Management and Business Administration Doctoral Programme

THESES

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Flexible Learning, Flexible Working

Exploiting the Potentials of Ontology Based Content Management

of Ph.D. proposal

Supervisor

Dr. András Gábor
associate professor

Budapest, 2011

Department of Information Systems

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RESEARCH CONFIGURATION

Human Resource Management (HRM) and Information Technology (IT) supported education and training have never been so close to one another as nowadays. Scientists and academics in both fields have started to recognize the interdependencies of these fields. A growing number of publications tackle the possible interactions and collaboration possibilities. This has led to many exciting new questions and a search for models and theories, which are valid in all fields and which will create a strong foundation for collaboration among researchers.

Moreover, given the fundamental nature and the scope of this multidisciplinary subject, the societal (Lifelong Learning) and the Industrial relevance (hands on, usable models and systems in everyday business processes) of such an endeavour is substantial, and its results will eventually feed through into society and into the corporate sector. By working at the cutting edge of HRM and KM supported learning systems, it is likely to attract great international interest, with the added scientific benefit of advancing this new intersectoral field in Europe, where structural unemployment is a great risk emerging from the global financial crisis. As it will be visible, this research also attempts to address this problem. As a result of this collaboration the theoretical and empirical foundations of an innovative job-qualifications matching system in a mobilised learning environment will be elaborated. Using this envisaged system, students and/or employees can assess their job knowledge against criteria of possible fields of employment, getting detailed information about their knowledge gaps. This enables them to target their learning efforts in order to gain or regain employment. Figure 1 shows the configuration of this research.

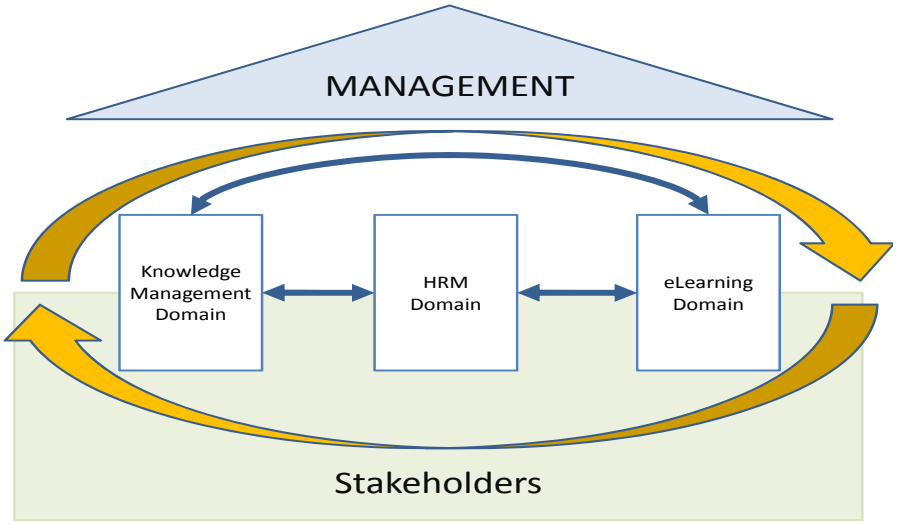

Figure 1: Research Configuration

This multi-domain research is highly interdisciplinary:

- HRM Domain is dealing with issues regarding selection, recruitment, managerial issues emerging from corporate trainings, social attitudes towards employment and training.
- Knowledge Management Domain has an emphasis on semantic applications and ontologies.

- eLearning Domain considering mobilised learning environments, incubating perspectives from Lifelong Learning, Context Sensitive Learning, Adaptive Learning Systems integration and Content Authoring issues.

There are experts, professors helping me in my work from all domains. These people have remarkable prior experience and knowledge on the given field with appropriate scientific research results. This domain based research challenges the theoretical foundations, aiming to develop new models for adaptive content management in many contexts, like selection and recruitment. The detailed description of the research objectives can be found in the subsequent sections. Although the theoretical work is domain specific, there are means in the project, which foster horizontal collaboration between the domains. This collaboration is indicated by the blue arrows (see Figure 1). Stakeholders (governments, industry, higher and vocational education) are connected to all domains, as the outputs, (described also in the sections, chapters below) should be leveraged into real, valid scenarios in case of success. These stakeholders do not only benefit from the results of academia, but also contribute with knowledge and information about the characteristics of their problems and expectations on the fields, in which the various results will be applied (orange arrows show this information flow). When deciding on research questions, the emphasis was on interdisciplinary and intersectoral issues, such as:

