Transition from e-learning to u-learning: innovations and personalization issues

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Abstract—**Use of mobile and sensor technologies in learning has emerged as a growing research area, and has given rise to a lot of research that takes advantage of learner's location, environment, proximity and situation to contextualizing the learning process. The adaptivity and personalization in these scenarios have taken a new meaning by bringing authentic learning much closer to holistic learning by seamlessly integrating physical objects available in the learner's vicinity with virtual information in real-time. Such ubiquitous environments not only break the barriers for education by widening the access to those who cannot come to a physical classroom but also increase the richness of the instruction by integrating multiple sources of instruction, contextualization and real-time location-aware learning, hence overcoming the limitations of classroom learning. This paper focuses on various contexts that arise in such environments where seamless immersion of formal and informal activities and interactions has potential to contribute to the learning process.**

Keywords-e-learning; u-learning; authentic learning; adaptivity; personalization

I. INTRODUCTION

The extremely rapid growth of wireless technology in recent years, increasing availability of high bandwidth network infrastructures, advances in mobile technologies and the popularity of handheld devices have opened up new accessibility opportunities for citizens. The true potential of e-learning as "anytime, anywhere" has finally begun to be realized, particularly for those with disabilities or those living in remote communities.

The primary goal of the research presented in this paper is to explore and develop different applications and content delivery systems, extending our understanding of ubiquitous learning to provide rich learning experiences in order to not only improve the existing educational environment but also to widen access to education for the disadvantaged, particularly those living in remote and rural communities, who generally do not have access to learning opportunities. The aim is to exploit the benefits of location, environment, device and learner modelling, and combine them with mobile technology to achieve personalized delivery of multimedia-rich learning objects: anywhere and anytime; collaborative problem-solving in the context of learners' surroundings, authentic problem-solving through multiple forms of input (such as text typed by keypad or in digital ink, images taken by mobile devices' camera, audio recordings on mobile device, learning games, and so on); and appropriate use of these different media formats as part of problem-solving for rich learning experiences.

To illustrate the overall concept, let us consider a potential scenario for personalized learning and collaborative problem solving in the authentic environmental context with multiple media input. Learner A in a remote working community is using mobile devices to learn a certain topic. The device is Wi-Fi, Bluetooth and GPS enabled. The content is being transferred to the device via Wi-Fi through an access point from a server, which also contains the learner's personal profile. The personal profile includes information about the learner's previous learning history, competence levels in different subject areas, cognitive capabilities and other attributes.

On this particular occasion, the system, with permission from the learner, observes learner A's current progress and infers that A is finding it difficult to progress in the current subject content. Using GPS tracking, the system identifies the learner's position and then checks to see if it can track any other learners nearby who have given permission to be tracked and are studying at a similar level in the subject content and may wish to join this learner to make an ad-hoc study group. The system brings these learners together at one place through GPS-based navigation. Once the learners are near enough to each other that they are within the Bluetooth range of each other, GPS tracking is switched off. The system then identifies the surroundings of the learners through a location-awareness mechanism and parameterizes a generic multimedia-based problem to align with the learner's environment. The problem is then divided by a dynamic problem creation module into smaller pieces to match the number of learners in the current study group. The system then pushes out appropriate problem items to the individual mobile devices. Learners then discuss the problem face-to-face and by interacting with the problem pieces on each others' devices, try to solve their own pieces using multiple media input, transferring intermediate solutions to other devices for further problem solving. Learners can then try to reach a conclusion through intensive dialog and collaborative learning. Once they have solved a problem, the archive of the interactions is sent back to the system so that the individual profiles of the learners can be updated and appropriate further content can be pushed out to the individual devices for further learning, based on how individual learners performed in the study group.

