Scan to Learn: A Lightweight Approach for Informal Mobile Micro-Learning at the Workplace

Katharina Frosch
Department of Business Management
Brandenburg University of Applied Sciences
Brandenburg an der Havel, Germany
email: frosch@th-brandenburg.de

***Abstract*— Informal learning at the workplace is a crucial ingredient in updating and upskilling today's workforce, but in many jobs, informal learning opportunities are scarce. Bite-sized learning via mobile devices (Mobile Micro-Learning, MML) can be a powerful means to enhance informal work-related learning also in such learning-deprived fields. Based on good practices of recent MML implementations, a lightweight approach is developed. It involves an instructional blueprint and an open-source, low-threshold technology for MML, and meets the specific needs of workers in learning-deprived fields. The main idea is a scan-to-learn system where Quick Response (QR) codes are attached to physical objects in the work environment. Workers can scan the QR codes to learn and are directed to short, interactive learning nuggets. For evaluation, a proof-of-concept is provided.**

Keywords-work-based learning; informal learning; mobile learning; micro-learning; QR code; instructional design; open source.

I. INTRODUCTION

Work-based learning is seen as a powerful means for continuously updating workers' qualifications on the job [1], with the lion's share of learning being informal [2]. Informal learning takes place outside a prescribed learning framework (no organized event or package) and without a professional trainer [3]–[5]. It may be conceived as learning *in* work [6]: Embedded ("situated") in daily work routines [1][5], informal learning is initiated in a self-directed manner by workers and triggered by "an internal or external jolt" [4], i.e., on demand when a specific work task is requiring it. Typical examples are observing, seeking help or feedback from others, discussing, experimenting (learning by just doing the job), trial and error, reflecting or searching the intra- or Internet for information [1][4]. Informal learning can hence rely on the interaction with others ("social learning"), or on self-initiated study, practice and experimentation ("learning by doing") [4].

However, in many occupational fields, the conditions for informal learning at work limited: In decentralized work settings (e.g., train, trucks or delivery drivers, mobile care workers), there is little direct interaction between workers. The same is true in highly mechanized settings with large physical distances between workers, and in work environments with a lot of noise or high language diversity among workers – all of which is rather typical for blue-collar work [7][8]. This hampers learning by observing, asking questions and receiving feedback [9].

Due to tight schedules or high degrees of automation, many jobs offer little autonomy, which is seen as a crucial condition for experimentation on-the-job or other self-directed learning activities [8][10]. Finally, access to codified organizational or external knowledge from the Internet [11] is difficult for those who have no permanent access to a stationary desktop computer. "Learning-deprived" jobs [9] typically suffer from reduced speed and intensity of informal learning at the workplace and jeopardize workforce upskilling.

Such limited opportunities for informal learning at work weight all the heavier as often, the knowledge or skills needed to continue one's work or to start with learning-by-doing would not require extensive educational content, but rather a little tweak. Learning based on bite-sized learning nuggets has been termed micro-learning or Mobile Micro-Learning (MML) as it is typically delivered by mobile devices [12] .

This paper shows to what extent MML can help to improve work-related learning in learning-deprived environments. We propose a lightweight approach to situate MML units in daily work routines with QR codes affixed to physical objects in the work environment (mobile tagging). The rest of the paper is structured as follows: Section II illustrates existing concepts and good practices of micro-learning at the workplace and explores its potential for informal learning. We then sketch our lightweight approach for informal MML at the workplace and illustrate it with a proof-of-concept based on a combination of freely available open-source tools (Section III). In Section IV, we discuss our findings, critically reflect on our approach and conclude with an outlook.

II. RELATED WORK AND GOOD PRACTICES

A. Mobile Micro-Learning

Micro-learning typically consists of short learning nuggets (1-5 minutes) that are focused on one narrow topic and that are provided in rich, interactive media formats [12]–[14], e.g., (animated) videos, podcasts, job aids, cheat sheets, flashcards, quizzes or even gamified elements [15] and virtual reality nuggets [16]. Micro-learning is undertaken

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just-in-time when needed ("on demand") [12]. In this context, mobile technologies are found to naturally match the concept of micro-learning and play an important role in its delivery [17][18]. The use of mobile devices (e.g., smartphones, tablets) for learning anytime without being tied to a tightly-delimited physical location [19] is termed mobile learning [20][21]. In what follows, we subsume the above-mentioned learning practices under Mobile Micro-Learning (MML) [13][14]. Note that in the context of informal learning at the workplace, the concepts of micro-learning and micro-training are often used interchangeably, as both refer to short, often digital training or learning activities that can be easily integrated in daily work routines [22][23]. In this paper, we stick to the term (mobile) micro-learning because it favors somewhat more the notions of self-directed learning that go beyond the mere acquisition of knowledge and skills.