- Improving the accurate assessment of job performance by adequately mapping the knowledge, skill and ability requirements for jobs
- Content, construct and criterion related validity validation approaches
- Greater theoretical understanding of the work process connected to job-roles
- Better mapping of students and employees to changing contexts
- Using technology to provide a mobile environment for learning and self assessment/development
- Incorporating semantic applications and business intelligence solutions to learning organisations
- Benefiting from ontologies in education

This research has been financed by a chain of research projects by the European Commission, which projects give also the foundation of this thesis. Altogether six projects have been carried out in the frames of this research idea. Half of them were analytical studies in order to identify several influencing factors on learning content management. The other half were projects, aiming for evidences to validate our ontology based content management approach (See Figure 2).
The first three studies were analysing and scaffolding the underlying political and societal factors essential for our system development. This work includes:

- A state of the art investigation about current eLearning trends in 10 European Union countries in comparison with the general performance of the European Union in the selected variables (eLearning in EU10).
- Setting up a framework about evaluating the importance and the impact of mobile technology on European lifelong learning actions. This evidence-based approach

includes the development of an evaluation methodology and a set of good practices in this domain (Motill).

- The last analytical study concentrates on the impact of mobile technology and eLearning on learners, as it is critical to know, how they perceive our approach and what do they think about mobile technology in learning in general (Impact).

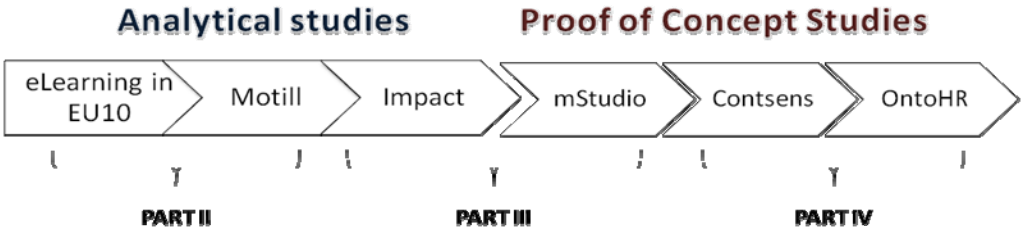

Figure 2: Studies in this book

After scaffolding the concept with analytical studies, three pilots have been organised in order to prove the concept of this mobilised learning content management system:

- A pilot study has been conducted about integrating a mobile interface and mobilised content delivery technology into the ontology based content management system (mStudio)
- The second study is investigating whether the incorporated mobile technology is capable of handling different learning contexts (from the learner's point of view) or not (Contsens).
- Finally it was attempted to enlarge the scope of this application and set it up as a selection and recruitment software. Regarding to this attempt the customization and the integration of workplace related concepts have been a key issue (OntoHR).

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As it is visible from the previous pages, in this research I want to investigate the following problems:

- How did mobile learning manage to break in the world of education? What are the student's attitudes towards this technology?
- How semantic educational applications delivered by mobile technology impact on Higher Education qualifications measurement and workplace enrolment?

These questions cover the complete cycle of a learner's educational activity from competency testing, through context based learning content delivery, until job-role suitability assessment in a mobilised learning environment.

Mobilised Learning Environment (MLE)

Fascinating questions arising when we take a closer look at Mobilised Learning Environments. Are these MLEs still in their infancy or did they make a step forward towards being an everyday learning experience? What do students and teachers think about mobile Learning? The extant literature of the impact of technology on learning is fragile and inconclusive according to the view of the World Bank in the USA and the Becta in the UK. These detailed researches of literature show that what research has been carried out is nearly all on the impact of technology on pupils in schools. There is little or nothing on higher education, on adult education, on lifelong learning or on distance learning. This research situation is unacceptable in an area that is costing European governments millions of Euros annually.

One of the major manifestations of the use of technology in education is lifelong learning, where use of technology is essential. The European Union therefore financed an empirical research project (IMPACT[1]), which aimed to fill the missing research areas on the following fields:

- Distance education – the provision of education and training at a distance by Open Universities, distance education institutions and distance education departments of conventional institutions
- E-learning – e-learning is the provision of education and training via the World Wide Web (WWW) for students who study mainly as individuals using Learning Management Systems (LMS) like SumTotal and Blackboard
- Synchronous e-learning systems – these are the provision of education and training on the WWW to students who study mainly in groups using LMSs like Centra or Horizon Wimba
- The use of the WWW for the provision of education and training on university and college campuses as a supplement to lectures and Instructor Led Training (ILT) given on campus or, alternatively, as a substitute for lectures when the courseware is provided on the WWW in the institution in place of lectures
- Mobile learning – the provision of education and training on PDAs (including palmtops and handhelds), smartphones and mobile phones.

