

Editorial

Charalampos Karagiannidis and Sabine Graf, Co-Editors

Welcome to the Bulletin of the IEEE Technical Committee on Learning Technology, Volume 15, Number 4, October 2013 issue. This issue includes two sections: the first section focuses on topics related to **e-learning at the workplace** and consists of five articles discussing cutting-edge research on this topic. The second section is a regular articles section and includes one regular article.

The first section starts with an article written by Edinger, Reimer, and van der Vlies. The article deals with e-learning for supporting teachers in further education. Two comprehensive empirical studies have been conducted, investigating issues such as requirements for e-learning tools, the use of tablets, and demands on the teaching and learning settings for teachers in further education.

In the second article, Ally, Samaka, Ismail, and Impagliazzo report on a study where a mobile app was used to train workers on communication skills. Quantitative and qualitative data were gathered and analyzed, showing as a result that workers enjoyed the flexibility of a mobile app for learning and the post-test indicated high level achievements.

In the third article, Di Valentin, Hegmans, Emrich, Werth and Loos present a domain ontology and a conceptual design of a system which uses this ontology to support users to learn social media skills in the workplace. The proposed tool aims at recommending media contents as well as other users who can be contacted for help.

The fourth article, written by Soualah Alila, Mendes and Nicolle, presents another system for workplace e-learning. The proposed system supports adaptive context-aware learning in industrial training settings, using semantic modelling of the learning content and the learning context.

The fifth article, written by Caudill, provides an overview of how to design successful e-learning initiative at the workplace. The paper discusses issues related to need assessment, content development, media development, testing, production, and assessment, focusing on the requirements and characteristics of workplace e-learning.

In the regular article section, an article, written by Vallance, Yamamoto, Goto and Ibayashi, introduces a new metric for robot task complexity. This new metric, called task fidelity, is based on tasks involving student interactions to program robots collaboratively to solve problems.

We sincerely hope that the issue will help in keeping you abreast of the current research and developments in Learning Technology. We also would like to take the opportunity to invite you to contribute your own work in this Bulletin, if you

are involved in research and/or implementation of any aspect of advanced learning technology. For more details, please refer to the author guidelines at <http://www.ieeetclt.org/content/authors-guidelines>.

Special theme of the next issue: *cloud-based learning and assessment*

Deadline for submission of articles: *Feb. 7, 2014*

Articles that are not in the area of the special theme are most welcome as well and will be published in the regular article section.

Teach the Teachers – E-Learning in Further Education for Lecturers in Higher Education

Eva-Christina Edinger, Ricarda T.D. Reimer, and Stefan van der Vlies

Abstract—The article focuses on how lecturers in higher education use e-learning – not only in a teaching role, but furthermore as learners in further education. An insight into two empirical studies concerning the use of media in e-learning contexts in general and social media and tablet use in particular built the basis. Requirements for e-learning tools as well as demands on the teaching and learning settings will be illustrated. Based on the empirical results innovative e-learning settings for further education have been designed.

Index Terms—Continuing education, Educational technology, Tablet computers, Web 2.0

I. INTRODUCTION

To offer further education on the topic of e-learning for lecturers at a college of education is probably the furthest one can get in the teaching chain. The materials, tools, and teaching concepts that are offered in further education for tertiary education will trickle down from the initial training to the lecturer, who passes them along to his or her student, who will one day introduce them to his or her pupils. The goal of further education in higher education is to enable lecturers to deal with diverse teaching challenges. This is especially the case for the topic of e-learning, where lecturers face three challenges. First of all, they will have to learn how a specific new tool works. Secondly, the lecturers also need to find out how they can integrate the associated teaching and learning materials didactically. Finally, a challenge for lecturers could be that the further education they attend uses a didactical setting they are not familiar with, like a blended learning or flipped classroom. In these particular settings a lecturer would need to have a certain degree of competence in the associated tools, like for example learning management systems (LMSs)

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or communication tools, to be able to complete the course successfully.

Hence a certain level of media and information literacy might have become a condition both for following further education about e-learning and for academic teaching as well. On the one hand, the importance of e-learning, which here refers to all electronically based communication processes that support teaching and learning including social media, increases in terms of reputation and career opportunities within the scientific community (science 2.0). On the other hand, all of the above-named challenges show the difficulties surrounding e-learning for lecturers at a school of education. Both the increase in reputation and the challenges support the need for more further education in e-learning.

The Department for Digital Teaching and Learning (DTL) in Higher Education of the School of Teacher Education of the University of Applied Sciences and Arts Northwestern Switzerland FHNW offers further education for the entire teaching staff (about 680 persons). This further education focuses on the use of e-learning in didactical settings in higher education, for example: the use of tablets, LMSs, research tools, presentation tools and mobile learning. Each offer aims to raise the level of media and information literacy among lecturers. Besides the range of further education, the DTL is involved in research projects to evaluate the educational processes as well as to promote innovation in e-learning, focusing on hard- and software as well as e-learning scenarios. This article describes some of the empirical results of studies of the DTL and traces their interrelation to teaching innovation and further education concerning teaching in tertiary education.

II. RESULTS OF EMPIRICAL STUDIES AND INNOVATIVE TEACHING CONCEPTS IN HIGHER EDUCATION

In order to offer innovative further education that promotes professional and critical-reflexive use of e-learning in higher education for the teaching staff, the DTL conveyed two empirical studies and an innovation project in the years 2012 and 2013. The innovation project was the first of its kind in the German-speaking countries. Since 2011 the DTL offers further education courses on the use of tablets in education for academic professionals that last several weeks. This pioneering project is permanently evaluated and continuously further developed with action research methods. The first study ‘Social media in learning and teaching scenarios in

(further) education' (<http://blogs.fhnw.ch/SMinLehre/ergebnisse/>) evaluated the possibilities of the use of social media in higher education [1]. The study contained three focus groups that included 18 participants (students and lecturers), an online survey among lecturers (n=288, full population survey, response rate: 15.6%), the design of scenarios and pilot tests [2]. The second study 'Media Education at the School of Teacher Education FHNW' pursued the question about the needs and requirements for the professional use of media in higher education. Following a kickoff event with 50 participants (students and lecturers) and a workshop (14 participants), an online survey (n=153, full population survey, response rate: 25.0%) was conducted among the lecturers of the School of Teacher Education FHNW.

A. Requirements of lecturers for e-learning scenarios and tools

In this paragraph some findings concerning requirements for e-learning in general and particular e-learning tools will be discussed. The following results cover the focus groups with academic students and lecturers of the first study and the workshop of the second study. It came to light that students as well as lecturers are "always chasing something". In the case of e-learning students chase content for them to study as well as information on examinations and lecturers chase new technologies that they can use when they teach.

Students feel unsure in matters that involve access to the information they need, for instance: Do they know all platforms the teachers use to distribute content? Did the lecturer hand out the content on paper and if not, is a digital version available on the LMS? Is e-mail the only way of communication? This last question is a legit concern, since most of the communication in higher education still happens via e-mail.

Lecturers are often uncertain if they are aware of the right tools and if they use these tools in the right way. Eventually this uncertainty leads to dissatisfaction and in the end to disturbance of teaching and learning. This could be the cause of the amount the LMS is being used: One third of the surveyed lecturers (study 1) use the LMS in every course, on the other hand another third don't use the LMS in any of their courses. When the LMS is being used, it is primarily used for the course administration and organisation (68.8%) and not for tasks like writing texts simultaneously and cooperatively. 22.6% of respondents are not familiar with collaborative text editing tools, which shows that the availability of innovative technology alone is not sufficient.

Students express a high expectation towards the professionalism of lecturers: They should choose the right tools depending on the didactic objectives and should use tools in the right way. The method-media match is very important. Students name unprofessional and therefore awkward YouTube videos as an example for wrong use of tools.

Both lecturers and students expect a high usability of the used tools and a device independent user experience that

allows working in an efficient and effective way. Especially the media discontinuity, when changing the device within one single task, increases inefficiency [3]. Switching the devices within one task is not only quite common, as a recent study from Google illustrates [4], but it will probably even increase in the future. This increase can be predicted by the current trend to bring your own device (BYOD), which means, that student and lecturers will be forced to combine devices that are provided by the institute with their own ones. Both students and lecturers (in the results of both studies) mentioned BYOD, which shows that it is indeed a current topic.

Lecturers (both in study 1 and 2) demand a 'landing page' that bundles information about both their further education as well as their teaching. This page could for example show which further education courses are available, which tools are recommended for teaching in higher education or who supports the training of these tools. Moreover, the lecturers expect a uniform graphical user interface as well as a single sign-in.

B. Further Education in Teaching with Tablets

The combination of technological developments on the one hand and media didactical implementations on the other hand led us to an innovative project that had high interest from the beginning. The current relevance of mobile learning and constantly growing user base of tablets motivated lecturers to change their role from teacher to student to address this issue. The online survey (study 2) showed that around 40% of respondents owned a tablet either personal or professional use. Additionally, around 110 tablets were purchased at the School of Teacher Education for use in teaching. Not only the faculty, but also the students use tablets for aid their learning and teaching.

It is important that further education in e-learning allows lecturers a direct transfer to their own teaching practice. For this project a course with blended learning design was created, this way lecturers could also be introduced to this kind of teaching. Furthermore, this course uses the university's LMS, evaluates mobile applications that support lecturers in the workplace, and ultimately helps lecturers translate didactical concepts of mobile learning and teaching into practical implementations. These translations are conceptualised by lecturers and are aimed to create workspace scenarios that involve tablets. Still during this blended learning course the participants actively perform these scenarios and finally they are collectively evaluated and discussed with the other participants. During the first three installments 35 lecturers have participated. The second study which is mentioned above added data about the usage of tablets by lecturers. These findings will lead to starting points as well as the potential for further development of university teaching. Figure 1 shows which activities lecturers of the School of Teacher Education FHNW perform with their tablets.

