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Personalisation of a U-Learning Environment for Third Level Education*

Yükseköğretimde yaygın öğrenim (U-öğrenim) ortamının kişiselleştirilmesi

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Özet

Bu makale, yükseköğretimde öğrenim deneyimini güçlendirmek amacıyla içerik özelleştirmeyi, işbirlikçi ve sosyal öğrenimi birleştiren ,"Kişiselleştirilmiş Yaygın Öğrenim Platformu" (PULP) adlı yaygın öğrenim *(ubiquitous learning – u-Learning)* sistemini sunmaktadır. Dublin Ulusal Üniversitesi (University College Dublin, UCD), üniversite içinde öğrencilerine farklı fakültelerden farklı dersler almalarına imkân tanıyan UCD Horizon aracılığıyla, gözetimli öğrenim ortamları *(managed learning environments*, MLE) sunmaktadır. Bu platformun ana amacı, uyarlanabilir ve işbirlikçi öğrenim ve herhangi bir yerde ve herhangi bir zamanda mobil ve masaüstü istemcilerinde insan-bilgisayar etkileşimi için koşullar sağlayacak ve bunları teşvik edecek mevcut MLE'lerin güçlendirilmiş bir sürümünü sunmaktır. Sistem, öğrencilerle bağlantı kurmak ve devam eden derslerinde içerik materyallerine erişmelerine yardımcı olmak amacıyla etmen odaklı öneri tekniği *(agent-oriented recommendation technique)* gibi kişiselleştirme tekniklerini kullanarak, yükseköğretim ortamında öğrencilerin öğrenim deneyimini güçlendirmeyi amaçlamaktadır.

Anahtar sözcükler: m-Öğrenim, u-Öğrenim, çok etmenli sistem, etmen odaklı kişiselleştirme.

Abstract

This paper presents a ubiquitous learning (u-learning) system, the "Personalised Ubiquitous Learning Platform" (PULP), which integrates content personalisation, collaborative and *social* learning for the enhancement of the third level education learning experience. University College Dublin (UCD) provides its students with managed learning environments (MLEs) and adaptive learning via UCD Horizon which enables tertiary students to take different courses from different colleges throughout the university. The main objective of this platform is to provide an enhanced version of the current MLEs that will act as a single supported intelligent and personalised ubiquitous learning environment that will promote and make provisions for adaptive and collaborative learning, human computer interaction on mobile and desktop clients anywhere and anytime. The system aims to enhance the students' learning experience in third level educational environment by employing personalisation techniques such as the agent-oriented recommendation technique to engage students and help them access the content material for their on-going studies.

Keywords: m-Learning, u-learning, multi-agents system, agent-oriented personalisation.

There is a huge demand for ubiquitous and personalised learning; this demand made the internet a channel for distributing content more efficiently anywhere, anytime in the 21st century (Bates, 2005). E-learning tools are used to enhance learning experience in second and third level educational environments, i.e. secondary and tertiary institutions, all over the world (Keegan, 2008). The traditional learning system is too restricting for modern students. These students need to multi-task and manage their time due to factors such as short attention span, part-time work and etc. Modern students find it hard to concentrate on a single task for a long period of time in a single space. Some of these students also have to work part-time and they need flexible learning process in order to balance their work rota and college timetable (Mifsud and Casey, 2004). Furthermore, since advanced wireless and mobile technologies now make it possible to offer learning outside the traditional learning environment (Amin et al., 2006), learning on the go or during flexible hours is feasible and can enhance their learning experience.

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Quality pedagogical techniques enhance students' abilities and save students time during learning process and period. The introduction of mobile learning (m-learning) enhances flexible on-demand learning and teaching via the use of mobile devices whereby users can access learning resources, experts, peers and learning services anywhere (Traxler, 2009). To further enhance and embed learning into learners' lifestyle and environment, ubiquitous learning (u-learning) is steadily growing. U-learning is the enhancement of distant learning that shows the potential of computer technology which is capable of enabling learning anywhere anytime (Hwang, 2006). U-learning enables learning via embedded objects or unobtrusive computing devices, therefore offers a higher level of embeddedness than mobile learning which only enables learning via mobile devices such as smartphones, PDA/handhelds and mobile phones that are carried everywhere by learners (Traxler, 2009; Liu and Hwang, 2010).