The ultimate goal was to provide a set of findings that help instructors to understand the implications of various technologies for their students, and to provide research-based principles for how instructors and learning environment developers can best use technology in their teaching.

My research was an element of the Impact research series, covering the last item of the list above: mobile learning in higher educational provision. This research focuses on Europe, as a culturally and technologically developed area, which may be considered paradigmatic of other situations elsewhere in other countries. Institutions from five different EU member states (Bulgaria, Germany, Hungary, Ireland and Italy) collected and analysed data.

[1] http://www.ericsson.com/impact

RESEARCH HYPOTHESES

As it was mentioned before, one of the main ideas of this research was to investigate the students' attainments towards technology – in my case especially towards mobile technology – in education. In order to reach this goal the following domain specific assumptions have been made:

Hypothesis 1 – H1:

There is no significant difference in the judgement of people with or without experience in mobile learning that the use of mobile technology can enhance the general quality of learning.

Hypothesis 2 – H2:

It is generally accepted that the use of mobile learning in education is beneficial for improving the communication between students and educators.

Hypothesis 3 – H3:

Incorporating Mobile learning into educational activities adds additional value for the learning programmes provided by higher educational institutions.

Hypothesis 4 – H4:

Learner's context is a crucial constituent of education. Therefore the deployment of context aware services in a mobilised virtual learning environment is a valid approach, with quantifiable benefits for learners in a personalised learning environment.

Proof of concept

To support H4, proof of concept studies were organised. In order to take benefits from the abovementioned research approach, we redesigned our ontology based content authoring and management system. The positive feature of educational ontologies, that they are capable to describe complex systems in a well structured way, therefore it is believed to be useable in a corporate environment for recruitment and selection.

Hypothesis 4.1 – H4.1:

It is possible to build up an ontology based personnel selection and training system, which can be employed to provide support for the inferences pertaining to the construct-, content- and criterion- related validity approaches that are described by Binning and Barrett (1989)

The aim is to build an information system, which can sample the skills, competencies and knowledge of an existing employee or an applicant. Based on this sampling this system evaluates whether the selected individual meets the criteria of a given job profile. The Binning and Barrett model with its 'predictor measure', 'criterion measure' and 'underlying psychological construct domains' also demonstrate a sampling mixture, which enables the predictor to facilitate decision making about an employment contract. These measures can be described by knowledge and competencies, which – as will be elucidated later – are also part of the educational ontology.

Hypothesis 4.2 – H4.2:

It is possible to sample jobs based on a competency based logic, which is modelled by the enhanced educational ontology model.

A Job-role is a set of personality, skills, technical competencies and factual knowledge. These items can be formalised and interpreted in an explicit way – e.g. widely used Job descriptions. I strongly support the idea of creating an organisational view of these sets with their descriptions, interdependencies and 'cause and effect' relations, which can be plotted by an ontology. Therefore as a part of the research plan a Job role will be chosen at a corporation, where the job specific constructs will be incorporated to and tested in a job specific (Domain) ontology.