MML has been found to increase learners' motivation, improved knowledge retention thanks to reduced cognitive load and repetition [14][18][24]. A the same time, it is an efficient strategy to integrate learning into busy schedules, also for employees working in distributed settings [24][25].

MML seems appropriate for and widely used in informal learning settings [15], also if implemented at the workplace [14]. It stimulates self-directed learning, allowing learners to consume learning nuggets on-demand when they get aware of a problem or question in a specific situation [26], [27]. MML can be easily embedded in daily work routines and allows for informal work-related learning, also in deprived work settings as described in Section I (decentralized work, limited opportunities for interaction, lack of access to desktop computers). If properly designed, MML is not limited to the acquisition of narrow knowledge or skills, but may also enable higher-order learning [26] which is particularly relevant for the experimental and reflective dimensions of informal work-related learning [28].

B. Examples of Mobile Micro-Learning at the Workplace

Researchers and practitioners highlight the potential of MML for onboarding, ongoing professional qualification, and just-in-time learning [29]–[32]. Typical applications of MML at the workplace are compliance training in occupational safety [33] or information system security [34][35], building knowledge on new and existing products [36]–[38], or improving customer service [32]. Other, albeit less frequent are providing procedural work instructions e.g., for installing or technical equipment [37] or in medical care [39], and machine use [40]–[42], as well as improving soft skills such as team management or goal setting [44][45]. Prominent examples from the industry are micro-learning initiatives for occupational safety at Walmart or Bloomingdale's that came with high participation rates and considerable savings [24] or the case of InterContinental Hotels Group to improve the management of complex customer service requests based on micro-learning which helped to reduce onboarding time for new employees from five to two weeks [45].

Recent scientific cases and evaluation studies on MML in real-life work settings cover a great variety of topics, e.g., how to keep costs in large building projects [46], dementia-friendly approaches for staff in neighborhood convenience stores [48][49], methods and approaches in pharmacovigilance [49] as well as a great number of examples from health and medical care [40][51]. Further attempts have been made in the hospitality sector [32], in logistics [51], in ICT [53][54], for public administration and NATO staff [30][55], for librarians [55], for school and university teachers [57][58] as well as for childcare workers [58], and even for employees of dairy farms [59]. However, these examples are either not validated in a real-world setting, contain little information about the actual approach, rely on relatively lengthy learning units, or were published before 2020. Recent topical reviews provide even more examples for MML [17][21][24][29][57][61]–[63]. However, many of these studies were tested in an educational setting, only.

Six studies were analyzed in-depth (S1 – S6, see Table 1) to investigate how companies and public organizations implement MML. All were conducted in real-work settings, underwent scientific evaluation, and contained sufficient details about implementation. The examples chosen rely on short learning nuggets (< 5 min) and primarily draw on rich, interactive media. Looking at studies published not later than 2020 allows us to get an overview of the state-of-the-art.

As the focus of this paper is to study the potential of MML for informal learning in learning-deprived work settings, four aspects are central:

- To what extent can learners self-direct their learning activities?
- Are forms of higher-order learning such as practice, experimentation, feedback, and reflection sufficiently triggered?
- How are learning activities "situated" in actual work routines?
- Do media formats and instructional strategies enable learning among workers who are not used to consuming longer verbal explanations or engaging in self-directed learning?

TABLE I. SELECTED MML STUDIES IN REAL WORKPLACE SETTINGS

Study	***Country no. of learners***	***Topic and learners***
S1 [49]	>100 countries (N>2000)	Pharmacovigilance (pharmacists, medical doctors, others)
S2 [46]	Norway (N=334)	Cost-efficiency in construction projects (project managers, engineers, architects and other)
S3 [47][48]	Japan (N=62)	Dementia-friendly customer care" (employees in neighborhood convenience stores)
S4 [39]	Australia (N>2000)	Clinical care and no-clinical topics (nurses, medical staff, non-clinical staff)
S5 [56]	USA (N/A)	Teaching skills and learning science (faculty at academic health centers)
S6 [50]	USA (N=26)	Point-of-care training for high-risk, low volume therapies (nurses)

Three of the six examples analyzed come with a prescribed learning curriculum to improve specific competencies. S1 to S3 fall in this category. S1 consists of four modules, each comprising 6 to 8 short (2-3 min) videos and a final quiz at the end of every module [49]. Here, learning nuggets are not self-containing as content, practice, and quizzes are separated from each other [48][50]. In such a setting, learners are less expected to engage in self-directed learning but directed toward the predefined learning objectives in small steps.