University College Dublin (UCD) has made a unique transition from its once traditional education metaphor to an increasingly modularized educational framework for its tertiary students. UCD adopted a modularised and credit-based educational system known as UCD Horizon that provides adaptive learning. The university facilitates ubiquitous access to the vast array of resources available throughout each college of the university through the establishment of a fast and efficient wireless local area network. This offers great opportunity for mobile devices' users and e-learning facilities. The vast scale of the undergraduate community undertaking third level courses at the university requires access to the numerous resources available across each distinct school hence resources must be seamlessly integrated into one learning management system. UCD provides managed learning environments (MLEs), such as Blackboard and Moodle, that act as resource repository and also as a learning environment that aids students through their learning stages. Though these MLEs enable students to access and submit content off-campus, research (Ayoola et al., 2008) showed shortcomings of these MLEs; it is observed that there are lack of personalisation, efficiency and interoperability and maintenance cost:

- The majority of the services the MLEs provide, such as collaborative learning, are redundant because tutors and students are not making use of them.
- Since students' information are scattered all over each MLE, the MLEs could not provide content that adjust to students' needs consistently. This is because the only similar information that the MLEs have about each student are their names and email address.
- The MLEs do not exchange information about the students that can help provide a consistent student profile that will enable better personalised content delivery. Hence these MLEs lack interoperability.
- UCD has to pay for maintenance of both MLEs.
- Furthermore, the skills learnt to use one MLE is not transferable to other mobile learning environments.
- And the existing MLEs are not ubiquitous enough for the current students who are mobile users because their designs are better suited for desktop users.

To enhance UCD's current MLEs, a single supported learning environment, personalised ubiquitous learning platform (PULP), was proposed and designed to provide personalised content, collaborative activities and services. This platform's intentions are:

- To save cost of operation and maintenance by having one standard learning environment.
- To offer intuitive user interface
- To offer personalised content to users.
- To offer content accessibility and submission anywhere anytime to users on broader variety of computer technology.

The purpose of this paper is to discuss an aspect of PULP which focuses on integration of intelligent agents into the platform for the enhancement and delivery of content recommendation in a ubiquitous learning environment for third level education.

Materials and Methods

E-learning is integrated into mobile clients such as game consoles, mobile phones for flexible learning (Laroussi, 2004). Since mobile internet has become a norm, distance learning has been enhancing the education of people living in different parts of the world including under developed and excluded regions. Mobile learning (M-learning) is highly linked with information retrieval, content delivery, ad hoc questions and answers, notes, comments and general communication between learning communities and etc. (Yuen and Wang, 2004).

A Leonardo da Vinci project provided m-learning and training on wireless devices that solved the problem of presenting m-learning by developing a course consisting of 1000 A4 pages on PDAs (Personal Digital Assistants). It used Microsoft Reader to create a study environment for students. This system provided assignment feedback and enabled communication between students, lecturers and fellow students (Keegan, 2008). Issack et al. (2006) developed a prototype application that is made up of a web-based interface, mobile access interface and an adaptation mechanism which provides justin-time personalised content to students to blend mobile and e-learning into a single computer-based infrastructure.

Personalisation and collaborative learning are among the techniques used to enhance distance learning. Personalisation is important in learning systems; it is essential for an educational system to adapt to users automatically based on its observation of the users' needs or user's preferences. Laroussi (2004) suggested the employment of agent-based expert model whereby

an agent consults another agent that is familiar with a specific domain in order to assist student for the integration of e-learning in mobile devices. Miao et al. (2007) proposed personalised recommendation agents that are called fuzzy cognitive agents, which were designed to provide personalised suggestions to online customers based on current user's personal preference, peer common preferences and the expert knowledge.