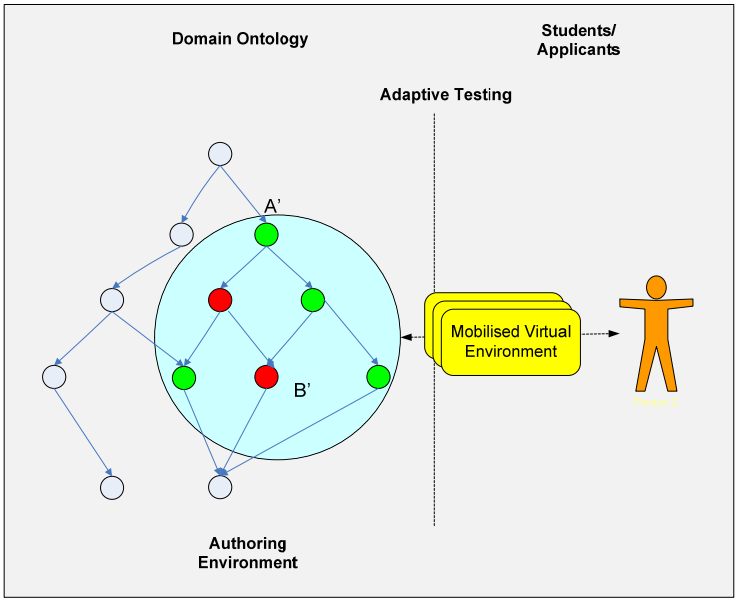

Figure 3: Framework for an ontology supported personnel selection system

As is visible on Figure 3 (The graph simplifies the structures to enhance understanding.) there are the Domain Ontology, an adaptive testing engine and a mobilised virtual (learning) environment in this proposed framework. The basic structure of the Domain ontology is generated from the enhanced Education Ontology. The Domain Ontology refers to a "global" view about the organisation's activities. This organised interpretation of tasks and activities also provides a detailed description about essential skills and competencies, which are required for employees to fulfil the given tasks.

A Job-role (The blue circle on Figure 3) is a subset of this Domain Ontology. The schema describes what skills and competencies one needs to fulfil this position and also how these skills and competencies are constructed – for instance the factual knowledge they require – and their inter-relatedness.

RESEARCH METHODOLOGY

This research used a variety of approaches to the subject areas subsumed under the three research domains (eLearning, Knowledge Management and HRM). In particular, desktop research played an important role as a research instrument for the generation of testable and falsifiable hypotheses. Data generated by questionnaires and experiments will both be brought to bear on my hypotheses.

Other predictions will be tested through laboratory experiments, field experiments, and questionnaire methods. A particularly exciting innovation concerns the conduct of field experiments in collaboration with industry stakeholders. For many of the empirical research questions that I am interested in, experiments are an important instrument because they allow me to focus on fundamental aspects and mechanisms (control), and to check the robustness of results through replication. At times, this will be the only empirical method available to investigate the hypotheses.

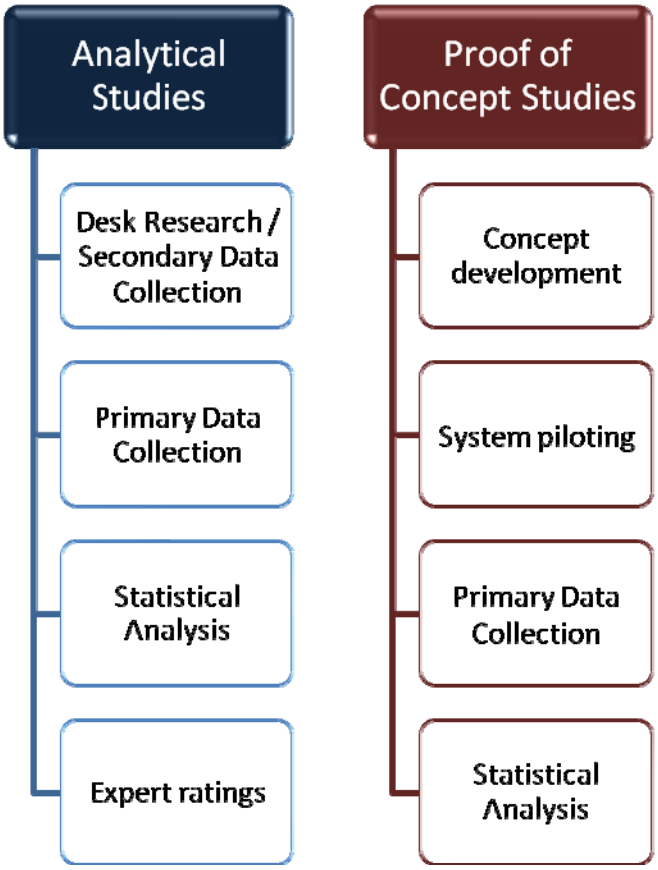

Figure 4: Applied methods

As it was mentioned before, my hypotheses were examined throughout analytical studies and proof of concept experiments. These two groups require different research methodologies (See Figure 4). By the analytical studies I will rely partly on secondary data and partly on primary data, which will be the foundation of several statistical analyses. In some cases quantitative aspects had to be considered, there I relied on expert ratings.