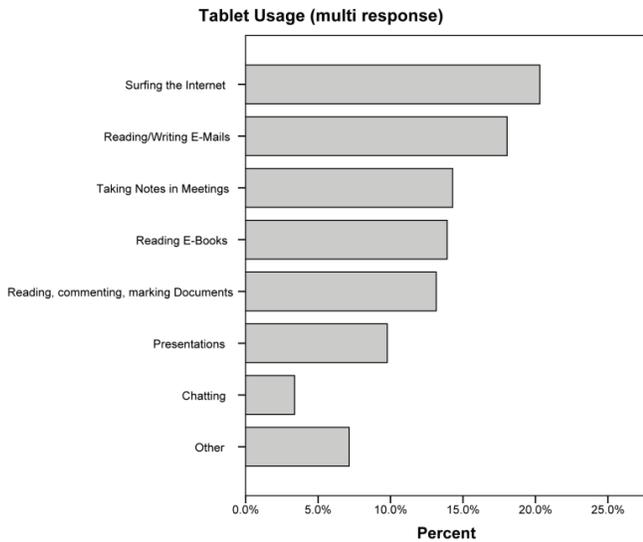


Fig. 1 Tablet Usage of lecturers of the School of Teacher Education FHNW.

C. Heterogeneous Demands for Further Education in Higher Education

Further education can only be successful when it meets the demands of the target audience. However, the target audience of lecturers is very heterogeneous, concerning its pedagogic and media affinity and competencies as well as the desired topics and settings for further education. The pilot tests of the first study showed a dual challenge for the lecturers: New tools have to be learned and at the same time the lecturers also need to find out how they can integrate the associated teaching and learning materials didactically. If they are not able to merge these new tools in their teaching, they risk that their students will not use these tools, since they do not see the benefit in using them. Thus, the skills mentioned above are success factors for the use of e-learning. The same is also true for further education in higher education and should therefore be focused on both directions: University teaching on the one hand, media and information literacy on the other hand.

Lecturers, who have completed further education in the areas of university teaching and/or media literacy in the last ten years, are twice as likely to implement e-learning in their learning and teaching activities. Only 20.8% of all lecturers without such training implement e-learning in their teaching compared to 44.5% of lecturers with training ($\chi^2 = 16.157$, $p < 0.001$). If e-learning or collaboration tools like social media are to be used increasingly, then further education on these topics should be offered to the teaching staff of the university.

The affinities for media and pedagogy in higher education were constructed with indicators. In Figure 2, these two target variables are related to each other. Four target groups for further education can be identified.

Group 1 has both a high affinity for media and university didactics. This group scores higher than 3.0 on both variables and includes about 55% of the respondents. It will likely be able to apply to e-learning settings successfully when a good infrastructure and environment is provided. The second

biggest group, group 2, consists of about 30% of the respondents and can be labeled as media savvy, yet is weaker in terms of university didactics. Further education in university didactics has great potential; since it can be assumed that this group is well versed in Internet based application and requires only a (new) stimulus to be able to integrate e-learning in their teaching. The opposite is true for group 3 (9%), whose respondents score higher on university didactics but lower on media affinity. This group could be empowered by the use of e-learning during the further education about new media and university didactics. Group 4 is the most critical group, as both variables are low, but it is small (6%).

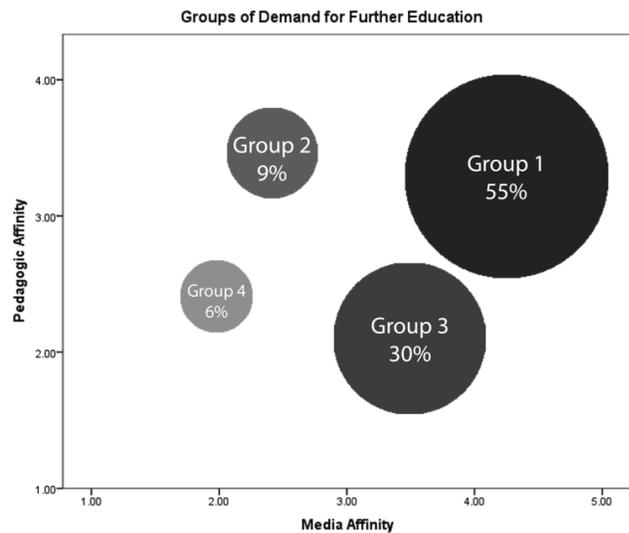


Fig. 2 Groups of demands for further education among of lecturers of the School of Teacher Education FHNW.

Moreover, there is a large spectrum of inquired settings and topics. Of the interviewed lecturers (study 1) 52.4% wished further education in blended learning settings and 21.9% wished pure online training (e.g. webinars). Study 2 identified a number of desired topics for further education in the areas of media education and university teaching, including university teaching in general (26.1%), use of tablets and/or smartphones in teaching (26.1%), use of new media in teaching (22.9%), and use of apps in teaching (22.2%).

III. CONCLUSION

With the above illustrated empirical results from the two studies and the innovation project, we can substantiate and widen theoretical findings like those from Mishra and Koehler [5]. E-learning in higher education, for both university teaching and further education of university lecturers needs, besides disciplinary expertise, an adequate ICT infrastructure, knowledge of innovative tools, competences in university teaching, as well as information and media literacy.

The presented results can be used to help lecturers learn in the workplace by focusing on two factors: On the one hand

the institutional offer of training and coaching, on the other hand the teachers themselves. Training and coaching for lecturers should be on-demand, i.e. they must be aligned on the form and content requirements of the lecturers. Moreover, individual services should be available just-in-time. Furthermore training and coaching should not just focus on tools; it is the interplay with information and media literacy and university teaching, which makes them successful. Consequently, the target group is characterised by the heterogeneity in the topics they teach but also the heterogeneity in their knowledge levels of university teaching and media education. With this in mind we reach the second level, the lecturers themselves. Professional disciplinary knowledge must be combined with competencies in university teaching and media teaching skills. Therefore it is important that lecturers set their individual goals for further education that are related to their competence. They can develop their skills by, for instance, attending training and coaching, do some self-studies, and participate in a community of fellows where ideas, concepts and experiences can be exchanged.

The DTL provides training, coaching and on-demand online counseling. On its website (www.digitallernen.ch) a large amount of self-study material can be found concerning e-learning tools, as well as the matching methods and settings in various formats like a blog, tutorials, screencasts, and an online community. This self-study material encourages just-in-time learning among the lecturers. The above introduced innovative tablet project based on a blended learning setting brings both levels, the named requirements for tools and devices as well as the demands on settings and topics together.

E-learning for teachers can be independent of site and time; this is due to the internationalisation of the university and higher education. However, it is crucial that it meets the needs of the lecturers; otherwise the training opportunities are not perceived as useful. At the same time the offers must be anchored to the lecturers workspace to reflect their personal situation. Last but not least: Bringing all the components together - disciplinary expertise, tools knowledge, media competency and concepts of university teaching – takes time; for both, learners as well as teachers.

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Use of Mobile Learning Apps in Workplace Learning

Mohamed Ally, Mohammed Samaka, Loay Ismail, and John Impagliazzo

Abstract - Organizations are starting to use mobile learning to train workers and to provide professional development of workers so that they can function on the job. The training can be delivered using mobile apps which provides the flexibility and security for the training. The apps can be preloaded on the mobile device or workers can download the apps on their mobile devices. This paper reports on a research study that used a pre-loaded apps to training workers on communication skills. The workers like the flexibility the mobile app provided for learning and they performed well on a performance test.

Index Terms - Workplace learning, mobile learning, mobile technology, apps, mobile learning apps

I. INTRODUCTION

Organizations are starting to see the benefits of using mobile learning for flexible delivery of training in the workplace. At the same time many countries are investing in mobile learning development and research to educate their citizens to prepare them to function in the 21st century workforce and to improve performance on the job. For example, Qatar is investing in research and development in mobile learning to train its citizens for the ever changing and global workforce. This paper presents an innovative research project in Qatar that is using mobile learning apps to train workers in the oil and gas industry to develop their communication skills to function on the job.

There are many advantages of using mobile learning in the workplace. Workers can access just in time training to apply right away [1] and they can access information relevant to the location there are working [2]. Workers can access current information for just in time application since information is stored in electronic database. In some countries citizens are moving directly to mobile technology rather than using desktop and notebook computer. Hence, delivering education and training using mobile technology will reach many citizens in countries, especially in developing countries.

II. LITERATURE REVIEW

Mobile learning apps are applications developed for learning using mobile technologies. The apps can be pre-loaded on the mobile technology or downloaded from a network. Development of mobile learning apps must follow good instructional design principles to achieve one or more

specific learning outcomes. There are many definitions of mobile learning. One definition of mobile learning is the use of electronic learning materials with built-in learning strategies for delivery on mobile computing devices to allow access from anywhere and at anytime [3]. Another definition of mobile learning is any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies [4]. A recent definition of mobile learning that was suggested by an international standards committee is learning using information and communication technologies in mobile contexts [5]. This definition emphasize that learners are mobile and they use technologies to learn while they are mobile. This is true for the workplace where workers are mobile and they can use mobile apps for just in time learning.

There is increasing use of mobile learning in the workplace [1] [6]; however, the mobile learning delivery must be flexible to allow workers to complete the training from any location and at anytime. In some workplace, learners may not have access to networks all of the time because they could be in different locations. As a result, it may be more convenient for mobile learning apps to be downloaded on the workers mobile devices. According to [6], there are many advantages of using mobile apps. The use of apps is efficient since they can be retrieved in a short time. The apps are secure since there is no external connection and there are built-in security measures in the apps. Organizations that are concerned about internet security prefer workers to use pre-loaded apps. The procedure to access the apps is simple which is important for the employees who are not familiar with mobile technology. An additional benefit is that the apps are independent of each other so that the lessons in the apps can be completed at different times. Also, learners can use the communication capability of the mobile technology using local networks in close proximity in the organization to communicate with each other.

Most apps developed to support learning rather than to provide the learning experience and activities for learners to achieve learning outcomes [7] [8]. This study went beyond providing support to students. The learning materials with feedback were included in the apps. In addition to completing the apps to achieve learning outcomes learners can use the mobile technology for inquiry learning [9] to get further information after using the app.

There are many benefits of implementing mobile learning in the workplace. With the use of wireless technology, mobile devices do not have to be physically connected to networks to access information. In some cases, learners can download the

learning materials as applications (apps) to learn without having to connect to a network. Mobile devices are small enough to be portable which allow workers to take the device to any location to access information or learning materials. An important advantage of using mobile learning apps in the workplace is just in time training where workers can access apps and apply what they learn right away to promote high level learning. They can also learn in their own contexts which make the learning more meaningful. For example, if a worker want to review the procedure to operate a piece of equipment, the worker can access an app for training on the use of the machine. Another example is if a worker is out in the field and has to complete a dangerous task, the worker can access a safety training app on a mobile to complete the task.

