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A context aware learning application for communities of service technicians

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Abstract— **The gathering of knowledge and competences needed to accomplish work related tasks is carried out in several ways. It can be done, planned in the long term to brace oneself for a new area of responsibility or in the short term to prepare for a concrete forthcoming task or while working on a task. The latter two happen quite often at the workplace. In this paper, we present a context aware mobile application supporting workplace learning of service technicians working at different locations including customer service. The originality of the presented application lies in the combination of the question & answering concept with the microlearning concept and in the context awareness of the application. A comprehensive evaluation of the application shows the positive appreciation of the application within the target group of mobile technicians.**

Workplace Learning, Question & Answering, Mobile Learning, Microlearning, Context awareness

I. INTRODUCTION

Employees nowadays have to learn continuously considering the needs of their respective jobs. Knowledge and competences imparted during education and formal training often are not sufficient to meet the demands of their job. The additional demands can be satisfied in different forms which can be distinguished in regards to the temporal extent and the point in time of the learning episode. We distinguish *curricular qualification*, which covers comprehensive learning tasks and goals and is scheduled with sufficient forward planning. Example arrangements for curricular qualification are classroom learning or blended learning. In contrast, *modular learning* is often placed with less advance notice, e.g. to prepare for a concrete working task which has to be fulfilled soon, and is on a smaller scale. Finally, *situated learning*, which is characterized that it takes place in the same context in which it is applied [1], is triggered by a concrete requirement occurring during a working task. This kind of learning is unplanned and limited to the currently required knowledge or skills.

In contrast to curricular qualification, modular and situated learning quite often take place at the workplace. If workers operate at different locations, the use of mobile devices and applications seems useful. Situated learning, which is related to a concrete working task, can be supported additionally by context aware functions considering the working task and adapting the learning application with respect to the working and hence learning task.

In a joint project together with manufacturers from the automotive sector, garages and training providers also in the automotive sector, we designed, developed and evaluated a specialized learning application which supports service technicians in modular and situated learning. These service technicians work at different locations: different garages, but also at the roadside. The high degree of mobility is a characteristic of their jobs. A survey [6] performed within the target group of our application has shown that especially for situated learning the support of experienced colleagues is significant. Another outcome of the survey was that almost all technicians are equipped with mobile devices in particular with smartphones or tablets.

In the following section, related approaches and solutions are summarized. Section 3 describes the concept of our overall application to support modular learning as well as situated learning. Section 4 presents the implementation, whereas section 5 summarizes the evaluation and its results. The paper ends with an outlook on current and future work.

II. RELATED WORK

Learning at the workplace happens quite often when and where the workers need it. This observation is often called just-in-time learning [3]. Mobile technologies are a major driver for this kind of learning since they allow learning on the move [1] and hence at different workplaces. A widely accepted design principle for content used in just-in-time learning on the move is the micro principle [5]. Micro content should be small, self-contained and granular learning objects. This is consistent with the knowledge, that people can learn better and more effectively when the content is broken down into digestible parts and learning thus takes the form of small steps [8]. Therefore microlearning, defined as learning with relatively small learning units and short-term educational activities, can be “considered particularly suitable for informal learning in specific activities in which learners are interested in information content which is short and specific rather than the access to a solid body of knowledge about a particular subject.”[7]. Microlearning can be designed in different forms like quizzes, small games, podcasts, videos or slideshows. Especially videos are widely used, for example in the Khan Academy[1], due to the simplicity of their production.

[1] https://www.khanacademy.org/

Question and answering (Q&A) systems are used quite often for knowledge acquisition and management especially as an element of learning at the workplace. In case of a problem, workers ask questions to more experienced colleagues. This is valid if people are physically present or can be called via phone. In the past years, the pattern to ask colleagues personally has been complemented with the evolvement of community-based web applications where questions are asked to a group of potentially responding people [9]. Answers given in a question and answering system might be good [10], but a major challenge are the possibly high response times, especially in smaller user communities [11].

The availability of mobile information and communication technologies and of smartphones and tablets allows the realization of manifold pervasive learning applications [12], whose use information about the context of the learner to adapt the pedagogical strategies and content offers [13]. The use of sensor technology to detect the learner's context is emphasized in the term *context aware u(biquitous) learning*, introduced by Hwang et al. [14]. According to an analysis performed in [15] the share of applications using sensor technologies is with 25 % relatively low. Most of these applications target students, whereas the learning support of employees is less considered. Examples for use of mobile technologies for workplace learning can be found in [16, 17].