By the proof of concept studies, first the circumstances of experiments had to be defined together with the details of system piloting. Primary data has been gathered and analysed from these pilots. Table 1 depicts the methods have been used in the various studies.

	eLearning in EU10	Motill	Impact	mStudio	Contsens	OntoHR
Desk research	✓	✓	✓	✓	✓	✓
Secondary Data Collection	✓	✓				✓
Comparative data analysis	✓	✓				✓
Expert ratings	✓	✓				✓
System Piloting				✓	✓	✓
Primary Data Collection			✓	✓	✓	
Statistical Analysis			✓	✓	✓	

Table 1: Research Methods matrix

Evident that the most common research method was desk research. This has been used for identifying relevant academic and practical background research results, setting up theoretical and practical frameworks and identifying measurable variables. Secondary data collection has been used in the 'eLearing in EU10', Motill and OntoHR projects, where wide ranges of databases have been exploited for existing data. It is not surprising that the data gathered has also gone through a comparative data analysis. These comparative analyses have been validated by domain experts in all cases. In case of the Impact project primary data was gathered and analysed. Altogether three system pilots have been organised in the frames of this theses, what in two cases followed primary data collection and analysis. In case of OntoHR, the primary data collection and analysis will be completed after the submission of this piece of work.

At the statistical analyses the employed methodology was based on the 'Identifying and implementing educational practices supported by rigorous evidence' of the US Department of Education, probably the most recent and most authoritative educational research methodology. This research methodology is a combination of blended quantitative techniques (questionnaire with general learning questions plus specific questions and questions on educational background of respondents) and qualitative analysis (in-depth statistical analyses).

During the various stages of this research the below mentioned procedure had to be followed:

- Collect topics and related issues to be investigated from partner institutions
- Constitute a sub-committee of experts in social science data analysis. This task force was responsible for: (a) developing a conceptual model guiding the data analysis and (b) editing a questionnaire based on the problems contributed in stage 1.
- Project teams review, test and approve the questionnaire
- Project teams administer the questionnaire to the six target groups after translating into the local language – if necessary.
- Project teams assemble the responses acquired by each institution and perform suitable data analyses individually on their respective fields of expertise (in my case: mobile learning).
- Project teams evaluate the analysis results and present them in a comprehensive report individually

By the particular chapters further, more detailed information is given about the applied methodologies.

The tools build to provide support for these emergent theories, follow the latest system development methods. In general, two-phase iterative prototyping approach has been followed during the development work. This approach is superior to the waterfall approach (completing in strict sequence the phases of requirement analysis, design, Implementation/ integration, and test) because:

- It allows taking into account changing requirements.
- Integration is not one "big bang" at the end; instead, elements are integrated progressively – almost continuously.

Risks are usually discovered or addressed during integration. With the iterative approach, one can mitigate risks earlier. As developers unroll the early iterations, they test all process components, exercising many aspects of the project, such as tools, off-the-shelf software, people skills, etc. The responsible actors can quickly see whether perceived risks prove to be real and also uncover new, unsuspected risks when they are easier and less costly to address. Iteration facilitates reuse; it is easier to identify common parts as they are partially designed or implemented than to recognize them during planning. When one can correct errors over several iterations, the result is a more robust architecture.

FINDINGS

In my thesis, I collected evidences of my research about the integration of personalised, ontology based learning content management into real educational practices, which resulted in a system capable to select and train applicants for a certain job-role.

At the beginning of the book I stressed the importance of this investigation and showed what the major driving factors of this research were. As it was visible from Part II, this is the right time and the right place for eLearning related research. The world of education is changing rapidly and

behind these changes important factors are the advancing technology and the changing (digitalizing) society. I also showed that in the region of Central-Eastern Europe – including Hungary of course – is lagging behind Europe and the world, when it comes to eLearning developments. Therefore significant amount of research should be done in this field both on academic and on industry levels. There is an articulated policy movement in this area, aiming to support investments into eLearning research, which is a very promising fact for the future. However, these policy efforts are currently lacking coordination and common objectives. Also an emphasis has been given to the importance of informal learning, which is very technology driven and contributes significantly to reshaping today's education (and society) rapidly.

Education is only a follower of the advances of technology, especially mobile technology. Mobile technology as such is already grown out from its infancy many years ago, still, mobile technology in education is only getting into the mainstream nowadays. Evidences – as it is written also in Part II – show that incorporating mobile technology into educational practices demonstrate clear benefits for learners, educators and also for educational institutions. Nevertheless this incorporation should be planned very carefully as, despite many successful mLearning projects, failing to utilise mobile technology for education is not very difficult. In order to scaffold the inclusion of mobile technology in lifelong learning, an Evaluation Grid (EG) has been created. This Grid, on the basis of academic research, industry experiences and policy related works, aims to identify mLearning practices to be followed and implemented. The EG clearly articulates that any improvements in educational technology without putting it into a managerial (strategic), pedagogic, political and ethical context is not sustainable by any organizations organising formal educational programmes.