The three other studies, both from the medical and health care field, allow for more self-directed learning: In S4 [39], a group of Australian hospitals provides the micro-learning format "Take 5 – learning for busy people" to their care, medical and non-clinical staff. Learners go through slide decks with condensed information about clinical and non-clinical topics. A learning nugget could explain the procedure in case of a "code blue" (a patient having a medical emergency such as cardiac arrest). Learning bites last about five minutes. Delivery happens browser-based by the internal website so that staff can search for learning nuggets whenever a problem or question arises during the work process. S5 applies an almost identical approach ("Take 5" on teaching skills and learning science for faculty members in academic health centers [56]): A website contains 41 Take-5 videos, jointly with other resources for learning and development. The videos were professionally recorded, prepared in conversational language, and not longer than 800 words. A blueprint suited for just-in-time learning was suggested and used: A teaser with statistics, an expert testimonial, a question, or a call for action pointing out why the topic is relevant. Then evidence from the literature, expert advice, or tips and tricks were provided. Integrating animations helped to improve the retention of central issues.

In S6 [50], nurses can access point-of-care training for high-risk, low volume-therapies based on Quick Response (QR) codes affixed to work equipment. Scanned with a smartphone, they link to short training videos (2-3 minutes).

The preferred format used in the five examples of MML is slide desks, short video clips (sometimes animated), and quizzes. Only one study additionally uses animated videos and mini-simulation games [47]. Text-based information still plays an important role, as in some work situations, learners cannot play the audio, and videos have to come with transcripts, then [49].

The focus of the analyzed MML seems to be more on information and learning and less on practice, experimentation and reflection. In study 1 [49], learners explicitly point out that they see included quizzes as a valuable instrument for self-assessment, feedback and reflection, but would like to get more opportunities to practice. In S4 to S6, MML primarily relies on static microsites and video clips and does not offer quizzes or other activities related to reflection or practical exploration. A higher degree of self-directedness in learning seems to imply fewer opportunities for higher-order learning and vice versa.

To conclude, the potential of MML for informal, work-related learning depicted in Subsection II is realized only very selectively. The first three studies use MML as the little brother or sister of e-learning: "e-learning courses […] based on micro-learning" [49, p. 1171] seem to be the method of choice to meet the requirements of a remote, distributed workforce that has little leeway for learning when at work. There is only low potential for informal learning while at work, as micro-learning is neither self-directed nor anchored in the work tasks employees perform when learning. In contrast, in S4 and S5 (website with an index of self-contained learning nuggets), learners use learning nuggets as needed when administering a specific work task. Moreover, applying the same instructional blueprint and format for the learning nuggets to meet the needs of the learners appears to be a viable strategy.

However, searching indexes of available learning nuggets using a mobile phone is unlikely to be effective in settings where workers tend to be less savvy in the self-directed use of large amounts of digital information. A promising approach seems to be letting learners access learning nuggets just in time at the workplace by linking them to QR codes in the physical work environment. So far, this approach is not widespread in the workplace. More MML implementations of that kind can be found in work-related laboratory settings [40] and education [62] or again in health and medical care to quickly access guidelines [63].

The instructional strategy adopted in the examples mainly underlines the use of (very) short learning nuggets, often based on videos or text-based information. Workers in noisy settings or with limited skills in verbal comprehension will, however, be less apt to understand spoken or written text. Furthermore, apart from using quizzes to self-assess learning progress, the examples analyzed do not provide novel insight into how we could enhance practice, experimentation, and reflection beyond the mere acquisition of knowledge and skills. This being a general problem in the design of MML [26], it constitutes a particular challenge when MML shall enhance informal work-related learning in very hands-on (and less academic) fields.