A personalised recommendation education system (PeRES) which is based on multi-agents and SCORM was designed by Zhu et al. (2008) to encourage knowledge sharing, content reuse, personalised information delivery, personalised content recommendation and comprehensive service solution for e-learning. Dinsoreanu et al. (2003) employed organisation of agents for student assessments; they focused on evaluating issues such as communication, security, evaluation types, student's answer analysis and grading in a virtual learning environment (VLE). The assessment service they developed is only efficient for technical domains, which have limited range answers (Dinsoreanu et al., 2003).

The recent trend of learning styles and digital device diversity creates different challenges for content delivery, presentation and management. These challenges have prompted the adaptation of content version of a learning resource that suits and is compatible for specific learning device-context and the learning style requirements of e-learner (Sudhana et al., 2013). Sudhana et al. (2013) proposed the context aware adaptation mechanism based on rules derived from ontology for context aware course in e-learning environments. They aim to use their ontological framework that is based on three different dimensions of contextual information to make context model design of each device independent in an adaptive e-learning system. In comparison to PULP, the mechanism they proposed is device-specific, that is, it fashions content delivery based on device type and capability, while PULP's mechanism offers generic delivery and presentation that targets most portable, mobile or static device.

Lee et al. (2013) investigated the essential features of mobile devices for ubiquitous learning via a consumer preference approach. 224 respondents were interviewed via a web page and the study used four attributes, such as screen size, platform, office productivity and data access, to examine consumer preference on mobile devices for ubiquitous learning in higher education. In u-learning, the screen size is crucial for the detection of mobile device and the platform states the capability and features such as hardware configuration, operating system of the device. The office productivity refers to the editing software, e.g. Microsoft Word, the device offers. While wireless data access is required to support seamlessness of u-learning. Findings showed that the survey respondents prefers to access learning content on 12 inches devices which current tablets do not have. Result also showed that correspondents prefer editor such as Microsoft Word which means they are accustomed to PC-based platform. So, though they enjoy using the smart phones and tablets, for their educational purposes, they want mobile devices with tools that are consistent with that of their PCs at home or at the university. They also revealed that they do not require comprehensive functions when they make office document or other content. Furthermore, they prefer to receive content via Wi-Fi and cellular technology.

In comparison to the systems mentioned above, PULP blends a fusion of adaptive personalisation techniques, content management, and social and collaborative learning in order to provide learning resources, personalised content delivery anywhere anytime and facilitate content reusability. This paper focuses on the integration of intelligent agents for personalised content delivery and presentation as part of adaptive personalisation technique the system employed. Other main goals of the system are to provide;

- students with an application that can be used intuitively and accessed anywhere anytime,
- and content that suits students' needs.

Results and Discussions

A ubiquitous system (Alcaniz, 2005) should be intuitive, easy to use and it should possess good display quality and transparent file system. It should also be responsive to user's input. In order to meet up with the standards just described, limitations of context-aware design and delivery on portable and mobile devices, such as power durability, screen resolution, and connection bandwidth, have to be tackled and overcome.

Fortunately, due to the consistent, advanced and progressive development of mobile devices in a very competitive market, the enhancement of personalisation and content delivery have improved and are more feasible, hence a mobile user can have access to most or all services and content a desktop user has access to.

PULP is designed based on a hierarchical model-view-controller architecture that handles authentication, social interactivity, user modelling and content management. This architecture provides solid structure for implementation, maintenance and sustainability that will aid PULP as an efficient learning environment. The structure provides access to PULP via encrypted authentication, handles messages and collaborative interaction via social and collaborative group tools and services.

It also handles adaptive hypermedia, web personalisation and e-learning by employing the use of Lucene[1], SOLR[2]

[1] Lucene is an information retrieval library that is used for text indexing and searching.

[2] SOLR is a popular and fast open-source enterprise search platform that uses the Lucene Java core search library for full-text indexing and search.

