Towards an Adaptive Study Management Platform: Freedom Through Personalization

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Abstract: Technological advancements have brought abundant freedom to our lives. In an educational context, however, the technology utilization is still relatively low despite recent developments on various learning platforms such as e-learning, mobile learning, MOOCs, and social networks. The contemporary technological advancement in smart gadgets enables us to bring learning resources with appropriate content format to the learners at the right time in the right learning situation. Yet there remains a need for an adaptive study management solution that would apply data mining algorithms to assist university students both before and during their studies in a personalized manner. This assistance can be of many kinds, such as campus orientation to new students, course curriculum recommendations, and customization of study paths. In this paper, we present the concept and an initial implementation the Adaptive Study Management (ASM) platform that aims at facilitating a university student's academic life in different phases by tracing the student's activities and providing personalized services, such as a course curriculum recommendation, based on their behavior and achievements during a period. The ASM platform creates a profile for the student based on their achievements and competencies. Consequently, the platform aims to grant freedom to students on their study management, eases teachers' workloads on assessing students' performance, and assists teachers and administrators to follow up students and dropouts. The goal of this platform to increase graduation rates by personalizing study management and providing analysis services, such as dropout prediction.

1 INTRODUCTION

The use of ICT in education and training has caused several paradigm shifts, e.g., the Internet has offered flexible and powerful ways to accomplish a range of pedagogical goals (Anderson and Dron, 2011).

Higher educational institutes often organize an orientation week for new students. The orientation week has significant impact on students psychologically, sociologically, and for future learning efficiency. Already in 2002, Murphy, et al. (2002) utilized a web-based college orientation to help students to adapt with the new environment. Orientation week is also important for new employee in companies. Acevedo & Yancey (2011) designed a framework which focuses on a Realistic Orientation Program for new Employee Stress (ROPES).

Furthermore, recent advancements in mobile and wireless technologies have enabled learners to carry out educational tasks anywhere at any time. This trend is evolving, as mobile learning has become more than an add-on in e-learning platforms. However, providing learning materials to mobile devices is associated with design and development challenges (Dirin, 2016).

Smartphones and other context-sensing technologies have enabled context-aware learning experiences. These smart devices may overcome the traditional educational and classroom constraints, such as place, time and presence, as they enable learning to happen anytime, anywhere, with presence when needed (e.g. via videoconferencing). A range of context-aware learning systems have been proposed for different purposes (Schmidt, 2005; Gómez *et al.*, 2014), but most of them do not tackle the task of managing one's academic life in an efficient and personalized manner.

Bloom (1984) demonstrates that the one-to-one expert tutoring is more efficient than conventional classrooms and master learning. It is therefore a desired feature of an adaptive study management system to provide one-to-one expert tutoring in a

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personalized manner. To understand the learner's context and thereby achieve personalized one-to-one expert tutoring, a system must collect and analyze large quantities of data. Fortunately, there exists an abundant repertoire of knowledge discovery and data mining algorithms that can be utilized to achieve this.

In this paper, we propose a novel concept for a Adaptive Study Management (ASM) platform that utilizes knowledge discovery and data mining algorithms to achieve context-awareness to the student's individual academic profile, including academic performance, preferences, behavioral data, competencies, and study activities. The platform's goal is help students efficiently plan and manage their studies, thus resulting in improved competency. Through presenting the ASM concept and implementations of first components of the prototype, we discuss the advantages and disadvantages of this future trend of adaptive study management where academic life is facilitated by seamless context-aware interaction with classroom and peers.

2 BACKGROUND

2.1 Mining Big Data

Sagiroglu and Sinanc (2013) define big data as massive data sets which have a complex and varied structure, with challenges of storing, analyzing, and visualizing for further processes (e.g. personalization of learning). Big data are often collected from multiple autonomous sources. Big data analytics is the process of identifying patterns among the collected data, and it has become popular across industry domains. Big data analytics help develop new business opportunities for companies (Schultz, 2013), but research and applications of it in the educational context less common. Wassan (2015) recommends applying big data anaalytics to educational contexts, as there are vast amounts of valuable data involved especially in online courses.

One of the essential methods of big data analytics is data mining, which refers to the process of extracting hidden knowledge from a large amount of data. The generic goal of data mining is to identify patterns and relationships in the data, which, in turn, can be used for making predictions of future events (e.g. student dropouts). There are various approaches to data mining, such as association rules, classification, decision trees, clustering, neural networks, and clustering. Many of these are defined under the term of machine learning (ML), which is a family of algorithms making predictions based on what they have previously been learning of the data.