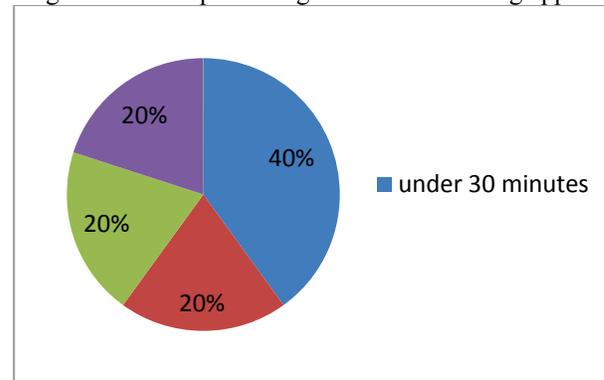
III. METHODOLOGY

The research used mixed methods where qualitative and quantitative data were collected. A total of ten subjects completed the mobile learning app lessons. The qualitative data was obtained using a questionnaire. The quantitative data was obtained using post-test performance data. The data obtained was analyzed by a research assistant who was not involved in the data collection. The development of the app was done by a group of experts consisting of content experts, instructional designer, and mobile technology experts. The team developed the mobile learning app to train workers on Presentation Skills that was delivered on Android smartphones. The app was pre-loaded on the mobile phone and provided to the learners. To complete the training, the learners click on the App to access the lessons. The effectiveness of the App was evaluated by a test to determine how much the subjects learned from the App. The test was based on the learning outcome of the training lesson in the App. The App was also evaluated by asking learners to complete a survey to determine their satisfaction level with using the App and how the App benefited them. At the end of the training, the learners completed a post-test to determine how much they learned from the mobile learning App. The post-test consisted of multiple choice, completion, and matching questions. This was followed by the completion of the survey to determine the satisfaction with the mobile learning app experience.

IV. RESULTS AND DISCUSSION

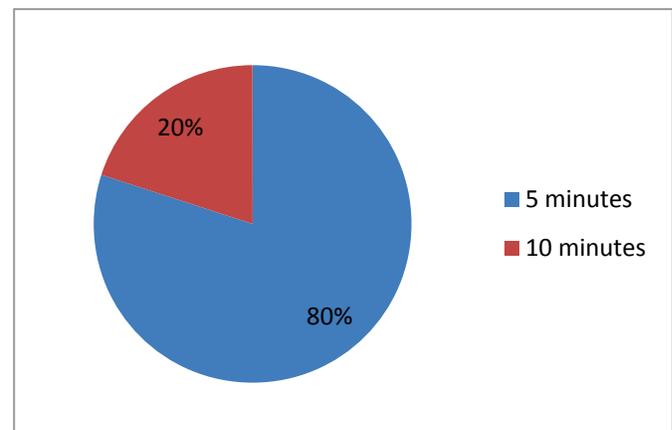
After learners completed the training using the apps, they were asked to complete a survey to obtain information on the use of the apps. Learners were ask how long they spent using the app. The amount of time spent using the app to learn ranged from less than 30 minutes to more than 3 hours (Figure 1). The majority of the learners used the app for under 30 minutes.

Figure 1: Time spent using the mobile learning app?



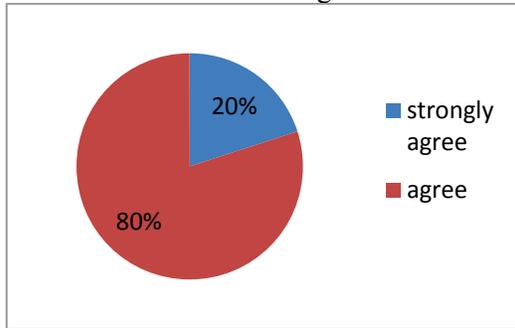
The learners were asked how long they spent on the app outside of the formal training sessions. The majority of learners spent five minutes while others spent ten minutes using the app outside the formal training session (Figure 2). The reason is because the instructor gave students some time during the formal training session to access the app individually. However, some learners did access the app outside the formal training session. This shows that there is the potential of learners using mobile apps to learn on their own time. Learning from anywhere and at anytime are major advantages on using mobile technology to deliver training.

Figure 2: Amount of time using the app outside the formal training session



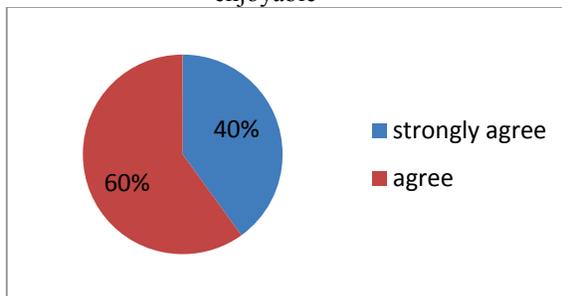
The learners were asked whether the mobile learning app provide flexibility to learn anywhere and at anytime. All of the learners either strongly agreed or agreed that the app allowed them to learn anywhere and at anytime (Figure 3). This is one of the major benefits for use of mobile learning in the workplace.

Figure 3: Mobile learning app provide flexibility for learning



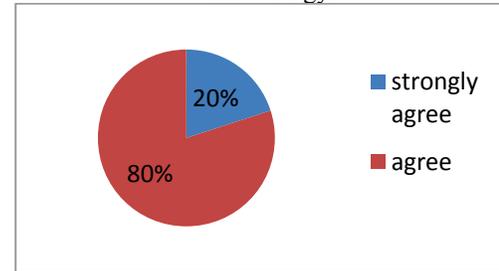
Learners were asked whether the mobile learning app increased their enjoyment of learning. All of the learners either strongly agreed or agreed that use of the mobile learning app increased their enjoyment of learning (Figure 4). The mobile learning training lesson was interactive and relates what the workers were learning to what they were doing on the job. This made the learning more meaningful which resulted in positive experience with using the app. Also, learners were provided with feedback as they completed the training lesson which allowed them to check how they are doing with the lesson. Timely feedback and relating to the job environment are important for workplace training. It seems as if the learners were comfortable using the technology because they have used mobile technologies in the past. They were able to transfer the technology skills while learning with the mobile apps.

Figure 4: Learning with the mobile technology is enjoyable



Learners were asked whether would like to take other lessons using mobile technology based on their experience using the mobile app for learning. All of the learners either strongly agreed or agreed that they would complete other mobile learning lessons (Figure 5).

Figure 5: Would take other lessons using mobile technology.



Upon completion of training with the mobile learning app, learners were given a post-test to determine how much they learn for the mobile learning app. The average score was 79 percent indicating that the mobile learning app resulted in high level achievement.

The learners were also asked to provide general feedback on the use of the mobile app for learning. Learners reported that they like the flexibility the mobile learning app provide for learning. They also reported that the technology allow them to re-use the app to learn at a later time. This is important for review and future skills development. They also like the portability of the mobile technology which makes it easy to move around to learn. However, some learners said that they prefer to use the app at work rather than at home. Possible reasons are (1) the learners, who are full time workers, are tired after working all day and do not want to do “work” at home and (2) they have family responsibilities that they need to attend to at home. Future research studies should investigate how motivate workers to use mobile learning apps to learn outside the workplace. Some learners whose English is a Second language said that the app should be presented in English and in their own language to make it easier for them to learn. This project deliberately developed the app in English since one of the outcomes of the project is to improve the English skills of the workers.

V. CONCLUSION

This is the first time the workers are experiencing the use of mobile learning apps to learn. They have used mobile devices before for communications but not for learning. They reported that they like the flexibility that mobile learning provided to learn at their own convenience. They said that mobile learning is a good method for workplace learning. The workers in this study are always on the move and downloading the app on their mobile device allowed the workers to control when they can access the app to learn. This is important since in some workplace there is limited access to networks for workers to access learning materials to complete their training. The use of apps for workplace training should give learners the option of downloading the apps on their mobile device and then

completing the training at a later time or letting the learners access the training if they have connectivity to a network. Additional research is needed on how to integrate the use of mobile learning apps with hands-on practical training since some training on the job requires hands-on skills. This required research on location-based learning and contextual learning in the workplace using mobile learning apps.

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Conceptual design of a tool for personalized and context-based learning on the job

Christina Di Valentin, Julia Hegmans, Andreas Emrich, Dirk Werth, Peter Loos

Abstract—An appropriate use of media is a key success factor for communicating information efficiently in educational and professional context. The vocational education and training community would benefit from tools that foster media usage both from trainee and teacher / trainer perspective. Aspects like co-creation and information sharing influence collaboration in the web. Hence, competence-related knowledge is crucial to use media in an efficient way. This paper presents a domain ontology and the conceptual design of an assistance system which fosters an efficient use and reuse of media content in professional context by receiving recommendations about appropriate media usage.

Index Terms—Context-based learning, decision support, assistance system, vocational education.

I. INTRODUCTION

THE last decade has been characterized by an arising popularity of key technologies which have established in many settings [1], [2]. The educational sector has become aware of these developments and the potentials that come along with these trends [3], [4]. Most users of social and digital media are familiar with those applications in private context [5]. However, when it comes to efficiently integrate social media in professional or educational context users often show a lack of competences.

The main goal of the presented research is to improve the social media skills of all stakeholders in vocational education and training (VET). Therefore, the conceptual design of an assistance system is presented which supports trainees, trainers, teachers and staff developers in VET to develop and apply social media skills in their teaching and learning processes. In doing so, users are individually recommended appropriate media contents that match to their current context in VET. Thus, trainees learn how to efficiently use social media tools in their apprenticeship whereas teachers and trainers are provided educational concepts for teaching scenarios or training programs. The research method follows a

design science oriented methodology, which aims at the artificial construction and evaluation of innovative artifacts [6], [7].

First, a collection of relevant definitions in the context of decision support in VET is given in Chapter 2. The derived definitions have been classified into models and methods, which will be implemented in a next step. Furthermore, this chapter gives an overview about related work of recommender systems that support learning at the workplace. Based on the state of the art, shortcomings for the concept of the assistance system are collected as requirements. Chapter 3 explains the concept and the domain ontology of the VET assistance system, whereas Chapter 4 presents the developed software design. The paper closes with a summary and gives an outlook on future research.