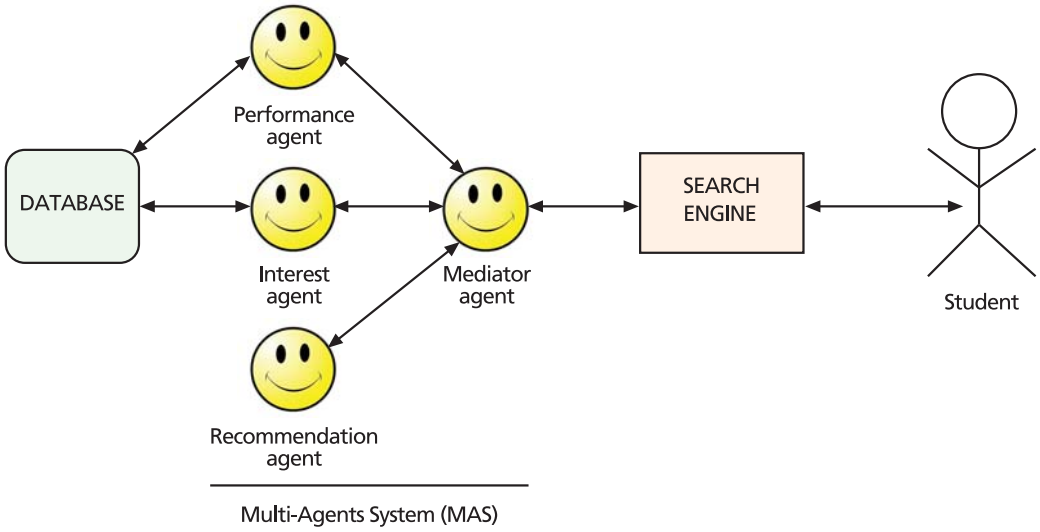

Figure 1. The architecture of PULP's intelligent agents.

which enables a better way of incorporating Lucene to web applications, multi agents system (Figure 1), adaptive content presentation and adaptive navigation support. Its content management support takes care of retrieving, storing and presenting content for publishing on student's devices. SOLR which employs Lucene to provide content based on keyword frequency is used for search queries and results while the multi-agents system comprises of four benevolent agents that retrieve, filter and deliver content in accordance to students' interest and academic strength.

This structure is adapted to tackle the three limitations of context-aware design and deliver mentioned previously. The structure will offer and deliver content in a way whereby too much connection bandwidth and power will not be require to access content and content will be viewed intuitively.

Since this paper is only going to focus on the multi-agent system and search personalised content design and delivery, there will not be more details about the content management, social and collaborative learning aspect of the system.

Integration of Multi-Agents System

PULP employed Java agent development (JADE) framework for the implementation a multi-agent system (MAS) which is built with programming, mark-up and scripting languages. The MAS consists of four intelligent agents known as mediator agent, performance agent, interest agent and recommendation agent, as shown in Figure 1. These agents are benevolent and cooperative, they work together to achieve a common goal. Though, only the mediator agent interacts with the other three agents, these agents together create a single profile for each student. This profile holds data that is used to enhance search results. The mediator agent also acts as a middleman between the agents and system's model.

When students log onto the system, the interface and the model trigger the MAS by creating four unique agents that act as a clone of the mediator agent, performance agent, interest agent and recommendation agent for each student. The interface detects student's need via user gesture (Figure 1), which occurs when the search button is pressed. As mentioned earlier, the MAS is responsible for creating a profile that consists of data. The data is basically keywords which describe users' preference and academic strength. These keywords are retrieved from assignments' of modules the students registered for and students' profile in this order: weak, average, strong and interest. Hence the recommen-dation commences in accordance to what is available in that order. For instance, if the student has no weak grades, there would be no keywords stored for "weak", so the recommendation will commence from average.

The system displays all re-ranked recommended content processed from the user profile first before showing the rest of the search results that are provided by SOLR; it also strips off repetitive content hence items that were recommended at top are not shown again. The recommended content is shown at top with annotation to specify that they are recommended (Figures 2-4).