A fundamental design consideration is the use of the multi-agent system (MAS) paradigm to seamlessly

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integrate and deploy software components, devices, learners, educational services, and situations to form pervasive learning communities and facilitate collaborative problem solving. Another important design consideration is the incorporation of a student model and a student modeling agent which captures specific information about the learners, in particular learning styles, location, environmental factors, behaviours, actions, and performance. The student modeling agent is responsible for gathering the required data from the respective components and making the information accessible for all components. The components themselves are responsible for providing learners with an adaptive and pervasive learning environment. The location-awareness service is used to help mobile learners forming face-to-face-learning groups. Moreover, social networking issues are considered and integrated in the infrastructure. An adaptive mechanism is responsible for providing learners with learning materials that fit their individual learning styles. The situation-awareness service, in conjunction with learner's personal agent identifies the personalized knowledge structure in a ubiquitous/pervasive learning environment and directs individual learners to learn and move in the real world using automatically generated guidance messages. Furthermore, learners are supported by an intelligent and multimodal asynchronous Q&A knowledge sharing platform. Another component deals with providing effective integration of problem based learning in adaptive and ubiquitous learning environments. Moreover, different multimedia inputs are considered for providing a richer source of interaction in mobile learning.

Various activities being undertaken in this research are described in the following sections.

II. KNOWLEDGE IDENTIFICATION FOR PERSONALIZATION MODELING

The investigation under this activity aims to acquire a comprehensive understanding of various environmental factors that can influence effective personalization of learning experiences in ubiquitous scenarios. For this purpose, a methodology is developed to adapt the learning content and activities to the location of the learner, the pre-identified real-life objects available in the surroundings of the learner (the learner's environment), the capabilities and functionalities available on the device that is being used to access the content [13], and the learner's performance, cognitive capabilities [9] and learning style [5].

A global student model has been developed in accordance with all other components/services of the proposed learning environment. When aiming at providing learners with an environment that adapts to their individual characteristics, interests and needs, this information about learners has to be discerned by the system. A student model is a crucial component of every adaptive system, as it stores and updates the relevant information about learners which is needed by the system in order to provide adaptivity.

Our student model includes the following categories of information about the learners: profile, usage of the system, progress, interests and knowledge level, learning styles, problem-solving abilities, social closeness, and location. Each of these categories includes several kinds of information which are gathered from different components. The student model is developed using the concept of agents. Agents are responsible for gathering data from different services, calculating the respective information, storing it in the student model, updating the information if necessary, and providing services with access to this information.

In addition to the student modeling, this research also deals with using the information gathered in the student model for providing adaptivity in the learning environment. For this purpose, a comprehensive framework is being developed for adaptivity of visual elements of online courses. Furthermore, an adaptive mechanism has been developed that enables learning management systems to automatically generate courses that fit to learners' learning styles. The adaptive mechanism is currently being evaluated through a pilot study in western Canada.

III. MODEL FOR DYNAMIC CREATION OF SITUATION-ADAPTIVE PROBLEM SCENARIOS

This research has identified ways in which generic problem scenarios can be adapted to the individual learner's surrounding environment and divided into smaller meaningful pieces when there are two or more learners present in a study group. For example, a problem related to a concept of accounting can be modeled automatically in the context of a chemical process plant for a learner situated in an oil sands plant, and in the context of an office work flow for a local municipality employee. Established technologies of location detection through the available information from GPS satellites, base stations of cellular networks, access points for Wi-Fi broadband wireless networks, QR Code technology, active radio frequency identification (Active RFID), and passive radio frequency identification (Passive RFID) technologies are used with content manipulation methods [8] to create a service that identifies appropriate multimedia objects in learner's surrounding environment, which are then used for dynamic assembly of authentic problem scenarios.

A location awareness service based on an optimal grouping algorithm has been implemented. The location based optimal grouping algorithm includes the detection of the location information availability. This information is adapted for use with various mobile devices capable of acquiring and preprocessing the location data. A location awareness service uses the location data and other learning factors in order to suggest an appropriate grouping of mobile learners.

In order to foster location-based learning, the R5 Adaptive Mobile Learning architecture and framework, i.e. right time, right location, right device, and right contents for right person, has been developed [12]. Furthermore, the Mobile Virtual Campus system has been developed and its prototype mobile application has been implemented running on Windows Mobile OS. An iPhone version is

also available and Android platform development is currently undergoing. Research on the design principles for facilitating collaboration in Mobile Environments led to the development of an iPhone based iCollaborator, which can be integrated into the Mobile Virtual Campus system to provide a collaborative learning platform. In addition, the research on Augmented Reality for location-based adaptive mobile learning resulted in the development of a multi-object oriented Augmented Reality system framework. Furthermore, a location-based microblogging framework with a proof of concept application has also been developed.