III. CONCEPT AND DESIGN

As motivated in the introduction, our goal is to support modular and situated learning in a group of service technicians, working at different working places and being equipped with smartphones or tablets. For modular learning, we choose the microlearning approach as explained in the previous section. To support situated learning we combine this approach with the question and answering approach. Besides the technical information provided by the car manufacturers that is already available to the technicians, the knowledge of the colleagues is rated as the most important source of information in situated learning by the service technicians [2]. Q&A is very well suited and accepted as means for knowledge acquisition at the workplace in the form of mutual knowledge exchange between the employees. The particular situation of a service technician is considered by detecting his current activity on two levels and take the information about the activity as context to realize context-aware features, as described later.

A. Features of the Q&A System

The basic feature of the Q&A system is the possibility to ask questions and to get one or more answers from the colleagues using the system. In addition, like in other Q&A systems known from the web, users can rate the answers, comment answers and questions and mark questions as solved. Another feature of our Q&A system is the possibility to add videos and photos to illustrate questions and answers. Using a mobile device with a camera this can be done immediately at the workplace. This is in line with the result from our survey [2] that more than 80% of the surveyed technicians agreed that videos and photos are helpful to understand problems of their colleagues.

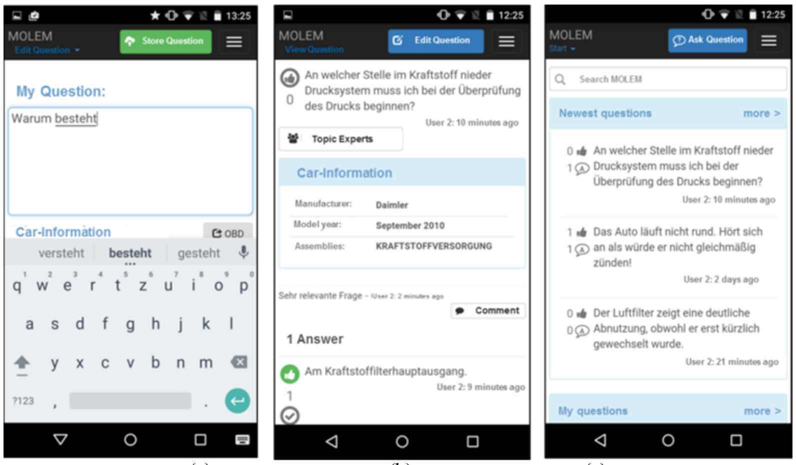
As also shown in the survey, service technicians often need an answer to a question quite fast and outside of the garage. Therefore and since the group of technicians using the application is rather small (in the range of 50 to 200 technicians) we actively inform the community of colleagues about a new question. Another result from our survey is that the willingness to help colleagues differs depending on the activity the technician is currently performing. Therefore we implemented a non-intrusive method to detect the workers current activity and push questions only to people who are currently available or interruptible. Thereby the disturbances and the response time are to be reduced and the acceptance of the application is to be increased. Our classifier distinguishes between the eight most widespread activities of car technicians based on short audio snippets recorded using the microphone of a mobile device [18]. The classification is done on the device so that privacy is preserved. Examples for the activities are on a rough granularity level *repairing a car in the garage*, *repairing a car on the street*, *taking a break* or *driving by car*. Whether a technician is available or whether he accepts an interruption during a defined activity can be configured by the user himself.

B. Design of Microlearning

As explained in the previous section, the microlearning approach can be realized in different media formats. We decided to use videos as main format, since in our scenario mainly very specific practical knowledge and know-how in a technical area needs to be imparted. The communication and exploitation of this kind of knowledge by the means of videos offer many advantages over text and images. Besides the selection of the video format, our concept proposes the use of learning modules which can be processed by the technicians in around five minutes. This length usually allows the presentation of a complete working operation and can be viewed during a practical task. If work operations are more complex, the presentation of the operation should be broken down in smaller parts. Exceptions are learning modules which impart basic knowledge and are mainly used during modular learning.

C. Indexing of Learning Content by Context Information

To reduce the obstacles for the service technicians to find content related to their current working task, we want to detect their current activity on a fine granular level, as a second kind of context information. To not call for a manual information input, we read out these data via Bluetooth from the on-board-diagnostics (OBD) system of the car. In addition, the technician can enter the (well-known) codes for the assemblies affected during his current task. Altogether, this information extensively describes the context of the technician's task. It is used to index a tuple of a question and the given answers and the microlearning content and for the retrieval of the content. Our survey showed that the information about the car currently repaired or maintained by the technician in addition is of fundamental importance to understand questions related to a working task.