II. RELATED WORK AND REQUIREMENTS DERIVATION

A. Social Media Skills

Social media skills describe the capability of adequately applying several types of social media technologies which comes along with the ability of their constructive and receptive use (social media production and consumption) [8]. Thus, a person having social media skills uses social media technologies with the goal to reach specific objectives. Social media skills and knowledge about social media can be described according to four facets, which also form a basis for the assistance system [9]:

- 1) the ability to search and select information,
- 2) the ability to manage information,
- 3) the ability to communicate and comment on information and
- 4) the ability to create information.

B. Recommender and Collaboration Systems for E-Learning Scenarios in Professional Context

Several tools were identified which use social media in the context of VET or promote the use of such. Thereby, collaboration and personalized learning facilities as well as recommender systems were key factors in the selection of these tools. The *TARGET platform* provides multiple ways of interaction amongst learners with the objective of sharing experiences and collaborative reflection such as annotations, blogs, wikis, microblogging, tagging and creation of private

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groups [10]. *APOSDLE* recommends experts and colleagues' best practices based on the knowledge level and task of the learner [11]. Furthermore, the platform facilitates a networking of its users [11]. *Mediencommunity 2.0* is a tool for all stakeholders in VET which consists of the two main areas [12] "information and training" as well as "networking and collaboration". It is mainly used in terms of exam preparation [12]. There also exists a trainer community on how to apply multimedia methods in class. The project *MIRROR* focuses on motivating employees to reflect their operations in order to foster learning experiences. The main goal is to develop creative solutions for current problems that occur in day-to-day work [13]. The *Blok Online Portfolio* has been developed especially for the dual apprenticeship system, motivating

apprentices to write a personalized learning diary on a blog and offering tools to get in contact with teachers and trainers [14]. Collaborative knowledge building and training for teachers in VET and adult education about the use of social media in class is the prime objective of the *SVEA platform* [15]. Individual and group dashboards provide the user news, whereas group work is facilitated by to-do lists, calendar, microblogging, bookmarking and private messaging. The project *India Web 2.0* developed a platform with teaching scenarios for the use of wikis, podcasts and blogs in vocational training for IT application specialists [16]. The following table presents the results of the related work analysis and describes whether an approach or tool has fully met a requirement (+), partially (o) or not at all (-).

TABLE I
RELATED WORK ANALYSIS

		[10]	[11]	[12]	[13]	[14]	[15]	[16]
Content	subject-related	+	+	+	+	-	-	-
	social media literacy-based	-	o	-	-	-	+	+
Provided Content	structured training units	+	-	+	+	-	+	+
	recommendation of content	+	+	-	+	-	-	-
	recommendation of users	-	+	-	+	-	-	-
	integration of external content	-	-	o	-	-	-	-
Collaboration	creation of learning groups	+	o	+	-	-	+	-
	wikis/blogs/forums/chat	+	o	+	o	+	+	-
	add content	+	+	+	+	-	+	-
	share content	-	o	-	+	-	-	-
	rate content	+	o	+	o	-	-	-
Recommendation	content (personalized)	+	+	-	-	-	-	-
	content (context based)	-	+	-	+	-	-	-
	users (personalized)	-	+	-	-	-	-	-
	users (context based)	-	+	-	+	-	-	-
	processes (personalized)	-	o	-	-	-	-	-
	processes (context based)	-	o	-	+	-	-	-

The table shows that so far there is a lack in recommending contents to users with the goal to increase their social media skills. Furthermore, current tools so far do not support the recommendation of users to other users in the learning or teaching process under consideration of increasing media literacy. Three tools provide learning areas where users can group share and recommend others. However, none of the approaches offers storage functionality, to synchronize media contents with a device and the online library of the user to access content offline.

Based on the gap analysis from the related work, we derived the following requirements for decision support in VET: Requirement 1: Stakeholders must be able to use, share and reuse media content as well as media related knowledge in a simple manner. Thereby, users should be able to define common spaces to share with fellow students or topic related with people of similar interests. At the same time users should also be able to define personal spaces to have a private learning pool. Requirement 2: Users should receive recommendations that help them with their media usage and they should be able to explicitly search for media contents. Thereby, every decision support action should consider the specific social media skills of the user as well as the current

step in the work process. Requirement 3: External information should be integrated to keep the system up to date.

III. FUNCTIONAL DESIGN OF THE ASSISTANCE SYSTEM

A. Overview of the Concept

The VET assistance system is a tool which provides all stakeholders of teaching and learning processes information in form of links, documents or tools (tests, e-books, etc.). If a teacher e.g. carries out a project which aims at an integration of iPads in teaching classes, s/he first might want to find out if this project has been carried out at other schools or trainee companies. An interface to the web enables the teacher to receive information about similar projects e.g. in form of teaching scenarios, educational methods, teaching concepts, didactical methodologies, curricula or relevant media. The assistance system is not only a pool for documents, tools and further contents. It also focuses on a networking of its users. In our example the teacher could contact other teachers and trainers via the assistance system who already dealt with this topic. Hence, the experience knowledge of each individual can be efficiently integrated in teaching and learning processes. Thereby, an increase of the user's social media skills is always

in the focus. Hence, several functionalities are provided by the assistance system. Users receive recommendations about an efficient use of media contents under consideration of their current situation in the learning or teaching process. In addition to proactive recommendations users are also able to search for relevant media under consideration of their current working context. The individuals' activities are logged to derive support frameworks and best practices. By this means,

an adjustment of content, pedagogy and technology can be achieved.

B. Domain Ontology

The following figure shows the knowledge model that depicts the associations of all related concepts that are needed to derive the recommendation results.

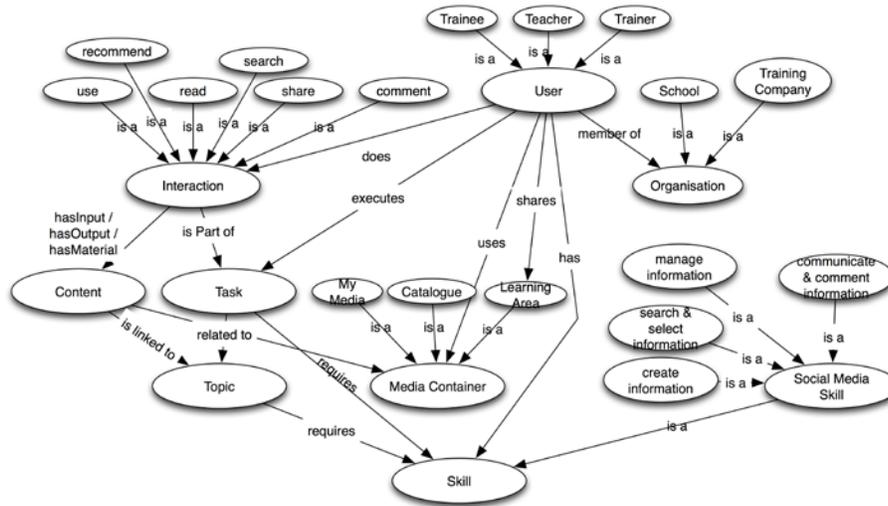


Figure 1 Domain Ontology.

Users interact with specific media contents when they carry out a specific task. Thereby, users can actively search for content and they are recommended content that matches to their current context. The content is organized in form of media containers consisting of the components *My Media*, *Catalogue* and *Learning Area* which structure will be described in the following section. A task is related to a specific topic in the curriculum of vocational education and training (e.g. “requirements analysis” within the apprenticeship of “Qualified IT specialists”), which requires specific social skills that are described according to the four facets (see Chapter 2).

recommended media contents by dragging them into their personal learning area *My Media*.

IV. SOFTWARE DESIGN

When logged in to the system, users get proactive recommendations on the welcome page via the *Activity Stream* about media contents that match to their current context (e.g. videos, news, tweets or announcements from social networks, etc.). At the welcome page, users can select between the functionalities *My Media*, *Learning Area* and *Catalogue*.

The *Catalogue* comprises all media that are freely available within the VET assistance system (see Fig. 2). The stored media is already processed and indexed. Search and recommendation activities enable deep searches on media contents (cf. Req. 2 and 3). Users interested in specific media can request further details about selected items. Search and recommendation results can be rated in form of an “I like Button”. Additionally, users have the possibility to tag and comment on information. Users can manage and classify



Figure 2 Catalogue View of the assistance system.

The component *My Media* describes the users' personal area in which they can import and store media content that has been selected in the *Catalogue* or in the *Activity Stream*. In doing so, users can classify media contents according to their preferences (Req. 1). The following figure shows how media contents can be arranged within this component:



Figure 3 My Media View.

The *Learning Area* covers aspects about collaboration within learning and teaching activities. Users can bundle media contents that have been stored in *My Media* regarding specific aspects and share them with other members of the VET system (e.g. videos and documents about creating and moderating a blog). Hence, teachers can prepare lessons and share contents with their classes, whereas trainers invited to specific groups can stay up to date about current teaching and learning content and adapt their trainees' tasks to current teaching activities (Req. 1). Trainees can create learning areas to collaborate with other users (e.g. in terms of group work). Additionally, trainees are recommended users to contact if specific questions within a learning process arise. Learning areas can also be published in the *Catalogue* (after agreement of their creators), where they can be found by other users of the system. Hence, other users can benefit from already published learning areas.

V. CONCLUSIONS AND OUTLOOK

This paper has presented the concept and software design of a tool that supports the development of social media skills in the workplace by recommending its users the right usage of digital and social media tools. A comprehensive analysis of already existing recommender systems for e-learning scenarios has shown that even though a number of tools concerning collaboration and participation in learning scenarios exist, so far there do not exist tools which provide personalized and context aware recommendations of media contents in VET.

In a next step the conceptual design will be implemented and evaluated according to rigorous design science methods within a research project. The domain ontology presented in this paper will be refined by relevant topics and tasks on the basis of expert interviews and focus groups from the field of VET. Furthermore, the ontology will be expanded by already existing ontologies such as FOAF (Friend of a Friend) and ALOCoM [17]. The developed ontology will improve information sharing and communication between training companies and vocational schools as well as the media competence of each individual based on personalized recommendation of teaching and learning material. In addition to the ontology, filtering and ranking criteria for the evaluation of search results and recommendations will be developed. The implementation will follow an iterative approach to be able to continuously integrate feedback loops.