ML algorithms can be divided into two categories: supervised and unsupervised. Moreover, semi-supervised ML algorithms are hybrids of the two main categories. Supervised ML algorithms are provided with a set of instructions and a definition of what the predictions should aim at (James *et al.*, 2013). For example, a supervised ML algorithm detecting the learner's emotions is given a time of day, the learner's heart rate and galvanic skin response, and examples of correct predictions. With this training data, the algorithm learns to make accurate predictions using similar data sets in the future. Supervised ML is useful when the data to be analyzed is consistent and the number of prediction classes is reasonably low. In contrast, in unsupervised learning the input data is unlabeled, and the algorithm must decide what the appropriate output should be based on data clustering or association from the example data (Ghahramani, 2004). Unsupervised learning is useful in scenarios with a wide range of acceptable predictions, such as recognizing students by their facial features.

In the domain of educational applications, as with many other domains where large amounts of data are generated, data mining can be used for many purposes, such as predicting dropouts, personalizing learning experiences or even increasing security of an educational platform. Chen, Hsieh, & Hsu (2007) applied an association rule method – whereby correlations between variables in the data set are revealed – for diagnosing the learner's common learning misconceptions. As another example, Romero & Ventura (2013) applied data mining to gain an insight on how students learn in order to improve educational outcomes. Almazroui (2013) conducted a survey to learn about the use of data mining in the e-learning context.

2.2 IoT and Learning

The Internet-of-Things (IoT) is an emerging technology that is said to affect the way we live, learn and play more than the Internet has done so far. Already today this technology is used in a number of areas, such as healthcare and education. The IoT is an extension to the Internet as we known it, through bringing everyday objects and sensors online. These IoT devices enable truly smart environments and applications that finally realize Weiser's vision of ubiquitous computing (Weiser, 1999).

With the IoT, it is expected that huge amounts of data about different entities, like learners and their environments, will be produced. This means that the IoT has the ability to become a core technology in future educational applications that utilize the analytical power of data mining algorithms. For example, Njeru et al. (2017) utilized IoT in online learning to collect and min the data to improve the course materials and the delivery of their online courses. De La Guia et al (2016) investigated the benefits of using wearable and IoT technologies in providing task-based language learning scenarios. They demonstrate that by applying these technologies freeing the instructors oh having to keep records of the task performed by each student during the class. Xu et al. (2015) predicts that the application of IoT in education will increase due to its unique advantages for improving the quality of education.

2.3 Context-aware Learning

IoT and data mining are essential for developing context-aware learning solutions, whereby the learning system is able to detect and act upon the changes in the learner's context. Chen (2008) defined context-aware and ubiquitous learning as a computer-supported learning paradigm for identifying the learner's situations and surrounding context to provide integrated, interoperable, pervasive and seamless learning experiences. By this enhancement, learning contents are not only accessible from anywhere and anytime, but learning can happen at the right time and in the right place with the right resources. To enable this, context-aware learning is typically supported by mobile devices with sensing capabilities such as GPS, camera and other sensors.

A context-aware learning space can detect and act upon changes in the learner's context, thus resulting in the provision of learning content relevant to the learner's situation. Context not only includes physical location but also environmental parameters, states of the learner's body and mind, social group, and any other information that constitutes a situation in which the learner is embedded. The learning system's awareness of the learner's context depends on its technical capabilities; the requirements for this stem from the desired experience – what does the learning space need to know about the context to provide a purposeful learning experience? It may be enough to know the learner's location within a geographical area (Ballagas *et al.*, 2007), or it may be necessary to detect parameters of the learner's body (Zhang *et al.*, 2012). All these approaches require technologies ranging from wireless networking to GPS and from bodily sensors to environmental sensors. As creating a highly context-aware learning space requires money and time, trade-offs are often necessary.

Burns (2002) defines learning as relatively permanent changes in behavior, with behavior including both observable activity and internal processes such as thinking, attitudes, and emotions. Following the constructivist view, learning is a process where an individual manipulates information to create knowledge. This knowledge creation activity is individual as it happens in the learner's brain. Therefore, different learners have different cognitive processing approaches for learning.

In recent years, the approaches to learning have significantly changed due to technological advances. In traditional learning environments, teachers were the main actors who delivered knowledge to students. In contrast, in the Internet era, vast amounts of resources are accessible with small effort to anyone to learn through smart devices (Dirin, Nieminen and Kettunen, 2013). Thus, the learner becomes more active, with a higher degree of freedom to choose study activities; the teacher becomes a facilitator who assists the learner in the learning process.

