed picture. At this stage, information interrelationships can be time-based or consolidated by defined categories. Thus, tools supporting self-regulated learning and reflection on the learning process in particular should provide data aggregation as well as different visualizations and statistics reports based on captured data. Data aggregated and visualized meaningfully support a learner in identifying causal attributions correctly.

At this point, facts and causal attributions exist within a mental structure that consciousness can process, for example, to predict future consequences, or to make inferences. As the human mind uses this knowledge to choose between alternatives, behaviour becomes intelligent. Finally, when values and commitment guide intelligent behaviour, behaviour may be said to be based on wisdom. [21] Wisdom is referred as “evaluated understanding” and is the ability to perceive outcomes and determine their value. For reflective learning, it means perceiving the own role in a reflected situation and awareness of consequences of own behaviour, as well as subjective attitude to the consequences. Wisdom is indispensable for deciding what should be done to achieve desired goals in a given situation. [2] Thus, the ability to improve the learning process and learning strategy by evaluation of learning process data and the learning progress, which refers to a positive adaptive self-reaction within the self-reflection phase of self-regulated learning, is the aimed outcome of reflection on the learning process.

Thus, a learning experience alone and its observation do not suffice to learn from it and to improve a learning strategy. Experience has to be “arrested, examined, analysed, considered and negated in order to shift it to knowledge”. [8] “Arresting” an experience can already be a challenge for a reflecting learner. Firstly, all details that can be relevant to a reflected situation, event or process have to be noticed by a person. And secondly, a reflecting person has to return all these details to mind at the time of reflection. These two prerequisites are also emphasised as important elements of reflective learning [7]:

- weighing up: all factors have to be taken into accounts,
- standing back – gaining a better view or perspective.

Standing back is indispensable to gain an objective view on a reflected situation. The longer a time span between the reflected situation and reflection is, the less the reflecting learner is influenced by emotions in regard to an experience and the more objective he can analyse it. On the other side, the longer this time span is, the more difficult it is to recall all relevant details. That is it, where software tools capturing data and information related to learning experiences become very useful.

The next section introduces prototypes of software tools for self-regulated learning supporting the learning process itself as well as self-recording including statistics reports and visualizations for self-reflection on the learning process. A showcase scenario demonstrates how these tools can be applied within the self-regulated learning process.

4. SHOWCASE SCENARIO

The application of described process models can be demonstrated by a scenario of mentored self-training of an employee.

An employee has to learn a new programming language. The programming language is new and becoming very popular, and all classroom learning courses for the next half year are already fully booked. His mentor decides for self-regulated learning by reading a technical book, executing programming exercises and regulating his learning process within a mentored reflection session. It is the forethought or planning phase of self-regulated learning, in which learning goals has been set and a learning strategy has been defined.

The mentor chooses an eBook that fits best for the learner’s specific needs. The employee downloads it on his smartphone. As the book is only available in English, which is not his mother tongue, he calls a translator each time he misses a word. A translator offers several translation options. He chooses a translation that matches to a given context and stores a new word including context in his personal vocabulary list of the Vocabulary Trainer tool on his smartphone if deemed important.

While executing programming exercises on a desktop PC, the learner sometimes needs additional detailed information about
particular programming concepts. To improve his English in parallel to learning of the programming language, the learner uses a language learning widgets bundle in his personal learning environment while reading technical documentation in English. The widget bundle includes three widgets: a Language Resource Browser, a Vocabulary Trainer and a Translator (Figure 4).

![Figure 4. PLE: language learning widget bundle](image)

In the Language Resource Browser, the learner searches for a text and starts reading it. Also here, each time he misses a word, he selects it and opens a context menu on it. The system then proposes to either look it up in the Translator widget or send it to the Vocabulary Trainer widget. So the employee adds words that he considers as important to the Vocabulary Trainer and others he only looks up.

After reading an eBook or a text in Internet, the learner has gathered a list of words to be repeated in future using the Vocabulary Trainer widget. [16] The Vocabulary Trainer is a slightly modified implementation of Leitner system. [9] A vocabulary list consists of five different buckets. If an item is added, it will be put in the first bucket. If the user is training a list and knows the right translation, the item will be moved to the next bucket, or else it will be moved to the previous bucket. [18]

Thus, the learner chose tools for his PLE and selected learning resources, which were recommended by his mentor. While learning, he searches for additional learning resources and use them as well.

To optimize the learning process, the employee reflects on it together with his mentor weekly within self-reflection phase. To collect data that can be relevant for reflection on the learning process, Activity and Task Tracker tools are used for self-recording. The eBook reader provides an interface for activity logging, which logs automatically how much time was spent reading which chapter. The learner also writes down the time spent on learning in general using a Task Tracker app. As he uses his mobile device for reading and a desktop PC for programming exercises, the Task Tracker app is available as a smart phone app and as a web-app in form of OpenSocial widget, which is integrated in his PLE.