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A Context-Based Adaptation In Mobile Learning

F. Soualah Alila, F. Mendes, and C. Nicolle

Abstract—Recent developments on mobile devices and wireless technologies enable new technical capabilities for the learning domain. Nowadays, learners are able to learn anywhere and at any time. The dynamic and continually changing learning setting in learner's mobile environment gives rise to many different learning contexts. The challenge in context-aware mobile learning is to develop an approach building the best learning content according to dynamic learning situations. This paper aims to develop an adaptive system based on the semantic modeling of the learning content and the learning context. The behavioral part of this approach is made up of rules and metaheuristics to optimize the combination of pieces of learning content according to learner's context.

Index Terms—Adaptation, context, mobile learning, semantic web.

I. INTRODUCTION

MOBILE learning (m-learning) is a natural extension of e-learning. It has the potential to make learning even more widely available, thanks to the rapid development on wireless technologies and the widespread use of mobile devices.

In the professional environment, training employees is at the heart of the concerns of human resources. Indeed, developing employees' skills has become a critical issue because of the continuing evolution of companies, to make sure that employees gain new knowledge. At the same time, there is an increasing number of employees working outside the office. Given the speed of business today and the problems due to information overload, employees require information and knowledge just when they need it, in their desired format and on the device of their choice, particularly as the use of mobile devices has become second nature. This is why the traditional training paradigm is shifting to just-in-time transmission of knowledge and information to boost employee performance. With personalized m-learning, an organization can deliver targeted pieces of content that help an employee on the spot, rather than heavyweight classroom or just computer-based training.

The dynamic and continual changing of learner settings in a mobile environment and the diversity of learner's characteristics as well as mobile devices and networks, give rise to different learning situations and therefore requires

personalization for different cases. The search of educational content in a m-learning system can be defined as an activity whose purpose is to locate and deliver educational content to a learner according to his needs and the environment in which he is. So far, the learning environment was either defined by an educational setting (work, trainer, etc.), or imposed by the educational content (the learner must arrange his environment to receive training). In our approach we change the paradigm where the system adapts learning flow to the *context* of the learner.

The term *context* appeared the first time in 1994[1]. Here, location, identity, time, environment, and mobile technology have been suggested as primary types of context [2] [3] [4] [5]. Many previous studies in mobile computing provided various definitions of context. A commonly used one is: "any information that can be used to characterize the situation of an entity participating in the interaction between a user and a system" [6]. In the case of m-learning, location, time, identity and the mobile technology used to learn are the primary context types for characterizing the situation of a particular learner. These context types not only answer the questions of who, what, when, and where, but also act as indications for other sources of contextual information. For example, given a learner's identity, we can acquire many pieces of related information such as user tasks, roles, beliefs, desires, objectives, relationships with other users in the environment, etc. Furthermore, context can be information about devices (smartphone, tablet, connectivity, etc.), time (time of day, day of week, holidays, etc.), localization (in train, at home, at work, public place, etc.) and physical environment (lighting, noise level, etc.) since this may change the way users interact with any device they may be using. This set of information is useful to adapt the interaction and generally adapt the application behavior to the learner situation.

This paper presents ongoing research on an adaptive context-aware m-learning system that aims to offer a new approach for designing and adapting learning content as part of industrial training. This approach take into account the context of mobility related to the industrial training environment. To achieve this goal, it is necessary to improve the current e-learning systems with adaptation techniques to support the generation and management of m-learning environments so that, given a specific learner context, the system is able to suggest the most suitable learning activities to be accomplished in that specific situation.

II. ADAPTIVE EDUCATIONAL SYSTEMS

The objective of adaptive educational systems is to adapt the presentation of knowledge to learner. These systems have become very popular since 1990s, to allow users to access to

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personalized information [7]. In e-learning, learning content has witnessed high dropout rates as learners become increasingly dissatisfied with contents that do not engage them [8]. Such high dropout rates and lack of learner satisfaction are due to the "one size fits all" approach that most current learning content developments follow, delivering the same static learning experience to all learners, irrespective of their prior knowledge, experience, goals and context. Adaptive educational solutions have been used as possible approaches to address this dissatisfaction by attempting to personalize the learning experience for the learner. This learner empowerment can help to improve learner satisfaction with the learning experience.

In the recent years, many initiatives aimed at building educational resources to share and reuse them, have emerged. Learning Management Systems (LMS) are based on techniques of collaborative work, where communication processes come to support learning. These platforms should dispose of well-structured and organized pedagogical warehouses. Explaining a training course around items of knowledge offers advantages and opportunities to individualize training. In this case, the contribution of semantic web technologies is significant. We suggest the use of ontologies to allow the modeling of complex networks knowledge.

III. CONTEXT-BASED ADAPTATION MECHANISM

The aim of our adaptation mechanism described below is to satisfy learners' needs when connecting and interacting with the system.

Traditionally, adaptation systems in learning domain deal with applications that have two types of entities, which are users and items. To provide adaptation in a mobile environment incorporating contextual information, we propose a multidimensional adaptive model (MD model) based on the multiple dimensions of context (spatial, temporal, environment and device dimensions) and, therefore, extends the classical two-dimensional User \times Items paradigm to a multi-dimensional paradigm.

To develop such a m-learning system, we have to bridge the gap of two different levels of heterogeneity: semantic heterogeneity and heterogeneity of use between the current design of the learning content and the willingness to adapt these resources to different learner profiles and context.

On one hand, in e-learning, resources are designed and developed by different organizations and trainers, usually constituting semantically autonomous and heterogeneous data sources. Therefore, interoperability between these resources is complex: systems should be adapted to determine the required syntax and resource specific terminology to be able to combine relevant content and construct the final training result.

On the other hand, learners have different prior knowledge and objectives and are located in different learning environments (heterogeneity of time, learning time, visual support, ambient noise, etc.). By having a better knowledge of these learners

and of their learning environment, that we can efficiently query on pedagogical strategies, and set them up to respond to everyone needs.

To bridge this gap, our system is made up of a semantic level and a behavioral level (see Fig. 1.): the *semantic level* aims to express semantic characteristics of learning contents and learner context (what, how, when, where, via which device, etc.). Semantic modeling consists in describing the meaning of data by experts. This transfer of knowledge from experts to the computer enables our system to perform more intelligent reasoning according to changing constraints. The *behavioral level* is an adaptive system designed to overcome the problem of information overload by providing users with only the most relevant information. Here adaptation must be made considering the learner context while maximizing its benefit. The behavioral level contains the best learner practices (transformed in a set of logical rules) and algorithms of combinatorial optimization.

Combining the semantic and behavioral levels allows us not only to generate learning content, but also to generate learning methods adapted to the context of each learner. In what follows, we present these two levels.

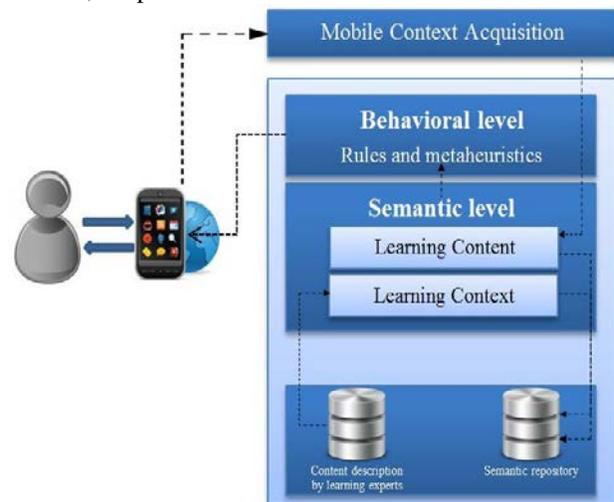


Fig. 1. M-learning context-based adaptive system architecture.

In the following, we focus respectively on the semantic level and behavioral level of our proposed architecture.

A. Semantic Level

The semantic web, envisioned as an extension of the current web [9], was proposed to provide enhanced access to information based on the use of machine-processable metadata annotating the web resources. To facilitate this process, RDF¹ (Resource Description Framework) and OWL² (Web Ontology Language) have been developed as standard formats for the sharing and integration of data and knowledge, the latter in the form of rich conceptual schemas called ontologies. Ontologies offer a way to cope with heterogeneous representations of resources on web and their interoperability. An ontology

¹ <http://www.w3.org/RDF/>

² <http://www.w3.org/2004/OWL/>

representing a model of a specific domain can be used as a unifying structure for giving information a common representation and semantics. Ontologies are becoming very popular due to their promise to allow a shared and common understanding of a domain that can be communicated between people and applications.

Realizing the potentials of semantic web technologies in education, initiatives using semantic web technologies in e-learning started in late 90's [10] [11]. The major argument for this is that the availability of massive information is of no use, unless the right information in the right context with the right level of details to the right person at the right time [12] is delivered.

In the recent years, to build an approach of quality and to make learning platforms and their contents interoperable, international standards are developing in educational technologies³. Standardization initiatives do not seek to standardize teaching methods or multimedia technologies used. They just aim to set up rules that will help in sharing and reusing educational modules. These standards are still in constant evolution. The IEEE proposes the LOM (Learning Object Metadata) standard⁴. This standard specifies a conceptual data schema that defines the structure of a metadata instance for a Learning Object (LO). For this standard, a LO is defined as any entity, digital or non-digital, that may be used for learning, education or training. ADL (Advanced Distributed Learning)⁵ has recognized the need for a model that aims to make learning platforms and their content interoperable. This model is the standard SCORM⁶ (Sharable Content Object Reference Model) which has become a major asset for distance learning platforms. It integrates a set of related technical standards, specifications, and guidelines designed to combine LOs around a package accessible, interoperable and reusable on other SCORM platforms.

To benefit from both the adaptive qualities of ontologies and the high scale interoperability brought by SCORM, we opt for an approach where the adaptive system output will be packaged as SCORM content. However, the learning content is modelled, indexed and manipulated by the system thanks to ontological models. This ontology is called *domain ontology of m-learning*. It presents the main concepts related to m-learning domain. It is largely based on concepts of LOM schema organization to describe LOs. Using a LOM model for indexing LOs enables a better understanding of learning contents, and therefore facilitates their descriptions. We followed some rules described in [13] to transform this schema into a set of ontological concepts and relations.