3 TOWARDS AN ADAPTIVE STUDY MANAGEMENT PLATFORM

Despite advances in learning technologies that enable provision of learning content to students in rich digital formats, most learning environments fail to provide personalized assistance to students regarding their study management, such as planning a study path or helping with competency development through offering an alternative solution to a predefined course curriculum. Personalization requires understanding of the learner's context, which can be achieved by applying data mining methods to the collected data on students' profile data. In the following, we describe the concept of a novel Adaptive Study Management platform, followed by first implementations of its components.

3.1 The ASM Platform Concept

Figure 1 presents the first phases of a student's academic life that the ASM platform supports. In the first phase, students receive an admission letter with a QR code. By scanning the QR code with a smartphone, the student downloads a virtual reality (VR) orientation game that consists of orientation activities related to the university premises, the curriculum of the Business Information Technology (BITe) program, and MyNet, a website with essential information about the university and studies, such as available pre-constructed study paths.

In the second phase, the student is eligible to select and start courses for the first semester. Each course is divided into weeks, and each week contains lectures, quizzes and performance reports. The second phase also includes tools for course registrations and management of first weeks of student life at a new academic environment; these are available for later phases as well.

The third phase commences after the first semester when the system proposes a study path and the student makes a choice accordingly. In this phase, data mining (e.g. machine learning) algorithms are utilized to adapt the study experience to the student's profile, which has been constructed during the first two phases, and which will be updated throughout the studies. The student's competencies, performance and personal preferences are inputs to the adaptation algorithms, which then provides personalized study management services, such as a recommendation on which study path would be the best, links to extracurricular courses that would be helpful for competency development, and adaptation of course contents to match personal preferences. More phases (e.g. thesis authoring) can be added later. In this paper, we merely focus on phases 1 and 2.

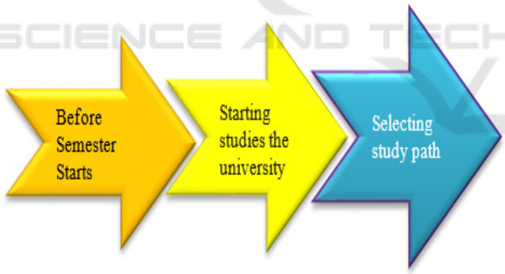

Figure 1: Study phases supported by the platform.

Scenario for phase 1

Eric Chan received his acceptance letter from the HH University in June. He is a freshman student in the BITe programme. With the letter of acceptance, Eric also received a barcode to a link to download the HH Orientation Game. Eric accesses the link and loads the game to his mobile phone. He can then start to learn about HH and BITe while playing the game.

Within a few days, Eric has gained visualized knowledge about his the HH campus, his HH profile, and teachers, as well as hands-on information about using campus and online services. By playing the Orientation Game, featuring a VR tour, Eric now knows which the service locations (e.g. library, computer rooms, printers, cafeteria) at the campus.

He is able to use school benefits such as M-Drive, VDI, Office365, and student discounts. He has also learned the process of looking for course information and timetables, registering for courses, creating own timetables and tracking performance by playing minigames related to the university's online services (MyNet, Asio, WinhaWille).

By the end of the week, Eric has completed all mini-games within the HH Orientation game that help plan his studies for the first and second period of his first semester. He also knows how to access various services using his school items such as library card, student credentials, and lunch card.

When the academic year starts, Eric goes to HH and is able to easily access and use school services right away. He knows what his planned courses offer because he has learned about the courses' introduction through Moodle minigames.

Scenario for phase 2

Eric participates in the User Experience course. He learned from the course description that the course's lectures are compulsory. Therefore, he checks his mobile and found the lecture room in time. As soon as he arrived, the teacher asked Eric whether he is willing to attend the course virtually. By Eric's confirmation, the teacher asked him to point the finger to the touchpad and take a photo. The teacher then introduces the learning application, the course schedule and the first teamwork assignment.

In order to join the next lecture from home, Eric opens his laptop's camera and opens the course webinar app. He learned that some of his team members already participated in the lecture physically. Eric and his other three team members successfully managed to share the teamwork results with the class both remotely and in-class.

The teacher in the course can see all students' progress (e.g. answers to quizzes) by one click. He can also upload links or files and create quizzes based on the links or documents the students have to study.

Through the mobile app, Eric is not only able to access learning contents and take lectures remotely, but also trace his progress at any time. To consolidate what Eric learned, he uses the mobile app to take quizzes. With the quiz results, Eric and the teacher can track his progress in the course. After the semester, the platform recommends Eric courses that he should and he could to take next semester.