The context-awareness service aims at taking individual's interest(s) and/or request(s) from the student model to identify a specific context-aware knowledge structure from among the knowledge structures in different domains in a pervasive/ubiquitous learning environment [3]. In order to help a learner plan his/her learning activities when learning in the real world, an ubiquitous/pervasive learning system should be able to know what the learner is looking for and/or really interested in [2] and guide the learner through the learning environment. Therefore, a role-playing learning activity generation on mobile phones for learners doing informal learning in a museum has been developed. This generator plans an efficient sequence and automatically generates meaningful activities for the roaming learner. The mobile phone is then able to provide the learner personalized role-playing learning activities by integrating historical features/characteristics and context-awareness information, e.g. which room the learner is in and what artifacts are in the vicinity of the learner.

IV. MODEL FOR SOCIAL NETWORKING

A significant number of learners are nowadays already participating in online social networks outside their institutions. A recent study suggests that up to 96% of young online users engage in social sites such as MySpace, Facebook, YouTube and Flickr [11].

One of the most significant issues when exchanging data between informal social networks and the more structured groups of formal education is control. On the one hand, not all learners are willing to have their private life information accessed by their educational institutions [11]. On the other hand, the danger of spamming, malware or malicious and mischievous outsiders invading the trusted space of educational institutions is real. Institutional Web sites are open and potentially abusable by learners, leading to legitimate criticism of the wild and uncontrollable Web 2.0 [7]. An interesting research challenge is to provide a controllable, safe interaction between these formal and informal worlds. The agents need to be able to ascertain and assert trust at both system and personal levels to help bridge the trust and credibility gaps that are becoming an increasing issue on the social Web [6].

Considering these issues, a social computing platform, namely The Landing, has been developed. The Landing is based on the Elgg framework and offers a social sharing and communication space, as well as a personal learning environment. The prototype system is being used to aggregate data from other social sites, including RSS feeds and Twitter (both input and output), which has potential to help construct the personal profile (student model).

Furthermore, research on social networking is also dealing with tracing learners' communication in social networks. A key contributor for the development of social models is the ability to trace the entire process that the learners underwent during social networking. Software mechanisms have therefore been identified that would capture such real-time, continuous, traces of social contributions of learners. The process traces can then be mapped to competencies of learners in real-time.

V. MODEL FOR QUESTION AND ANSWER SERVICE

As a direct and convenient way to exchange and share knowledge, question/answer support is important in problem-based learning. Presented as Frequently Asked Questions (FAQs), this type of support is quite common and appears as an essential part of many online learning environments. This component promotes the Question & Answer (Q&A) services such as discussion forums and adaptive FAQ to the integrated system by providing common Q&A knowledge representation and deeper questions and answers processing through question answering (QA) technology [4]. QA benefits from natural language processing (NLP) and information retrieval (IR) research, and aims to automatically retrieve answers from specific resources to learners' questions in natural language text. It provides techniques related to analyzing questions, and retrieving and generating answers from natural language text resources. Figure 1 shows the structure of this component. An FAQ authoring tool provides a convenient function for picking up question-answer pairs directly from discussion forums, and question analysis and automatic answer extraction help in getting potential Q&A pairs from the threads of discussion forums and from domain ontologies by adopting ontology querying and reasoning. An important feature of this component is the use of situational information from the situation-aware service and learner profiles. The main functions of this component include discussion forums with value-added functions inherited from the discussion forum extension module eQuake [14], such as answer type feedback, forum monitoring and notification, FAQ authoring, deeper understanding of questions and effective answering by QA, as well as ubiquitous learning environment support.