The second step to define the semantic level is modeling mobile learning context. We believe that ontologies are key requirements for building context for two reasons: first, a context can be considered as a specific kind of knowledge; and

as such, ontologies are the state of the art for an efficient modification of context. Ontology-based models of context allow representing complex context knowledge and provide a formal semantic to context knowledge, which supports the sharing and integration of context information [14]. Second, a common ontology enables knowledge sharing in an open and dynamic distributed system [15]. To describe context, we model concepts related to different context dimensions:

- 1) Temporal dimension. In this dimension we try to answer two questions: "when?" to define the exact temporal localization of an event, and "how long?" to define the duration of an event. With the concept *Laps* we can measure the duration of an event (15 min, 2 days, etc.). With the concept *Time* we can determine when an event should take place. We distinguish two sets of temporal localization type: *Abstract_Time* (in the morning, at the week-end, monday, etc.) and *Concrete_Time* (at 10 am, the 12/10/2012, etc.).
- 2) Spatial dimension. This dimension refers to a position or a place. A position is a *Concrete_Location* and refers to *Geographic_Coordinates*. A place is an *Abstract_Location* (at home, in a restaurant, in a train, etc.). We have also collected some characteristics of environment such as *Location_Type* (dynamic, public, etc.) in this dimension, and *Location_Properties* (comfort, noise level, etc.).
- 3) Device dimension. Information related to devices is generally divided into three sets depending on the type of information they provide [16]: *General_Description*, *Hardware_Description* and *Software_Description*. *General_Description* contains basic information related to a device such as *Device_Name*, *Device_Type* (smartphone, tablet, etc.), etc. *Hardware_Description* regroups hardware properties of the device such as *Connectivity*, etc. and *Software_Description* regroups software properties of the device such as *OS*.
- 4) User dimension. This dimension regroups all data concerning LMS's user. To support the interactions of the various users intervening during the training and to propose LOs corresponding to their role, we suggest quoting them with the concept *User_Type* (learner, teacher, author, etc.). These users are described by a collection of information. A set of *General_Information* such as *First_Name*, *Last_Name*, *Birth_Date*, etc. is assigned to any type of user. Further, a set of *Specific_Information* is assigned to a specific user in the system. For example, an *Author* is assigned a *Biography* and a *Reputation*, whereas a *Learner* is assigned *Goals* and *Centers_Of_Interest*.

Once the content of the ontology is determined, we must consider the representation formalism we have to use to model it. RDF and RDFS are not powerful enough to define the complex relationships that exist between LOs and context elements. The proposed OWL recommendation actually consists of three languages of increasing expressive power: OWL-Lite, OWL-DL and OWL-Full. They are basically very expressive description logics (DLs) with RDF syntax. DLs are a family of knowledge representation languages that are widely

³ http://www2.tisip.no/quis/public_files/wp5-standards-for-elearning.pdf

⁴ http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf

⁵ <http://www.adlnet.org/>

⁶ <http://scorm.com/scorm-explained/>

used in ontological modeling. An important practical reason for this is that they provide one of the main underpinnings for the OWL. To model our ontology we need a set of constructors of DL. In particular, the DL *SHOIQ*, corresponding to OWL-DL, is used to define all complex relations and concepts of our model.

Once the ontological schema is achieved, we integrate data from CrossKnowledge database using Talend Data Integration tools⁷. Then, we use the OWLIM Sesame middleware⁸ as a triple store, to store the corresponding ontology. The mobile context-aware ontology is stored in the triple store and is connected to the learning repository containing the physical data of learning modules.

B. Behavioral Level

To implement contextualized learning, each learner's context is saved into the m-learning ontology. Given the learner's activity at a given time, location, learning style, and the course of study; the learner can be offered corresponding LOs. Using the Semantic Web Rules Language (SWRL)⁹, specific rules are written. Then a reasoned tool can infer the list of LOs that will be offered to a given learner. These rules are defined by experts in the learning domain. As these experts do not necessarily have the technical competences to write SWRL rules, we developed a rule generator to easily manipulate m-learning ontology concepts and generate automatically SWRL rules. This rule generator is provided as a web application to experts.

When connected to the mobile learning system, the platform should propose an optimized panel of LOs corresponding to the current context of the learner. Optimization algorithms may improve various objectives such as minimizing learning time, minimizing the number of non-required LOs for training, maximizing learner satisfaction, etc. If each LO was accessible on every learning device, it would be easy to choose at any time the best support for training according to the learner's context. Actual cases that we studied showed us, on the contrary, a great heterogeneity of LOs available according to different devices. Training has different structure and different duration, depending on the device used. This forbids changing learning devices while training without risking redundancy of some LOs. In our case, the problem can be reduced to a variant of the well-known shortest path problem called the *multimodal shortest path problem*.

This challenging problem extensively studied in recent years [17], consists of rallying a point B from a point A by taking various means of transport, with different traveling time, routes and transportation costs. We can make approximation considering that an optimized training is equivalent to the shortest path to join learning objectives by different means of transport (here different learning devices). Just like two paths may follow different routes depending on means of transport,

two training courses may include different LOs. Similarly, just as traveling time between two points depends on the means of transport, the time needed to learn a set of LOs may vary depending on the broadcasting device. Finally, the availability of each learning device varies over time, like the availability of means of transport.

This problem cannot be resolved by an exact method, because of the exponential growth in complexity depending on the size of the problem; we propose to use metaheuristics in order to ensure the achievement of a solution in a reasonable time. The metaheuristics used must be adapted to take advantage of rules described by learning experts. We therefore link the semantic modeling techniques in the training offer and user profile with powerful algorithms derived from combinatorial optimization. The objective is to provide an adaptive system that maximizes the availability of m-learning. Various heuristics have been proposed for solving the problem of multimodal shortest path search [18] [19].

IV. CONCLUSION

In this paper, propose an approach for context-based adaptation for m-learning, making use of learning practices already deployed in e-learning systems and adopting them in m-learning. Our system is built around an ontology that both defines the learning domain and supports context-awareness. The use of this ontology facilitates context acquisition and enables a standard-based learning object metadata annotation. We also use a set of ontological rules to achieve personalized context-aware LOs by exploiting knowledge embedded in the ontology. The future adaptive system will offer an optimized panel of LOs matching with the current context of the learner.

In future work, we are going to compare the effectiveness of some heuristics for solving the problem of multimodal shortest path search with a metaheuristic inspired from simulated annealing that has been already successfully used in the TourismKM project [20].

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⁷ <http://www.talend.com/>

⁸ <http://www.ontotext.com/owlim>

⁹ <http://www.w3.org/Submission/SWRL/>

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Designing Workplace E-Learning

Jason G. Caudill

Abstract—Workplace e-learning is both rooted in the principles of instructional design and also a unique instructional environment with different goals from the traditional academic environment. By utilizing sound strategic planning and deliberate instructional design the modern firm can develop quality e-learning products that help to build and maintain competitive advantage.

Index Terms—e-learning, training, instructional design, competitive advantage

I. INTRODUCTION

LEARNING is an increasingly important component for the modern firm. Because of the dynamic nature of markets it is critical that organizations become learning organizations in order to build and maintain competitive advantage. Indeed, effective employee and organizational learning is a key issue for firms operating in a competitive environment (Chen & Kao, 2012). Oye, Salleh, and Iahad (2012) explain that the survival of organizations and individuals in the 21st century depends on learning and applying that learning. This process means providing learning opportunities to employees and those opportunities increasingly occur through the medium of e-learning.

E-learning specifically is valuable to businesses in this dynamic competitive environment. Jan, Lu, and Chou (2012) identify workplace e-learning as a fundamental tool for firms to remain competitive. It is so important, in fact, that businesses are continuing to invest in e-learning for employees even during recent times of economic downturn (van Rooj, 2011). These combined factors, both the importance of e-learning to competitive advantage and firms' willingness to continue to invest even when they are divesting other assets, place workplace e-learning as a strategic component for the business process today.

As with any strategic aspect of business the planning process is critical to a successful e-learning initiative. This process must first focus on the goals and objectives of e-learning in the workplace. These are different in the workplace than in an academic e-learning environment. Ubell (2010) explains that the academic e-learning is; education, conceptual learning, constructivism, and collaborative while corporate e-learning is; training, procedural learning, behaviorism, and autonomous. These differences form the foundation of planning for e-learning in the workplace.

The goal of this paper is to provide workplace trainers and others involved with workforce education and development with an overview of how to design successful e-learning initiatives in the workplace. The main contribution of the work is to bridge traditional instructional design theory, which primarily focuses on formal educational environments, with the demands of the workplace. To do this the paper introduces the design concepts of e-learning and discusses each stage of the process with a specific focus on building learning modules appropriate for workplace e-learning applications.

II. DESIGNING E-LEARNING

Essentially, workplace e-learning is focused on improving the capacity of employees in order to better create value for the firm's customers. This creation of value is the source of competitive advantage for the firm; customers exchange their financial resources for a good or service to which they ascribe value. Thus, the output of the business is value for the customer. Workplace e-learning can be defined, "...as the means, processes, and activities in the workplace by which employees learn from basic skills to high technology and management practice that are immediately applicable to their jobs, duties, and roles" (Cheng, Wang, Moorman, Olaniran, and Chen, 2012, p 885). These jobs, duties, and roles are the activities that drive the business and are keys to the success or failure of the firm in the market.

To best address these needs for a firm the design of e-learning has to be founded on sound instructional design processes. This means that there needs to be an appropriate focus on the design of the instruction. Specifically, the core of e-learning planning has to be founded on pedagogical and organizational issues and not just the technology being used to deliver the content (Mahammad & Kavitha, 2012). Beginning with sound pedagogy and organizational issues the planning process then moves forward to the full instructional design experience.

There are many different models of instructional design and each of them have unique steps and sometimes different numbers of steps but all of them follow an overall general path from beginning to end. For the purposes of this discussion the author has identified six general stages to instructional design for workplace e-learning. These six stages are: needs assessment, content development, media development, testing, production, and assessment.

A. Needs Assessment

While needs assessment is an important part of any

instructional design plan it carries particular weight in workplace e-learning. The jobs, duties, and roles being supported by e-learning are essentially competencies of the employees. "Competency-based training has been widely used by organizations to drive workplace learning initiatives to enable employees to respond quickly and flexibly to business needs" (Cheng, Wang, Yang, Kinshuk, & Peng, 2011, p 1318). Ascertaining just what those business needs are is the first step of any e-learning development.