Informal work-related learning based on MML requires a concise implementation strategy that allows for self-directed learning, anchors learning nuggets in work, allows for practice, experimentation, reflection, and feedback, and lowers learning barriers for less savvy users. Given that this is quite a challenge, it is not surprising that apart from a few applications in occupational safety training in large corporations and some examples from the hospitality sector, farming, and convenience stores, the majority of empirical studies on MML still refer to (higher) education and often related to science in general or medical and health services in particular, or foreign language acquisition.

III. Approach

Based on our findings in Section II and general design principles for MML [15][26][27], we provide recommendations on instructional strategy and technical implementation for a lightweight MML that fosters informal work-related learning in learning-deprived occupational contexts.

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A. Suggestions for Design and Implementation

A good point of departure for designing and implementing MML are the four principles for MML design summarized from earlier research by [26] and validated in a pilot test by [27].

- *Principle 1*: MML content should fit on the small screens of mobile devices.
- *Principle 2*: MML should address learners in the moment they feel the need to learn something. Connected to this, MML content should be short (no longer than 5 minutes).
- *Principle 3a*: MML learning nuggets should be designed following an instructional flow that starts with an information snippet to provide an aha moment about the relevance (step 1), followed by instructional snippets with short exercises (quizzes, micro games, ideas for practice and experimentation at the workplace) and instant feedback (step 2). This instructional flow is based on an earlier model of Gagne [64], as cited in [27].
- *Principle 4a*: MML content should be designed in a way that triggers interaction between the learner and the content (e.g. using practical and/or gamified activities).

These four principles are an excellent starting point to design MML for informal work-related learning. To make them even more suited to support and trigger informal workplace-related MML in learning-deprived occupational contexts, the following clarifications and additions are put forth:

- *Principle 2a (revised):* We favor short learning nuggets covering a single topic (1-2 minutes) to fit tight schedules, meet a single, specific question arising from the work context and to reduce cognitive load for learners. This is particular important in the workplaces we focus that often are characterized by high time pressure (e.g. in health and care services) or a noisy work environment [42].
- *Principle 2b (Mobile tagging system).* To trigger learning from within work processes, several approaches [40], [62], [63] have found QR codes affixed to work equipment and locations to be a good practice to link to learning nuggets that might be useful in the respective work context.
- *Principle 3a (revised):* The instructional flow suggested helps to design learning nuggets that go beyond the mere acquisition of knowledge and that are still self-contained. However and as pointed out already by [26], besides opportunities for experimentation and practice, learning nuggets for effective workplace-learning should also contain practices for reflection, which further enhances higher order learning.
- *Principle 4b:* Animated videos or visual, interactive work aids should be preferred over text-based and verbal information to enable learners who are less used to consume large amounts of texts or speak another language.

Revising and complementing the four original principles for designing MML content by [26] makes MML more lightweight: First of all, short videos preferably with visualizations and animations lower the barrier for learning for those with less favorable prerequisites for effective informal workplace-learning. Second, self-containing learning nuggets that also comprise reflective activities help to enhance higher order learning processes that are vital for successful workplace learning. Third and last, mobile tagging based on QR codes are a strong trigger to engage in informal learning activities when encountering questions and challenges in the work process.

Similarly, implementing MML for informal workplace learning should be also lightweight from a company perspective. This is captured in two additional recommendations:

Recommendation 1 refers to an easy-to-use authoring tool: Learning managers should be able to generate learning nuggets without too much effort, as studies show that time constraints, a lack of technical skills and inadequate infrastructure are major barriers for the implementation of digitally-supported learning activities [65]. Content types should support the instructional scheme suggested above and support mobile display. H5P allows the user to create HTML5 interactive content and publish it in learning or content management systems such as Moodle, Canvas, WordPress, or Drupal [66]. It is free and open source, appears easier to use than most commercial e-learning authoring tools, and offers many predefined interactive formats that support active learning [67]. Moreover, H5P content can be shared and reused, and open licensing is encouraged [66]. An example of MML that uses H5P to implement interactive content is [52], whereas others use authoring tools such as Articulate Storyline 360 [51] or iSpring Suite [49], or simple video recording and editing software [40][51][57].

Recommendation 2 refers to a secured platform to manage, store and distribute learning nuggets: In most cases, developing a custom micro-learning platform will not be viable. Instead, many companies use a Learning Management Tool (LMS) with support for eLearning [68]. Most LMS support authoring and distribution of H5P content. However, introducing and operating a fully-fledged LMS exclusively for MML might be perceived as too high an investment. This will often be the case for Smaller and Medium-Sized Enterprises (SME). As an alternative, a more lightweight Content Management System (CMS) such as WordPress seems to be sufficient: It supports H5P content generation and storage, comes with user authentication and offers an appropriate structure to manage modular learning nuggets [68][69].