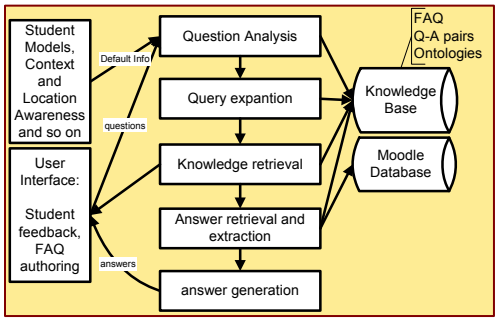

Figure 1. The structure of question and answer service

We have studied and developed a semantic relation extraction and population system for ecology concept learning. The overall idea is to bootstrap the instances of a semantic relation representing a certain concept by using online text resources, starting from a few pre-defined small set of instances of the relation. We use the small set as input to search engine and obtain the relevant raw sentences. We then parse the sentences using a commercial parser and extract the related candidate instances of the relation from the parsing results. We then use as input a portion of them selected by applying a threshold for further search. This process will continue until we obtain enough instances of the relation or concept for the ecology learning system. A game is designed based on the obtained instances for students to play and learn the concept.

We have also explored image recognition and retrieval based on support vector machines (SVM) and latent Dirichlet allocation (LDA), which are used to process images and their annotation respectively.

Furthermore, we have developed two prototypes, MI-Writer and QuickRate. These systems offer significant advantages to students in terms of continuous monitoring, self-regulation, peer review mixed-initiative communication, and real-time feedback in the context of writing and online communication [10]. MI-Writer can construct a model of transactional writing practices of learners and offer system-initiated feedback at real-time and context-aware tutor-initiated feedback. We are currently integrating a commercial parser to MI-Writer to facilitate grammar-oriented feedback to students. We plan to evaluate MI-Writer in assessed online discussion tasks in Moodle-based online courses and coding tasks for novice programmers in online courses that use BlueJ IDE.

In addition, research has been conducted on marking learners' short answers of open-end questions. The project uses ontology and canonical form to solve the problems that traditional NLP-based assessment solutions have.

VI. MULTIPLE INPUT BASED PROBLEM SOLVING

This phase of the research makes use of innovative embedding of multiple media formats using problem solving and multiple input techniques that mobile devices readily provide. Mobile devices can enable authentic problem-solving in learners' own work context, providing opportunities for multiple forms of input such as text, digital ink, audio and camera shots for richer and more authentic problem solutions. GPS coordinates can also be attached to images if the mobile device has GPS capabilities. The investigation of this research has focused on how these rich input facilities offered by mobile devices can be combined in authentic problem-solving to enhance interaction and learning experience.

We have developed a self-directed learning interface that can engage students in multiple types of media-based content interaction. Using this interface, we have developed content in Moodle to introduce a set of concepts in the domain of Java programming. The content includes elaboration of concepts using video, audio, animation, text, online discussions, and live camera interactions. The content also includes introduction to study skills that are relevant for the concepts. We have developed a prototype that employs multi-input multi-media self-directed learning using the models of self-regulated learning and experiential learning. We are currently conducting a study to evaluate the utility of multi-modal inputs and its effect on student's performance.

VII. ARCHITECTURE DESIGN

The architecture of the personalized mobile learning system utilizes and combines the findings of previous phases. Java Agent Development Environment – Lightweight Extensible Agent Platform (JADE-LEAP, http://jade.tilab.com/) is used to develop FIPA-compliant MAS in mobile devices. JADE has a run-time for J2ME-CLDC (Connected Limited Device Configuration) and CDC (Connected Device Configuration) platforms. The MAS-based architecture (Figure 2) allows greater flexibility and scalability in the integration of components. It provides a simple yet extensible and powerful software layer to develop further pervasive learning environments, while simultaneously running multiple stationary and mobile agents on a CLDC/MIDP equipped resource-limited mobile device [1]. JADE-LEAP serves as the agent platform.