Identifying needs that require training to address is a process that should be familiar to most business professionals. Just as most approaches to quality that grew from the initiatives of the 1980s and 1990s focus on engaging every employee in the quality process needs assessment should involve every employee in identifying opportunities. Training at its core is concerned with closing a gap between existing performance and desired performance. Knowing where those gaps exist and how training can address those gaps is a function of examining the details of operations throughout the firm.

The needs assessment process should utilize this input from managers and employees to identify opportunities to improve employee effectiveness and efficiency. If multiple opportunities are identified then these may be ranked based on projected value to the firm. However the process is completed the important activity is to systematically determine where training can best be applied to improve the company's performance.

B. Content Development

Once the topic of training has been identified the next step is to begin developing the content of the training. As with the needs assessment stage content development is not limited to just instructors, but it requires the input of people throughout the company. While responsibility for training is often housed in the human resources department the responsibility for designing training carries across the firm. In content development subject matter experts (SMEs) play a critical role in the process.

A SME is an individual who possesses a level of expertise in the subject of the training and how that training will be applied in practice. In workplace e-learning SMEs may come from management, from the supervisor level, from team leaders, or even from veteran practitioners who can share their experiences as part of the training development process. In many cases the SME will not be just one individual, but an array of experts, each with their own contributions. These SMEs will work with the instructional designer to compile the material that will be included in the training and, possibly, ideas about how the content can be best delivered to the employees.

C. Media Development

After content development is complete the process moves on to the stage of media development. Media in an e-learning environment can range from text documents to interactive

animated elements as well as photo, video, and other media elements. Basically the media development stage focuses on creating all of the elements in the virtual environment that will be used by learners.

As with other elements of design, the focus of media development is to move towards the goal of the learning experience. E-learning research shows that media is an effective student learning element (Donnelli, Dailey, & Mandernach, 2009). Specifically, media needs to enhance the interaction among students and between the students and the course content (Abrami, Bernard, Bures, Borokhovski, & Tamim, 2011). This process reflects the overarching requirement to focus on pedagogy ahead of the technology itself so that the learning experience is an effective one for the participants.

Multimedia is not only an important aspect of the online learning environment but also the single largest cost driver in an e-learning development (Whalen & Wright, 1999). From the perspective of planning and execution this makes multimedia development a critical element. Media is important to the e-learning environment, but in order to maintain appropriate return on investment in the training cost also has to be carefully managed.

D. Testing

The development of content and media is the bulk of what will actually be delivered to the learners, but at this stage the course is not ready for use. Testing is required before learners can access the course. This testing takes multiple forms. Technical viability is one part of the process, the evaluation of whether or not all elements of the course are accessible, functional, and dependable. The other aspect of testing is user testing. This involves having learners or others access the system and evaluate its capability to deliver a quality learning experience. The user interface, navigation, and other elements of the course should be tested by a sample population. This will provide feedback on ways to optimize the course before it is deployed.

E. Production

The production process is when the course is deployed for use by the learners. While there are technical aspects to this stage, such as opening a learning management system (LMS) for learner use, there are also organizational aspects. Promoting the new training opportunity to employees, incorporating the training into overall strategic plans for the firm, and preparing employees to be successful in the e-learning environment are all parts of production for an e-learning experience. Some of these activities, particularly regarding the strategic role of the training and the preparation of employees, can be started or completed during earlier stages of development, but all contribute to production. Once production is complete, however, the development process is not over.

F. Assessment

The final stage on the list of workplace e-learning development is assessment, but in practice this is a constant activity. Throughout the development process the e-learning course needs to be assessed. Once it is deployed to learners the execution of the course needs to be assessed both during and after employees complete the training; both formative and summative assessments should be applied. Based on the results of these assessments the course will be modified to optimize outcomes. This assessment process will be a continuous process to ensure that the course remains current and productive for the firm.

III. CONCLUSION

The development of workplace e-learning has been explained here as a series of stages, but in practice the stages often overlap and even move in cycles. Media may begin developing in parallel with content, testing may take place at any time, and assessment will be ongoing for the entire life of the e-learning product. This means that e-learning development is really a cyclical process rather than a set project with fixed end points. As is the case with quality initiatives in all areas of business, instructional design is an ongoing and never ending process that always seeks to further improve the product.

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Task Fidelity: a new metric for measuring task complexity involving robots

Michael Vallance, Takafumi Yamamoto, Yuta Goto, and Kenta Ibayashi

Abstract— There is no consensus regarding a common set of metrics for robot task complexity and associated human-robot interactions. In our research, tasks involving students in Japan and UK interacting in a 3D virtual world to collaboratively program robots to solve maze problems have resulted in quantitative data of immersion, Circuit Task Complexity and Robot Task Complexity which have subsequently been collated to create a proposed new metric for tasks involving robots, which we have termed Task Fidelity.

Index Terms— collaboration, metrics, RMI, robot task complexity, task fidelity, virtual world.

I. INTRODUCTION

In any task design it is important to consider its difficulty for the intended learners. Task designers such as teachers and Higher Education practitioners need to provide tasks commensurate with the expected successful outcomes that will, it is anticipated, be developed by the learners. In this paper we will demonstrate how tasks can be quantified within the particular context of communicating the programming of robots in a 3D virtual world. Circuit Task Complexity and Robot Task Complexity will be calculated alongside immersivity to determine a new metric for measuring tasks involving robots, which we have termed Task Fidelity.

Common metrics allow for benchmarking within a particular domain. For instance, road transportation such as cars, motorcycles and trucks can be compared by the metrics of top speed, acceleration, engine capacity, fuel economy, transmission and price. However, this is not the case with robots. Although there are a number of metrics which can be related to robot-related tasks and the complexity of the domain where robots are utilized, Steinfeld *et al* [1] state that “the primary difficulty in defining common metrics is the incredibly diverse range of human-robot applications” (p.33). When discussing robots that undertake specific maneuvers, some researchers provide a common metric labeled as Task Complexity. Tasks are defined as physical action units that are undertaken by a robot, and the designation ‘complexity’ is used to characterize the task that consists of parts in, potentially, intricate arrangements.

In an example of robots which maneuver around

obstacles and follow distinct circuits (or mazes), Barker and Ansoorge [2] derive Task Complexity as $TC = \Sigma S + \text{time}$, where ΣS is the number of sections or turns of a maze. Olsen and Goodrich [3] define Task Complexity as $TC = TE + IE$, where Task Effectiveness (TE) = the number of commands successfully programmed into the robot, and Interaction Effort (IE) = the amount of time required to interact with the robot (to take into account mistakes). Olsen and Goodrich [3] also suggest $TC = NT$, where NT = Neglect Tolerance which measures autonomy of robot (i.e. measures how robot's effectiveness declines over time when the robot is neglected by the user). In developing the metric, Olsen and Goodrich [3] additionally offer $TC = RAD$ (Robot Attention Demand) which measures the total time user must interact with the robot, where $RAD = IE / (IE + NT)$. If the tele-operated robot has a small NT and RAD approaches 1, then the user can focus on other things

In the domain of Artificial Intelligence and development of robots, Russel and Norvig [4] determine Task Complexity as $TC = PEAS$, where P = Performance, E = Environment, A = Actuators, S = Sensors. The metric though is descriptive and does not amount to a numerical number.

The USUS Evaluation Framework for Human-Robot Interaction by Weiss *et al.* [5] focus upon usability, user experience, social acceptance and social impact. Usability is the extent to which a robot can be used by specified users to achieve specific goals with effectiveness, efficiency and satisfaction in a particular context of use. Metrics include effectiveness (i.e. task completion rate), efficiency (i.e. speed at which task is completed), learnability (i.e. how easy the system can be learned by human users), flexibility (i.e. the number of different ways users can communicate with the system), robustness (i.e. the level of support provided, and utility (i.e. the number of tasks the interface is designed to perform). The outcome is descriptive, with no numerical representation.

Murphy and Schreckenghost [6] conducted a meta-analysis of 29 papers that proposed metrics for human-robot interaction. Forty two metrics in total were found. They determined that the metrics were categorized to the object being directly measured; such as the human (N=7), the robot (N=6), or the system (N=29). The systems' metrics were found to be subdivided into productivity, efficiency, reliability, safety and coactivity. They found that the metrics were often not

measured directly but most often were inferred through observation. The paper identified proposed metrics but it was recognized that they “have no functional, or generalizable, mechanism for measuring that feature.”

In summary, there is no consensus regarding a common set of metrics for robot task complexity and its associated human-robot interactions. Although many attempts have been made to develop a taxonomy of metrics, the community has yet to develop a standard framework, and many metrics are task-specific. Therefore, we feel justified in developing our own complexity metric, termed Task Fidelity, specific to the context of our robot-mediated communication discussed in this paper.

II. ROBOT TASKS IN A 3D VIRTUAL WORLD

Our research has been designed to collate data of students collaborating in a 3D virtual world to program a LEGO robot to successfully navigate mazes from start to completion in both the physical world and within a 3D virtual space (see Fig. 1). This is undertaken by (i) designing circuits which necessitate the use of robot maneuvers and sensors; and (ii) experiencing collaboration in a virtual world between students in Japan and UK. These experiences lead to personal strategies for teamwork, planning, organizing, applying, analyzing, creating and reflection. Complex problems are thus presented which necessitate the use of programming skills, collaboration, and cognitive experiences.

In our research we have re-named Task Complexity as ‘Robot Task Complexity’ (RTC) because the task focuses upon the robot and what the human has to do to manipulate that robot. We call this the ‘product’ of a robot task. Human-Robot Interaction. (HRI) is the ‘interaction’ between a human and a robot. The word ‘interaction’ assumes that the human and the robot are communicating two-way. We call this the ‘process’ of a robot task. Therefore, we do not consider our process to be Human-Robot Interaction (HRI) but consider our collaboration to be Robot-Mediated Interaction (RMI).