To conclude, the proposed principles and recommendations are considered effective in supporting our learners: They need short learning nuggets anchored in the work process that foster engagement in knowledge acquisition, practice, experimentation, and reflection. The low-threshold approach benefits learners in learning-deprived work contexts who may be less adept at self-directed learning. Similarly, creating and distributing

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learning nuggets is kept simple so that barriers to adoption are low, even for SMEs or companies with little experience with digital learning.

B. *Proof-of-Concept*

As a proof-of-concept, we use a simple website based on WordPress with an H5P plugin as a micro-learning platform. It comes with role-based authentication to protect learning nuggets against non-authorized viewing or editing.

Figure 1 shows how learning managers would generate a learning nugget and attach the automatically generated QR code to a physical object in the work environment, where learners "Scan to learn" with their smartphone camera.

An exemplary learning nugget has been developed and automatically equipped with a QR code. Hereby, an H5P content type "interactive video" is wrapped into a H5P element "KewAR Code" which auto-generates a QR code linking to the readily designed learning nugget when saved. Note that to reference H5P content instead of an URL or other text content, the content type "KewAR Code" has to be extended as suggested by [71]. The H5P plugin in Wordpress offers this combination of content types by default and provides comfortable authoring for such learning nuggets.

The learning nugget has been structured as suggested above, following a blueprint that allows triggering higher-order learning (see Figure 2). The example refers to using a car polishing machine in a garage. Starting point is a short video where learners see an employee operating the machine and explaining the most important do's and don'ts, which comes close to "learning by observing".

Visual overlays to the video present key aspects, so that verbal or written text is not a main mode of presentation. The video integrates quiz questions with immediate feedback to allow learners to assess their progress. The example you see in Figure 2 is a visual true and false activity the angle at which the machine must be placed on the coating surface. Learners provide their answers by dragging the correct and the wrong option in the respective places.

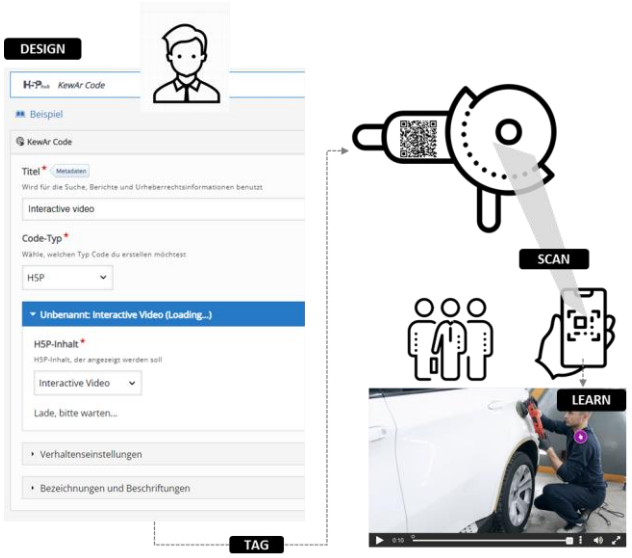

Figure 1. Scan to learn system

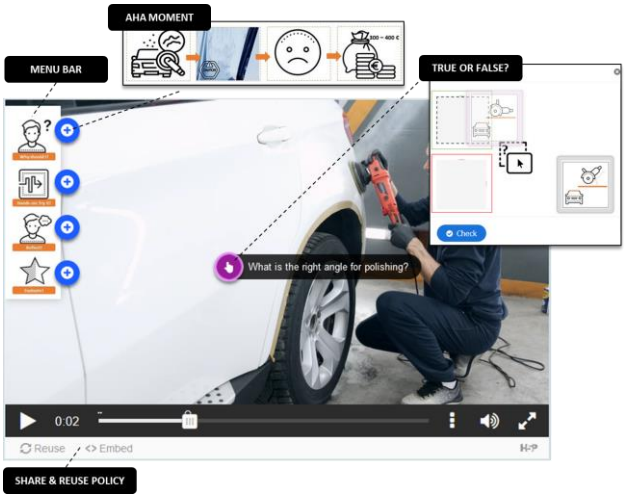

Figure 2. Example for micro-learning nugget

A sidebar with four activity buttons was added to the video. The first refers back to the relevance of the topic. In our example, an infographic provides an aha moment, showing how expensive it can be if workers apply the polishing machine to the car at the wrong angle and cause scratches to the paint. The second button contains ideas for practice and experimentation at the workplace. The third button offers starting points to reflect about the topic of the learning content. Workers can hit the last button to provide feedback on the learning nugget (optional). The activity buttons remain displayed throughout the video, and learners can freely decide whether and when to use it. freely decide whether and when they make use of it or not.