The MAS' recommended content enables students to easily access content that are useful to them without searching blindly for it. The agents work silently in the background without interfering with user activity or directly engaging the user in order to intuitively deliver suitable content. In order to

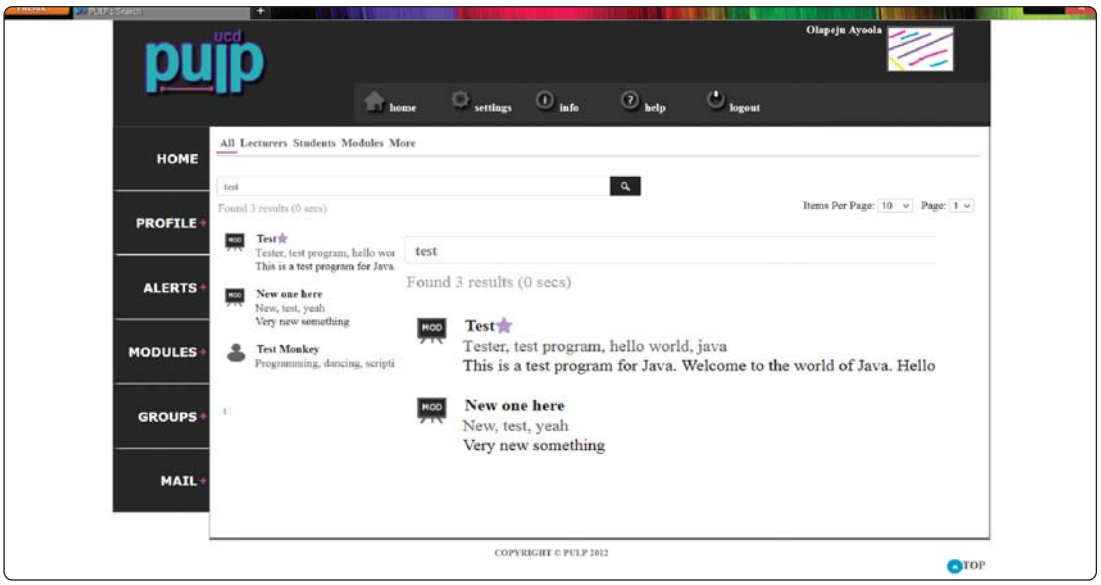

Figure 2. Returned re-ranked result; star annotation is used to emphasis relevance of new sug-gested information in PULP (desktop view).

delivery this content effortlessly on static and mobile devices, techniques such as responsive design, adaptive navigation support and adaptive content presentation were used, whereby the web design provides an optimised and intuitive learning environment and experience with

- Ease of reading and navigating with a minimal of zooming, panning, and scrolling on different devices.
- Effortless navigation and content display whereby some content can be hidden and expanded by user (Figures 5 and 6).