(a) (b) (c)

Figure 1. Mobile Web Application Interface

In our scenario, the working task can be described by the car's brand, vehicle type or model, year of construction or car equipment and the assemblies which have to be fixed or maintained. Based on discussion with technicians, we use two taxonomies for indexing of content. The primary taxonomy is defined by the assemblies, e.g. the gear. It can be refined on different levels of the taxonomy, e.g. gear shaft. The second taxonomy is defined by the vehicle model. By this a question is indexed by the model and the assemblies.

The retrieval is actively initiated by the user by means of a search function, but also when entering a new question. In the second case, a search runs in the background using the entered question as a search term and the sensed diagnosis information as additional information to rank the search results. The highest rank is given to content where both the assembly and the vehicle type match. The answers found are presented to the questioner before his question is finally stored and the colleagues are notified about the new question. The questioner has to confirm that none of the presented questions and answers helps, before storing and forwarding the question.

IV. Implementation

Since the service technicians work at the garages but also at the roadside and since many of them prefer to use a stationary PC which is often available in the garage, our application is implemented to be used on a mobile device and in a browser. Therefore we decided to develop a web application and a mobile application. The different components of the overall application are shown in Fig. 2.

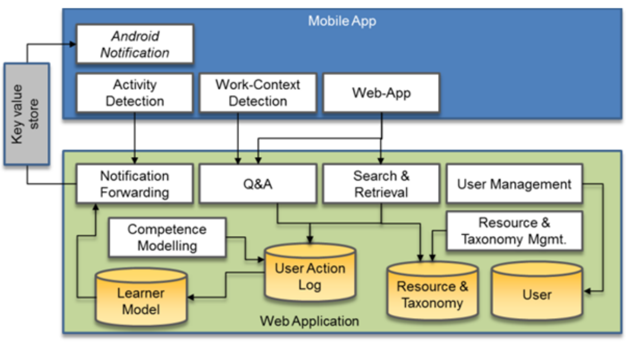


Figure 2. System and Application Components

For the mobile use, we implemented a mobile web application. It uses the Android WebView component to render the mobile user interface developed in HTML5 and JavaScript. It communicates with the webserver using HTTPS and JSON. Fig. 1 shows (a) the interface for entering questions, (b) the entry of a question with multimedia objects and vehicle data attached, and (c) the list of new questions. The app also includes the modules for the detection of the technician's work related context, as explained in the previous section, and for the activity detection.

The web application implements the question & answering functionality and a search & retrieval function, especially to access the microlearning content. In addition we implemented a competence modelling interface which allows to store technician's competence levels regarding different areas. This demand was expressed by the human resource departments of the involved companies. Administrative functions are the user management, resource management to manage the microlearning content and a taxonomy management. The latter is used for administering the taxonomies, previously described.

For the purpose of implementing the notification of users we use *redis*[2], which is a networked key value store. In the store we distinguish three lists of strings for each user, storing information about new questions, answers and comments. When there is any change on the server-side entries, the corresponding question ID is added by the *notification forwarding module* to everyone's list, who is related to the question. In case of a new question, the corresponding question ID is added to all currently available users' lists. In case of a new answer or comment, an entry is written to the list of the author of the question or answer which is being referred to by the new answer or comment. We employ a background service on the Android phone to register to the user's lists using a blocking read. Thereby the user is informed in the Android notification area whenever there are new relevant activities in the question and answering system. The microlearning content, in most cases short explanatory videos, is stored in the Resource & Taxonomy database.

[2] http://redis.io/

V. EVALUATION

For evaluation purposes, the application presented before has been used by service technicians from two companies over a four week period. At the first company ten workers from two different garages used the application, at the second company nine workers also from two different garages. Since they used the same application, they were able to collaborate across company borders. At the beginning of the evaluation phase all workers have been equipped with a smartphone and the application and were trained in a face-to-face seminar with respect to the operation and functionality of the application.

After the four weeks period, the participants have been asked in the form of an online survey about their assessments. 16 technicians participated in the survey. The first part of the survey investigated the overall usability of the application. A seven point likert scale has been used ranging from *1-"very negative"* to *7-"very positive"*. As shown in 0the assessment with respect to all four usability aspects was slightly positive.

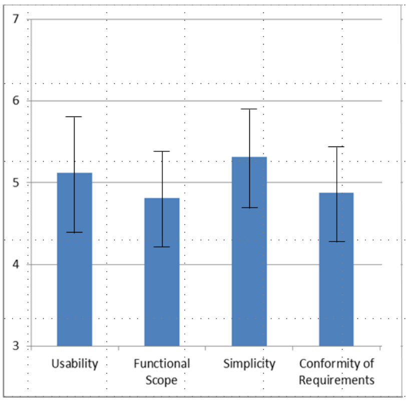


Figure 3. Results regarding different usability aspects (N=16; α=0,05)

In the following parts of the survey the participants have been asked about statements regarding the main functionalities of the application as explained in the previous section. Example statements are "*I find it easy to ask questions*" "*the system forwards me to an existing answer during the input of a question*". To ask about the agreement to the different statements we used five point Likert items ranging from *1-"do not agree at all"* to *5-"fully agree"*

Regarding the provided micro content the participants expressed a neutral or slightly positive estimation which can be seen in Fig. 4. In consideration of the free text answers, the relatively bad evaluation of the usefulness of the content can be explained by the quite modest coverage of the relevant topics; for some types of vehicles there was no micro content available.