Besides the policy and organisation level issues of eLearning and mobile learning it is also inevitable to consider the perspective of individual learners. This viewpoint is crucial for educational information system developers, as it indicates user demands. As the results in Part III demonstrate an individual's approach towards technology enhanced learning is clearly influenced by former experiences with technology. In general there is a positive attitude towards technology enhanced learning both from the perspective of an experienced or non experienced users. Those people however, who have significant user experience, show more criticism towards novel learning technology. This finding has substantial influence on system development as reliability and robustness are clear user expectations from mobilised educational systems. It is not surprising that these issues already influenced the development of our mobilised ontology based learning content management system development. Reliability is definitely high on the agenda by a system of many components. The system we constructed has six main components, the ontology editor, testbank, test item editor, content authoring, content representation and user interface. The novelty of this mobilised learning content management system is that all content is structured according to an educational ontology model. The ontology scaffolds both the assessment procedure and the content authoring and representation. Learning objects and test questions are organised according to domain ontologies (created by subject matter experts), which results in a highly personalised assessment and training based on a robust, but granule learning object structure. This granularity

and structure provides the possibility to create an infrastructure for mass-customized learning, which is a crucial step towards flexible learning systems.

Part IV demonstrated furthermore that the abovementioned flexibility can be further enhanced if we consider the context of the learner or if we extend the learning environment towards an industry related application for employee selection and recruitment. As we have seen the context of the learner is important in order to provide personalised learning content. Context on our case meant the user's geographical location in combination with prior and current learning experiences. However with the assistance of currently available mobile technology it is possible to add further factors, additional sensory information about the learner's and its environment's current condition. The plotted proof of concept study also supported the lessons learnt in the mStudio system development pilot, namely, that our ontology can successfully structure and scaffold learning content delivery and the connected assessment services.

The same applies for the third pilot, which attempted to trial our system in a corporate environment for selecting and recruiting employees for an organisation. However this is still an ongoing pilot at the time this work is written, preliminary results already indicate that the granularity of the data in the system provide HRM managers to constitute highly personalised jobs and job descriptions. These jobs are described with a certain set of technical competences, which are constituted by knowledge elements and general mental ability facets. The combination of these two adds up automatically to an employee training profile with the relevant learning materials. The advantage of this approach on one hand, is an improved employee – employer matching in the future, based on the real, valid competences of applicants, which on the other hand is also matched with the educational performance of relevant formal educational learning programmes (in this case VET programmes in Italian and Dutch educational institutions). This matching is capable to show the weaknesses of the educational programmes in the light of valid and current labour market expectations.

Results

Previously, I formulised four main hypotheses (H1- H4). H4 is also supported by two sub hypotheses. Despite the fact that some of these hypotheses have already been discussed in the text, here I repeat and also extend the findings.

Hypothesis 1 – H1:

Our empirical study in Part III showed that there is significant data available to demonstrate that this might not be true! Results show that people, who are engaged with technology based learning, are a bit more careful about articulating their expectations, especially positive expectations towards technology in learning situations. This is also in line with previous research using a similar methodology in the field of eLearning. There Johnson and his colleagues revealed that *"student satisfaction with their learning experience tends to be slightly more positive for students in a traditional course format although there is no difference in the quality of the learning that takes place"*. There is an obvious hype around using the latest technology in education, mostly learners demand these services in connection with their studies. Here I'm not arguing that

educators and their institutions shouldn't try to meet this demand. I consider this scepticism towards technology as a need for mature solutions in place. It is not enough to pick the latest and maybe the shiniest technology available. Reliability, scalability, robustness – basic information system development issues – should accompany such a decision.

Hypothesis 2 – H2:

Communication has great importance in education and using mobile devices might have a positive impact on educational communication between learners and educators. However this research didn't show significant differences between mobile technology assisted learning environments and traditional learning environments. Again, instructional designers are highly dependent on the reliability of technology, furthermore communication services worth only as much as their integration into the curricula of that particular course. In general mobile technology and mobile communication services have the potential to improve the quality of educational services, but it must be planned and implemented carefully. The reliability of technology was an issue during the Contsens pilot, where location based technology failed to meet the requirements of the course. As the learning process and the learning experience was based on the geographical location of the user, the malfunction of this technology also caused major problems in learning content delivery and learning content based user interactions. The Impact study also showed that students having experience in mobile technology based educational activities also downgraded the importance of mobile communication related services. This is a truly surprising result, which also has some important implications for the future. There is definitely more research needed in this issue as communication in education is gaining more and more attention. Collaboration is seen as a great benefit of educational processes and several studies supported the positive outcomes of mobile communication in education. From student's responses one possible answer for this contradictory result can be connected to the implementation of collaborative services in the mobilised learning environment. Learners prefer their traditional networking channels, including traditional calling and messaging services (like SMS or MMS messages) or social software related communications (microblogging, following). These services operate also as a benchmark when it comes to judging communication related services in educational software. Users prefer keeping their own pathways of communication with each other, rather than exploring new opportunities.