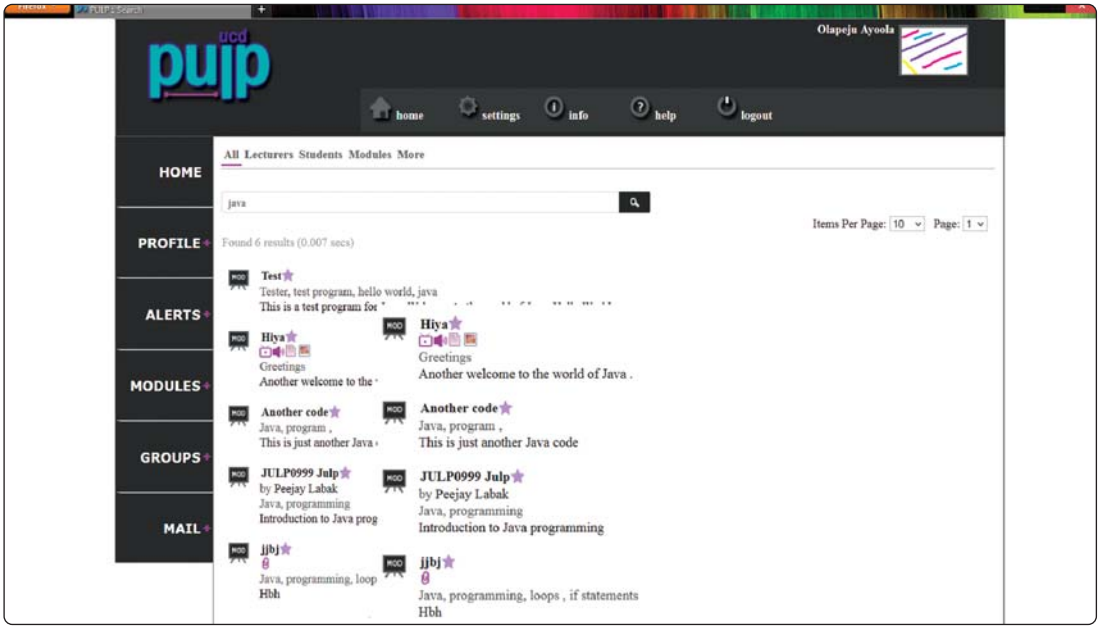

Figure 3. Icon annotations to show attached files in content of search results.

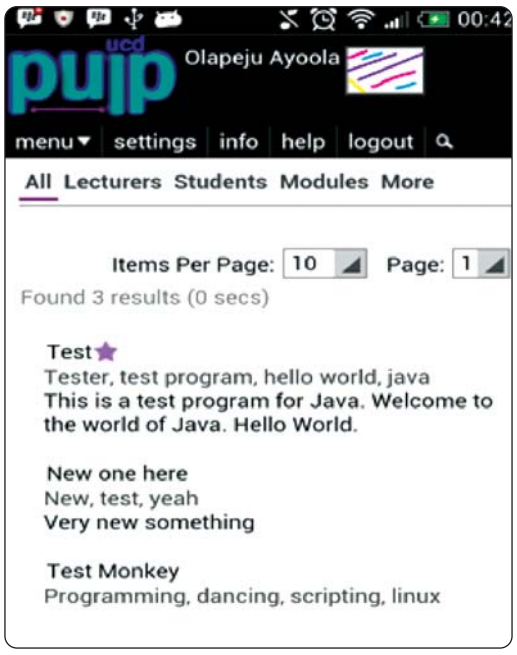

Figure 4. Star annotation that emphasises the importance of a search result item (mobile view via Android device on portrait view).

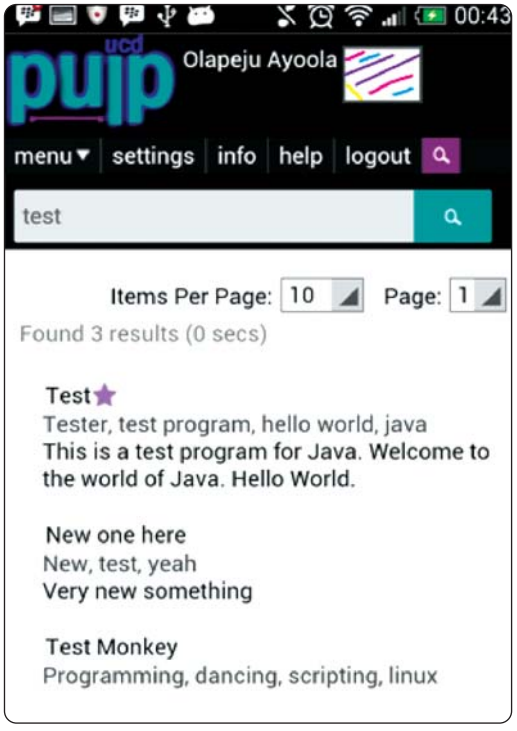

Figure 5. Responsive web layout, adaptive navigation support (e.g. design layout for menu, con-tent and toggled search box) and adaptive content presentation for mobile and portable device users.

Furthermore with the content delivery, the presentation and description of each content state if it comprises of attached files such as audio, document, video and compressed folder (Figure 3). Mobile technologies for instance, these days, come with an operating system that offers one or varieties of software which are similar to PC-based software, such as Polaris Office on Android, that most technology users are used to. Hence they can easily view documents, listen to audio and watch videos anywhere anytime.