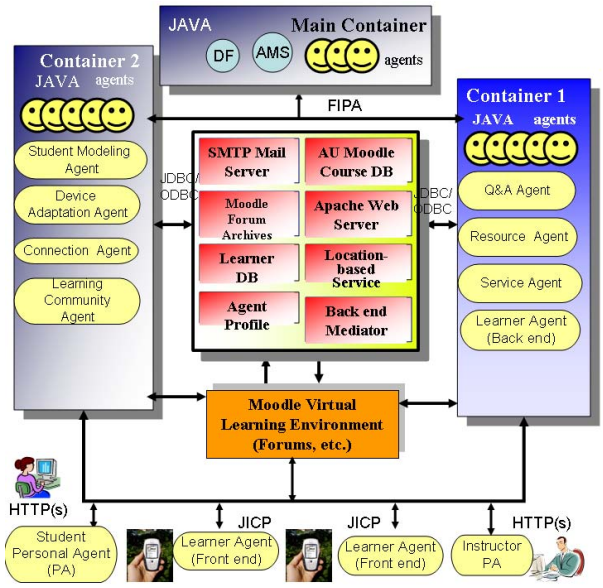

Figure 2. The MAS-based system architecture for pervasive learning

Each learner runs the front-end of a learner agent on his/her own mobile device supporting J2ME with the Mobile Information Device Profile (MIDP) 1.0 or greater APIs and Bluetooth JSR-82 or Wi-Fi APIs. A Back-end Mediator in the JADE-LEAP architecture, running on a host with a known, fixed, and visible address, automatically manages the back-ends for all front-ends active on the learner's device.

The overall system is being designed around a central component, the Personalized Adaptive Learning Dashboard (PALD), which provides students and teachers with access to various other components of the system through the student portal and instructor portal. The main techniques used in the integration of each component with the PALD are Web services, Ajax, JSON framework, and J2EE architecture. A two-way adapter software module has been designed and developed to implement the architecture of multi-agent, multi-platform compatible and distribution systems.

In the integration of the location-awareness based mobile virtual campus, a proxy server as a wrapper of the two-way adapter has been developed to provide Web services to the PALD. The services implemented in the proxy server include service of user authentication and authorization, service of user profile synchronization, data redundancy check, and service of downloading user's location and location history data to the PALD.

The learning style component is implemented in the Moodle, a learning management system. Therefore, instead of integrating learning style component with the PALD, the integration process is done between Moodle and one of the portal applications in the PALD, namely student portal. The learning style component is developed in the PHP web language in the Moodle. A PHP module has been developed to provide 'Single Sign On' function from the PALD and the student portal to the Moodle. This module can only be accessed via the PALD. In addition, a service module has been developed and implemented in the PALD to perform data synchronization between the PALD and the Moodle.

The integration to the component of Context-awareness, a web application with Web Service Description Language protocol (based on Apache CXF architecture) has been designed and developed and is ready for testing on the server. The services implemented in this web application include user authentication and authorization, data synchronization, and user's context information manipulation.

To integrate PALD with document management systems (DMSs), a software module, which is similar to the two-way adapter and the proxy server, has been designed and developed to gain access to DMSs, to retrieve documents from DMSs, and to store documents into DMSs from the instructor portal of the PALD. In order to organize documents such as learning materials and discover and construct knowledge from these documents, a Knowledge Management component has been designed. As part of this component, a web user interface has been developed and implemented in the instructor portal for the Knowledge Management component.

VIII. EPILOGUE

This research is addressing a number of research challenges that are pertinent to the adaptivity and personalization in ubiquitous learning environments. It is combining various personalization methods to create content delivery mechanisms and problem-solving environments that never existed before. In addition, it uses multiple media input for problem solving using real life objects from the learner's vicinity with the aim to improve learning and understanding of domain concepts/processes that are difficult to grasp in the absence of familiar scenarios.

Far-reaching benefits are anticipated for the existing educational approaches as a result of this research. On the one hand, access to high quality education is enabled for those who are unable to join mainstream education, while on the other, improvement in the overall quality of education are achieved by incorporating valuable pedagogies of personalized and situation-specific learning, and multimedia based problem solving through the use of emerging mobile technologies. The generic domain-independent nature of the research outcomes is beneficial for both practitioners who are able to use the results to enrich their educational practices and researchers who can incorporate the architecture and models into their own research work.

IX. ACKNOWLEDGMENT

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