Within the self-judgment phase, the employee reflects on his learning progress together with the mentor and analyse time effort expended in learning in detail. Software provides different visualizations and statistics reports for it. The mentor noticed that the employee spent too much time reading the book compared to programming exercises. Furthermore, it is noticeable, that the employee switched between learning of programming language and vocabulary training too often. As adaptive response within the self-reaction phase of self-regulated learning, they work out a new learning plan for the employee. The mentor advises to spend more time on exercises instead of reading syntactic definitions over extended time periods in the eBook and not interrupt the learning of programming language by vocabulary training.

Table 1 summarized functionalities of the introduced tools structured by supported sub-processes of self-regulated learning.

<table>
<thead>
<tr>
<th>Learning Sub-process</th>
<th>Outcome</th>
<th>Tool</th>
<th>Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Self-Recording</strong></td>
<td>Information about personal events</td>
<td>Task Tracker</td>
<td>Recording time spent on learning activities and working tasks, collecting learner’s comments on them</td>
</tr>
<tr>
<td><strong>Self-Evaluation</strong></td>
<td>Performance comparisons</td>
<td>Vocabulary Trainer, Task Tracker</td>
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<tr>
<td><strong>Causal Attribution</strong></td>
<td>Beliefs about the cause of errors or successes</td>
<td>Task Tracker</td>
<td>Statistics reports and visualizations</td>
</tr>
<tr>
<td><strong>Adaptive Reaction</strong></td>
<td>Improved learning strategy</td>
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<td>-</td>
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</tbody>
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5. TECHNICAL BACKGROUND

The described showcase scenario demonstrated benefits of combined usage of web and mobile applications. For mobile development, Android platform has been chosen as it provides easy data sharing between apps and has proven to be very flexible. Web-based apps are developed in form of OpenSocial widgets, which are small applications that can be easily integrated on OpenSocial platforms like iGoogle and flexibly combined with each other by users. Corresponding OpenSocial widgets and Android apps use same databases to enable the user works with same data independent of the underlying platform. Android apps are also available in offline-mode using local SQLite database, which is synchronized with the central data base once a network connection is available again.

As shown in the section 2, self-motivation plays a particular important role for success of self-regulated learning. Therefore, self-regulated learning tools have to provide good usability in order to motivate users to learn with these tools. Besides of easy-to-use user interfaces, fast response time of apps is essential for usability. To achieve it, data overhead has to be kept as low as possible, that is especially important for mobile apps due to limited bandwidth of mobile devices.

The analysis conducted within the ROLE project suggests that REST protocol should be the preferred choice for easy integration with web clients (such as AJAX). The detailed performance evaluation of SOAP and REST mobile web servers conducted at the RWTH Aachen University arrived at the conclusion that REST is recommended as an underlying messaging framework for resource-constrained mobile devices as well. This performance comparison was based on the performance metrics such as server
utilization, request waiting-time, throughput and average queue length. [3]

Two widely deployed data formats that can be used to implement the described scenario are XML and JSON. More data-oriented JSON is a lot simpler than rather document-oriented XML. XML and the relational approaches are built on different principles [12], whereas JSON is more isomorphic with the relational data bases that are used for persistence. Furthermore, browsers can consume large amount of JSON much more efficiently than they can consume large amount of XML and the gap is widening because the latest versions of the browsers are now providing native, safe support for encoding and decoding JSON. Thus, JSON is a candidate for lightweight, web-based environments due to its simple integration into JavaScript programs. Due to its lower overhead, which is especially important in case of apps for mobile devices, JSON is also the preferred data exchange format for mobile apps. Thus, REST protocol with JSON as a data format has been chosen for data interchange between apps on different platforms.

6. OUTLOOK

The described showcase scenario demonstrates an example of how tools developed in the context of the MIRROR and ROLE projects can be integrated within one learning application. As the next steps, tools supporting planning or forethought phase of self-regulated learning will be integrated in the introduced scenario. Data, created in the planning phase, can then be used in the performance phase for regulating of the learning process as well as in the self-reflection phase for self-evaluation of the learning progress towards set goals, adapting of the learning plan and so on. It will be also analysed which kinds of statistics reports and visualizations are needed for optimal support of the reflection phase. Furthermore, the scenario will be expanded by use cases and corresponding software prototypes for learning by reflection on working experiences and evaluated.

The next steps regarding technical integration are to specify a multi-platform integration framework in detail and to work out solutions for further technical issues and requirements such as data privacy and security. It will be investigated how apps developed for further platforms and devices like iOS operating system can be integrated easily and what requirements an integration framework has to fulfil to support it. Further technical issue is the semantic data description, which allows the data to be integrated, processed, shared, and filtered with much greater ease. The specification in form of XML schema (XSD) serves as a base for semantic data description with Resource Description Framework (RDF). On the other hand, data interchange using XML data format would be less efficiently compared to JSON as it would produce much higher overhead. A schema language specification for JSON (JSON Schema) uses concepts similar as XSD to provide JSON structure definition. [13] However, the JSON schema is still a draft, and there are no reliable standard libraries or tools transforming XSD to JSON schema. Thus, to fulfil technical requirements regarding performance and efficiency on the one hand, and to provide a basis for semantic data description on the other hand, the mapping rules for generating and validating of JSON accordingly to the XSD will be defined first, and afterwards tools or libraries implementing the defined rules will be developed. Also approaches to representing RDF in JSON will be explored in this regard.

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8. REFERENCES