Hypothesis 3 – H3:

Flexibility in learning is a rapidly emerging issue of nowadays digital society. Studies in Part II in this book show, that this issue is emerging from a significant demand of digital native learners and put pressure on educational institutions and systems to transform their rigid, outdated and massive educational practices into personalised, mass-customized, open and reusable learning services. This is an enormous workload on the shoulders of institutions. Besides the studies, the previously detailed pilots are also supporting this movement. It is a clear result that a mobilised learning environment, which considers personal learning situations, which is sensitive to the learners' context, is providing extra value for the learning process and throughout this learning process to particular learning programmes. This flexible, highly personalised (mass-customized) learning however requires a different approach to teaching than the traditional face to face education.

Teachers, educators should act more like a mentor of the student, facilitating the learner's own learning scenarios, as evidences show that tailoring down the learning content to the needs of individual learners benefits the learning process. Furthermore, mobilised learning content delivery also reflects the context of the user when offering the tailored learning content. This personalisation and contextualisation approach shows clear benefits for the educational institution, but of course it also has its price. Transforming traditional educational institutions into flexible education providers is a costly and timely effort.

Hypothesis 4 – H4:

As it was also mentioned above, the results of these studies clearly show the importance of context in personalised content delivery. Students using context aware services reported improved user experience, enhanced learning experience. Content delivery according to individual contexts fosters motivation and engagement in learning processes. Experiments showed that students were more interested, more connected and more enthusiastic in these mobilised systems than towards traditional learning methods.

Hypothesis 4.1 – H4.1:

As it was argued before, when it comes to employment, personal traits, features and prior learning are key concerns. Predicting potential job performance needs various – contextual – data in order to decide whether an applicant is capable to perform well in a particular job in the future or not. Literature showed that these predictions can be made throughout measuring construct, content and criterion related validity. Our experiments showed that these validity measurements can be assigned to our mobilised ontology based assessment system, when it was extended with measurement means for general mental ability. On the basis of the flexible enhanced educational ontology model, the combination of testing job knowledge and general mental ability adds up to a system, which fulfils the criteria of Binning and Barett (1989).

Hypothesis 4.2 – H4.2:

The challenge here was whether it is possible to construct competence based job descriptions, which are measureable over knowledge elements and general mental ability. It was proven that competency can be treated as a temporally stable, narrowly defined, and trainable latent ability to complete an organizationally valued prospective job task successfully. It was also visible that competences are contingent upon both specific cognitive ability facets and identifiable, specific, and distinct educational knowledge domains. In other words, with well articulated technical competencies it is possible to describe particular jobs – in this case the Information System Analyst job – and perform a competency assessment. One of the key issues here again is the granularity. Jobs differ across cultures and/or organisations. In order to handle these differences and provide a general description of a single job, it is necessary to create the widest possible competency set, what organisations can tailor down to their own needs. In our case that meant 72 different technical competences and more than 200 related learning objects. The ontology is used again to provide the structure for these elements, which also provides the domain of the assessment.

EXPLOITATION

The work that has been done has various implications for other academic and industry related research and business activities. This research – as it has also been depicted previously – is part of a bigger research environment, having several various streams. The abovementioned results therefore form the basis of future research efforts in those areas.

Academic perspectives

Form an academic perspective this research seamlessly in line with the controversial 'flexible educational systems' research agenda. The system, as showed here previously, has the abilities to support flexible learning and teaching. The concept proved to be successful in managing student's individual learning activities, in assessing student's knowledge in various knowledge and competence domains and also in bridging the fields of education and workplace with matching a valid job descriptions to students' and applicants' competence profiles.

One important factor of the success of these pilots was that these efforts were attempting to connect three different disciplines, namely HRM, eLearning and knowledge management. Domain experts, HRM practitioners and academics, educators, instructional designers, content developers, system developers, programmers, ontology engineers have been working together. This portfolio of different skills and knowledge added immense value to these experiments and it would be unwanted if the network of these professionals won't continue this sort of cooperation.