The Shortcomings and Challenges

In order for the agents to be able to recommend content, students need to have registered modules on the system and tutors have to upload tasks and submit feedbacks for assignments, projects and etc. If these two inputs are not available, recommendation re-ranking cannot be done. The system can only offer whatever data it finds in the system's database based on the frequency of the key terms SOLR computes. If no modules, users, groups are registered onto the system, no search results can be returned.

Furthermore the responsive design, adaptive navigation support and adaptive content presentation faced challenges such as uniform delivery and presentation on all mobile devices and desktop browsers. During testing, while some devices such as android and blackberry devices easily adapt to the technique, devices with windows phone had to have a slight adjustment in the design properties and detection technique in order to provide almost the same view as the other devices. The view on portrait and landscape slightly also varies on all devices. Meanwhile on the desktop browsers, proportion of layout and font size looked different and varied across browsers hence there is a slight variation of design on them. Notwithstanding all of the functionalities that are offered by PULP shows on all devices; both mobile and static.

In order to offer security for agents' communication so that message and agents are not tampered with, JADE-S was implemented. JADE-S requires authorization from user in order for agents to communicate in the MAS. During the implementation of JADE-S it was discovered that JADE-S accept authorization via a physical prompt window, this makes it impracticable for a system like PULP that requires little or no human interaction to perform and deliver most of its background work.

Conclusion

Distant learning has become a norm for modern students who need access to educational content and resources anywhere, anytime in order to accommodate their hectic lifestyle. Modern students require educational environment that adapts to their ever changing needs. UCD provides two managed learning environments which are not substantial and engaging enough.

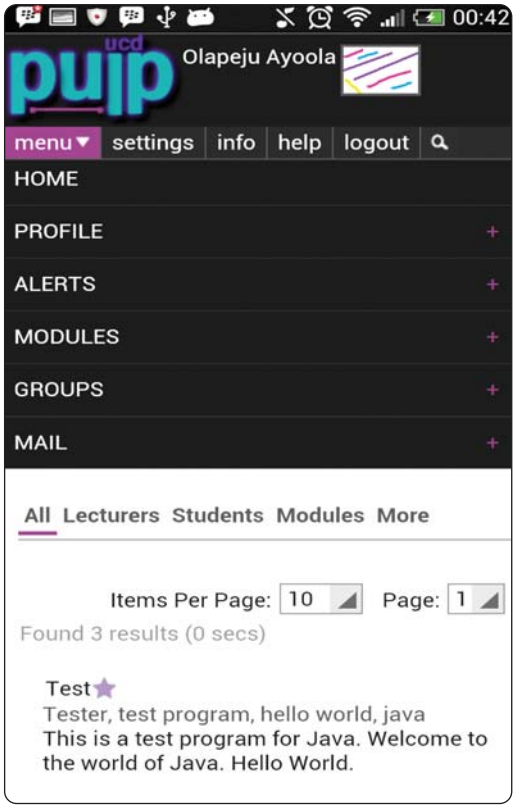

Figure 6. Responsive web layout, Adaptive Navigation Support (toggled menu) and adaptive content presentation displaying content and menu that has been adapted for a mobile or port-able device user.

Personalised Ubiquitous Learning Platform (PULP) blends adaptive personalisation, collaborative learning and content management in order to engage tertiary students and also enhance their learning experience. Different technologies are employed for personalisation and content management. Collaborative group tools are employed to provide real-time and effortless interaction for social and collaborative learning. PULP employs intelligent agents that act as expert model in order to enhance recommendation process and provide valuable search results for any of the devices the students can utilise. The system is still undergoing overall performance testing and updates, so user evaluations has not yet been carried out.

Though the project development and testing are already in the final stages, for the MAS aspect of the project agent security has to be incorporated into the system in the future. This is because the JADE-Security, also known as JADE-S, add-on that previously implemented for the system is not realistic for real world applications and has no longer been updated by its developers hence the latest addition and second security add-on, known as Trusted Agents, to the JADE development has to be deployed to protect agents from malicious and unauthorised attacks; Trusted Agents add-on only allows authenticated agents onto the agent platform.

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