The assessment of the Q&A functionalities was always positive. Especially the use of videos and photos for the explanation of questions respectively answers was appreciated as shown in Fig. 5. Just the agreement with the statement *"The answers already available in the platform helped me."* is slightly negative. This is not astonishing since in the beginning of the evaluation period there were no questions and answers available in the system.

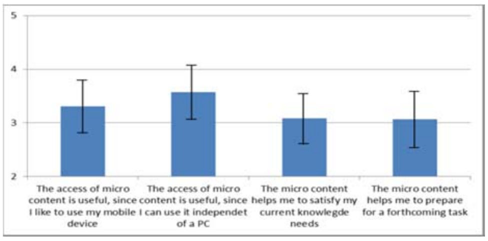


Figure 4. Results regarding the micro content (N=16; α=0,05)

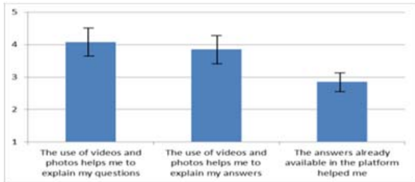


Figure 5. Results regarding the Q&A System (N=16; α=0,05)

At the end of the survey, we asked the service technicians whether they would like to use the application in the long term. As shown in Fig. 6 the interest in it is high.

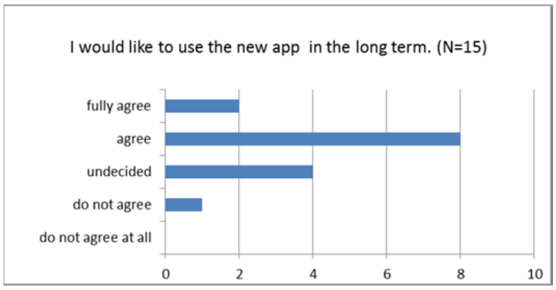


Figure 6. Willingness to use the app in the long term (N=15)

VI. SUMMARY, CONCLUSION AND FUTURE WORK

In this paper, we have presented a context-aware mobile application supporting workplace learning of service technicians working at different locations. The application supports the technicians in modular as well as situated learning by providing access to mircrolearning content and to colleagues and their experiences by use of a question and answering system. The design of the application follows the results of a comprehensive survey performed with representatives of our target group.

The sensor capabilities of mobile devices are used to detect the technician's context in two forms. We use small audio records to detect the activity currently being performed by a technician. This information is used to select available technicians only when forwarding new questions. We use information gathered from the onboard diagnostics system of the cars to identify information about the concrete working task a technician is performing. This includes the specific vehicle model or a specific year of construction and is used to retrieve information which might help the technician fulfilling his task and to index questions he has during the task processing.

The evaluation performed with workers from different garages shows the overall acceptance of the application by the workers. The conclusions we have drawn for the design from the survey, executed as part of the requirement analysis, are mainly confirmed by the evaluation results. Emerged weakness is especially the insufficient thematic coverage of the microlearnings. This can be explained by the goals of the research project, which was not to develop a broad range of learning content. We recognized potentials to improve the usability of the app. The open feedback of the participants gives us different hints for improvement.

Due to the relatively low use intensity during the evaluation period statistical values about the use, e.g. the time till a question is answered, are not meaningful. The same applies for statements about a change of the working practices or the effectiveness of learning using our solution compared to learning without our solution or alternatives. Therefore a longitudinal study and an allocation of the technicians to groups of investigation are needed. Especially the latter is very difficult to realize in companies.

Since it is cumbersome to model the competencies of the technicians down to granular levels manually – hardly any entries have been added by the companies – we work on implicit methods to determine the competencies. Currently we are working on algorithms to calculate competencies of the users based on the actions a user performs within the application. The fact that a technician asks many questions in an area might indicate knowledge needs in this area and vice versa many positively rated answers given by a technician in an area might indicate a kind of expertise in this area. We presented our first ideas in [19]. We plan to use the information about the user's expertise when forwarding notifications. Questions shall be forwarded in the first instance only to most experienced colleagues in the area of a question.

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