This research also shed a light on the importance of job knowledge in the recruitment process. In the field of HRM a great emphasis has been given to personality traits when selecting employees. The emergence of psychological tests in selection neglected job knowledge related discussions, as the common believes was that mental ability related assessment is significant enough to predict future job performance. However according to the current results there are signs which assume that such an ontology based approach can put job knowledge related HRM research again on the agenda. The granularity of knowledge related objects makes it possible to fine tune job requirement on a very specific organization or even on personal level. Therefore in theory it is possible to even create a job based on an applicant assessment – if this assessment also meets the requirements of the organization.

Another issue emerging from the results of this series of research is that flexibility of learning and working doesn't necessary mean that only the employee should be flexible and follow the demand of the labour market. Results suggest that this process may also work the other way round. It is imaginable that in the future not the organization will be the one, who picks employees, but employees will be able to pick organizations, based on their current competencies, skills, knowledge and personal traits. This means that after an assessment procedure the question will be – instead of comparing the results to the current organization's demand – whether it is possible to create a job, which suits the features of the test taker. This is something what definitely needs more consideration.

Running this ontology based learning content management system is an endless source of data to be analysed. It is possible to conduct cross-cultural analyses connected to a particular job or

competence. It is also possible to conduct longitudinal studies and follow up personal profiles in the system. How do applicant profiles change after a selection decision? Tracking students as they are entering the labour market and then try to maintain their presence there is a possibility of fascinating study, what may have been designed on the basis of this system.

Furthermore more consideration should be given to the possible feedback channels towards the educational institutions. How shall these institutions handle and process the data, which is coming from a system like this? How to set up a competence matching system, which enables the comparison of labour market input competences with educational sector output competences. Work has been started on developing a matching interface, which matches job-role and vocational education competences on a keyword basis, but there should be more in-depth investigation an analysis on this issue.

Additionally there is an envisaged impact of artificial intelligence on educational software. There are several fascinating research ideas emerging from this perspective. How to set up an educational system where personal traits are treated as contextual data? How to include and maintain learner's personality in automated learning processes? As every learner is different in the system, how can we discover patterns in their education related activities (including assessment and learning) and how can we re-implement these patterns into those educational systems? One way might be implementing case based reasoning, but it is worthwhile to check the enhanced reasoning possibilities provided by AI applications. If context is an issue AI is something what educational systems have to absorb.

Industry

From an industry perspective this research has also several practical future implementation possibilities. Firstly this application is definitely suitable for delivering adaptive, personalised education and training. It is also capable to be deployed as a complex selection and recruitment software, which also responsible for corporate training based on the applicant (employee) assessment profile. This function might be beneficial for a single organisation with knowledge intensive jobs, where the employee fluctuation is high (like call center positions, sales staff or technical support staff).

This solution might also be interesting for intermediary organisations – like headhunting organisations, student counselling organisations or labour renting organisations –, between education and workplaces. With the help of this software they can have a clearer view of the necessary competence allocation for the industry and also see the available competences on the market. This enables them to match demand and supply better.

Another emerging issue is the integration of this ontology based content management system into organisation's already implemented learning environments and ERPs (Enterprise Resource Planning). This step would enable on one hand the reuse of existing organisational learning content and on the other hand the financial planning of these personalised training activities would also more efficient.

Government

Potential demand in the governmental sector for such an application can also be envisaged. Labour market monitoring governmental institutions can use this software to monitor current trends and match that with also current output of educational institutions. That may help in employee re-distribution or re-skilling according to industry demands. Also, the means to challenge structural unemployment may encompass such a solution. It might also be an interesting application if the government continuously checks school or university graduates and match them according to their performance to particular occupations. This would support the carrier start of recent graduates with lowering the possibilities of a post-graduation unemployment status.

SUSTAINABILITY OF THIS RESEARCH

At the time of writing this work, there is a growing interest from academic and industry stakeholders for further exploitation of this complex training system. Besides the discussed pilots further trials are being organised in Italy, Netherlands, Switzerland, Germany and Belgium.

In order to meet any of the above discussed exploitation scenarios, obviously more work needs to be done on this currently trialled product. The first issue here is the content. In order to leverage the result of this research, the system needs to embed more content. One way of broadening the scope of this system is implementing more ICT related jobs, including their underlying competence related content elements. This practically also means the enlargement of the ontology with further concepts about ICT.

Also the matching algorithm between the job-role and the educational ontologies has to be further elaborated and customized. It needs to be examined that besides keyword based ontology matching what other options can facilitate the comparison of job-role related and educational competences. It also needs to be investigated how to automatize the feedback towards the educational institutions in the light of their student's performance.

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