IV. Discussion And Conclusions

In the future, we need even more informal learning to support the tremendous level workforce upskilling as we face major transformation processes related to climate change, population aging as well as ongoing digitization and automation. However, many jobs offer limited opportunities for informal learning, in particular if human-human interaction is scarce, access to stationary desktop computers is difficult, and workers are less experienced in self-directed learning. In Section II, we have shown that the concept of MML closely overlaps with the characteristics of informal learning. The anytime-anywhere options of mobile technology might help to foster informal learning in learning-deprived work settings. However, there are barely some examples for MML programs launched for workers in blue-collar, non-academic fields. Drawing upon good practices in MML, this paper offers suggestions for the design and implementation of MML in such "atypical" settings.

The proof-of-concept in Section III shows that based on a lightweight approach using a website with a simple CMS system, H5P interactive technology and QR codes, the design and distribution of short but engaging MML nuggets is achievable even for novices in the field of micro-learning and SME with limited resources for workforce training. Using short videos as a basis, placing visuals and animations

over "verbals", designing stand-alone learning nuggets with integrated quizzes and other activities that foster experimentation and reflection should help to reduce barriers for learning, and to allow reaping the full benefits of MML for informal work-related learning – also in learning-deprived settings.

The approach suggested comes, however, with some drawbacks. Learning managers who design, curate and manage the learning nuggets may dislike the specific nature and structure of H5P content and the way authoring is organized in our lightweight approach. Furthermore, our approach is a self-hosted solution. Considering this, one might argue that a commercial micro-learning platform would be a more viable option. Indeed, platforms like EdApp [70] offer all needed functionality for our lightweight approach for MML even in its cost-free version (authoring tool for interactive micro-content, automated generation of QR codes). However, the size of video uploads is limited, and learners who wish to quickly access a micro-learning content might, however, dislike the fact that more clicks are needed for learning as compared to our scan-to-learn approach. Platforms like EdApp also require learners to register.

Moreover, due to its anytime-anyplace nature, MML offers by nature only limited potential for learning through experimentation and practice at the workplace ("learning-by-doing") and even fewer opportunities for "social learning" through direct interaction in terms of observation, feedback, or help-seeking. When implementing MML for informal work-related learning, adequate instructional strategies should be adopted to – at least partly – make up for these drawbacks. Some authors point out that it is still an open question of how this can be best achieved [26]. Here we could argue that in the specific work context featured in this paper, social interaction is limited, anyway.

The biggest challenge, however, in helping MML to spread in order to reap its full potential for informal learning at the workplace is the generation of content. Content creation can be cumbersome and is time-consuming. The production of one 5-minute learning nugget can cost € 5000 or more if professionally produced [56]. The lightweight approach suggested in this paper tries to keep it as simple as possible for those designing MML instructional content. In this context, we also suggest to abstain from Virtual Reality or Augmented Reality (VR/AR) applications, even if advancements in mobile technology nowadays allow to implement AR-based MML at the workplace as shown by [71]. However, creating such learning nuggets is particularly challenging with little or no technical expertise in this field [72]. Indeed, the exemplary learning nugget has been produced in less than one hour (excluding video recording) thanks to the existing blueprint and the user-friendly authoring tool in the H5P plugin. The hope of the author of this paper is that the lightweight approach suggested and evaluated in a first proof-of-concept lowers the threshold for both – companies and learners from fields where learning while working with the help of digital and mobile technologies are not yet "daily business". The "scan to learn" system also offers potential to implement lean onboarding processes.

As a next step, the suggested approach should be implemented and evaluated in a real-life work setting, to identify potential improvements. Looking further, the integration of gamified elements and the use of augmented reality in the sense of "marker-based AR" [71] in MML will be promising paths to consider [71][72] – as soon as these rather complex technologies do not induce new barriers for companies and learners, in particular if companies are small and work is of rather non-academic nature.

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