Figure 1. UK and Japan students as avatars collaborating in our 3D virtual world

III. CIRCUIT TASK COMPLEXITY

In our first iteration (*cf.* Vallance and Martin), in order to

quantify each task complexity the programming of the LEGO robot required a determination of an action and a vector [7]. Given the specific purposes of the robot in our research, we utilized the eminent work in robotics by Barker and Ansoorge [2] and also Olson and Goodrich [3]; where task complexity is calculated according to the number of sections that make up a given maze. We called this Circuit Task Complexity (CTC) which equals the number of directions (d) + number of maneuvers (m) + number of sensors (s) + number of obstacles (o).

$$CTC = \Sigma (d + m + s + o)$$

For example, in Fig. 2 the robot must maneuver within a maze including 2 obstacles in order to reach its target. One interpretation of the problem can be: the number of directions to be programmed is 4, the number of maneuvers is 3, and the number of sensors is 2 (i.e. two touch sensors).

$$CTC = \Sigma (d + m + s + o)$$

$$CTC = \Sigma (4 + 3 + 2 + 2) = 11$$

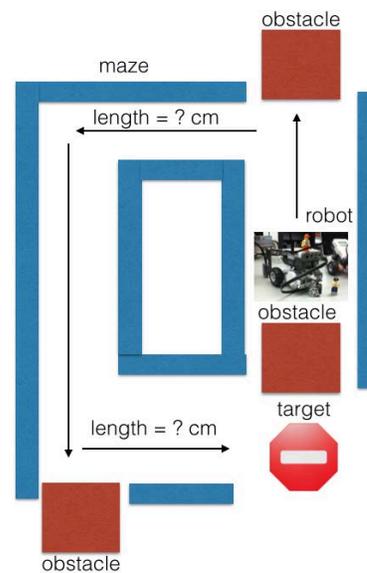


Figure 2. Example of Circuit Task Complexity.

IV. ROBOT TASK COMPLEXITY

However, we found that the logic of assigning task complexity to circuits was inadequate. For instance, initially we assigned complexity values to distinct maneuvers such as forward – turn – back. We found over the course of our previous research that as circuits became more challenging, the Mindstorms NXT programming became more complex. This was especially the case when we needed to add sensors to maneuver around and over obstacles. Simply adding the number of obstacles to the Circuit Task Complexity was flawed because the programming required to maneuver over a bridge using touch sensors, for instance, was far more complex than maneuvering around a box using touch sensors. Consequently, we modified our task complexity to be

determined by the NXT program solution rather than the circuit to be navigated. We call this Robot Task Complexity (RTC), which is measured as:

$$RTC = \Sigma Mv_1 + \Sigma Sv_2 + \Sigma SW + \Sigma Lv_3$$

where,

M = number of moves (direction and turn)

S = number of sensors

SW = number of switches

L = number of loops

where v = number of decisions required by user for each programmable block

$$v_1 = 6$$

$$v_2 = 5$$

$$v_3 = 2$$

In the NXT Mindstorms software, the Move block controls the direction and turns that the LEGO robot will take. There are six variables that need to be considered: NXT 'brick' port link, direction, steering, power, duration, and next action. In other words, the students have to make six specific decisions about the values which make up the programmable block. Therefore, we assign v_1 a value of 6. There are eight common sensors which are used in our tasks (timer, light, ultrasonic, color, touch, sound, distance, wait) with the sensors' capabilities determined by 5 variables (so we assign $v_2=5$). Although some sensors have 6 decisions built in and some have 5, the difference is that the extra decision is simply cosmetic as in 'speak an alert' so does not impact on the robot's performance or capability to complete the task. All sensors are tagged as S. A loop has only two variables to consider so we assign $v_3 = 2$.

Given the circuit shown in Fig. 2 above, the robot has to be programmed to move in 4 directions, with 3 turns and 2 touch sensors. A NXT program solution in Fig. 3 can then be used to calculate the Robot Task Complexity.

$$RTC = \Sigma Mv_1 + \Sigma Sv_2 + \Sigma SW + \Sigma Lv_3$$

$$RTC = (8 \times 6) + (3 \times 5) + 0 + 3$$

$$RTC = 66$$

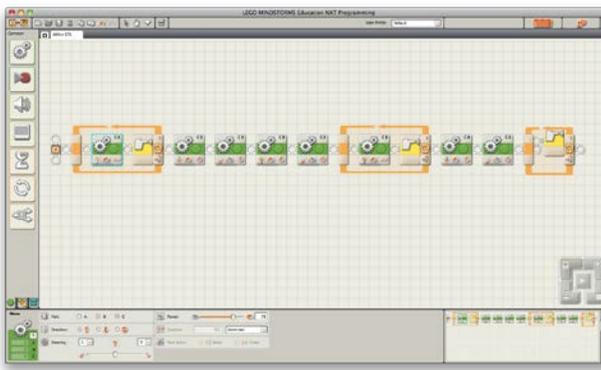


Figure 3. LEGO NXT program solution

We acknowledge that, at present, our modified Robot Task Complexity metric applies only to the LEGO Mindstorms robot, but it does provide a useful indicator in our attempts to analyze the experiential learning during the collaborative tasks. We are currently experimenting with LabView 2011 software with NXT module, and the LEGO EV3 software.

V. TASK FIDELITY

Given that our context is Robot-Mediated Interaction (RMI) in a 3D virtual space, this applied research can also determine how immersed students become within the process of each task. To record 'immersion' (a cognitive phenomena also referred to as 'flow' (*cf.* Csikszentmihalyi & Nakamura [8])), data are collected from the students during and after each task. Questions were chosen based upon research in immersivity by Pearce *et al.* [9]. With optimal challenge – skill relationship, the students become immersed in the Robot-Mediated Interaction (RMI) tasks.

The collated data included total challenge and skill values, Circuit Task Complexity values, and Robot Task Complexity values (*cf.* Vallance *et al.* [10]). In order to compare the data from twenty eight (28) tasks it was necessary to scale all the values between 0 and 1. For instance, for the challenge and skill values, in each task we simply divided the sum scores of the students by the maximum score possible. For the Circuit Task Complexity values we took the maximum CTC value and divided it into each CTC value. Similarly, for the Robot Task Complexity values we took the maximum RTC value and divided it into each RTC value. All values are thus represented between 0 and 1. This allows us to represent the data graphically and thus determine the immersion in the case of challenge and skills, and Task Fidelity (TF) (see below) in the case of Circuit Task Complexity and Robot Task Complexity values.

Consequently, the complexity of the task can now be quantified by a new metric which we term Task Fidelity. For example, from the data discussed in Vallance *et al.* [10], the graph in Fig. 4 of Circuit Task Complexity versus Robot Task Complexity graphically reveals the plotted differences in the researcher's (in the role of instructor or teacher) expected level of complexity (i.e. the Circuit Task Complexity) and the students' achievement (i.e. the Robot Task Complexity). Ideally one would expect the two plotted areas to merge; in other words, the researcher (or teacher) provides a task commensurate with the expected successful outcome developed by the learners. Looking at the graph in Fig. 4 this assumption mostly appears to be the case. However, we can also numerically represent the differences between anticipated task complexity and successful accomplishment. This is called Task Fidelity, and is calculated as:

Task Fidelity = Circuit Task Complexity - Robot Task Complexity

$$TF = CTC - RTC$$

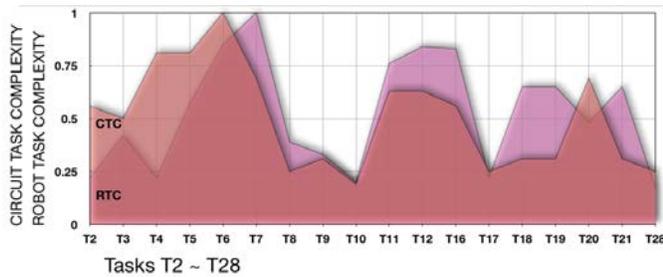


Fig. 4 Graph of Circuit Task Complexity and Robot Task Complexity for Tasks 2 ~ 28.

Figure 5 portrays the results of Task Fidelity plotted against the order of tasks of increasing challenge from the data discussed in Vallance *et al.* [10].

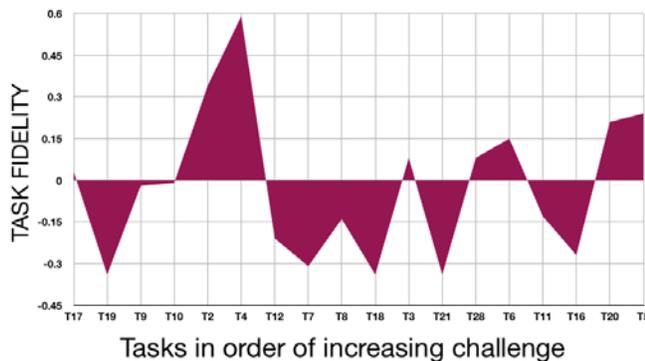


Fig. 5 Task Fidelity, where tasks have been rearranged in order of increasing challenge.

To reiterate, Task Fidelity is an indicator of the complexity of the circuit compared with the complexity of the program to complete the circuit. The zero line indicates ideal Task Fidelity; or ideal task complexity. Data plotted above the zero line indicate that the robot program was more complex than the circuit the robot had to maneuver. Data below the zero line indicate that the circuit was more complex than the robot program required to successfully navigate it. Our data reveal that for most tasks the programming required to complete the circuits was less than the considered complexity of the circuit (i.e. most data points are below the zero line of Task Fidelity). This appears to be the case across the range of challenges indicated by the students. The exceptions are T2, T4, T5 and T20 where TF values are above the zero line of Task Fidelity. These tasks involved sensors. Programming of sensors is indeed more complex for the students and this was also reflected in the immersion data mentioned above; students were most anxious when engaged in tasks requiring sensor programming and were thus less immersed in the challenge. However, as their skills of sensor programming increased, immersivity increased as indicated by Task 28 where Japanese students were taught by UK students within our 3D virtual space to program the robot's use of light and color sensors to initiate specific actions. TF value for T28 was only + 0.08; slightly above the optimal line. The challenge is to seek tasks similar to T28 where immersivity is close to or on the optimal path of immersivity, and task complexity is close to or on the

optimal line of Task Fidelity.

VI. CONCLUSION

In conclusion, the literature reveals that there is no consensus regarding a common set of metrics for robot task complexity and its associated human-robot interactions. Circuit Task Complexity and Robot Task Complexity have thus been calculated alongside immersivity to determine a new metric for measuring tasks involving robots, which we have termed Task Fidelity. We will continue to implement the metric in diverse robot scenarios within our 3D virtual space involving synchronous collaboration between students in Japan and UK.

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