3.2 Prototype Implementation

Here we describe the first implementations (phases 1 and 2) of the ASM platform. The orientation feature (phase 1) was implemented as a 3D VR game with the Unity 3D game engine. The game allows the player to explore the campus, its lecture rooms, offices, and classrooms. We used 360-degree video presentations of the campus through which the user may interact with the surroundings. Moreover, the phase 1 prototype includes information about the BITe program and MyNet. The details about the concept development process, architecture, and applied technologies are to be presented in a different paper. Figure 3 presents screenshots of the orientation game.

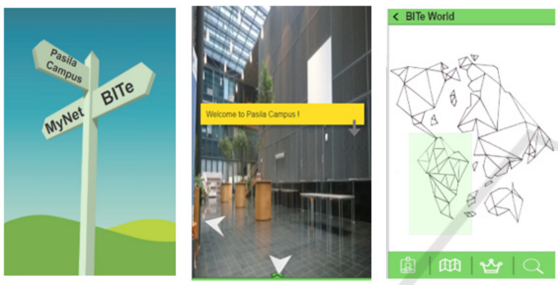

Figure 2: Samples of phase 1 prototype screenshots.

The implementation of the phase 2 prototype has two parts: 1. teachers' tool that enable teachers to create activities, such as lecture notes, quizzes, and notices; and 2. students' application with assignments, lectures' activities and course performance. We utilized a NoSQL database for storing all the data and a NodeJs/ExpressJs server to connects the front-end (mobile application and website) to the back-end (database). The React Native framework was used for the mobile application implementation. Figure 4 presents sample of screenshots of the students' application. The database design of the mobile application is presented in Figure 5 and the overall architecture is given in Figure 6. Figure 7 shows the interaction between the learner and the system in the phase 2 prototype implementation.

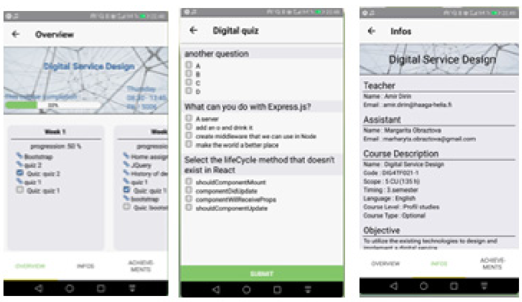

Figure 3: Samples of phase 2 prototype screenshots.

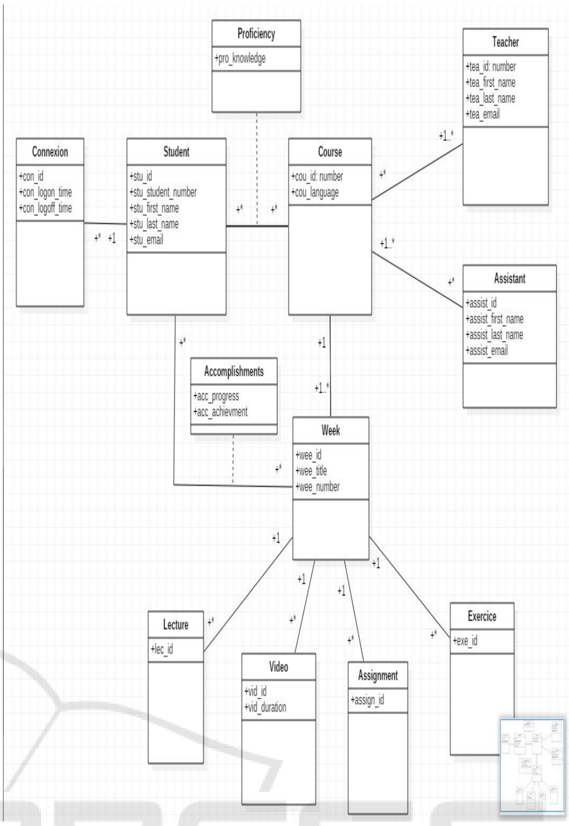

Figure 4: Design of the phase 2 database.

The implementation of the system is based on a three-tier architecture. The details of each tier are considered to be out of the scope of this paper.

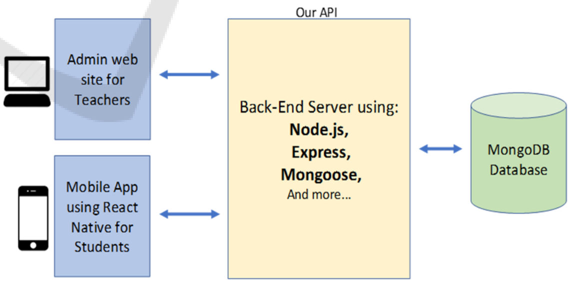

Figure 5: Phase 2 implementation architecture.

4 OPPORTUNITIES AND CHALLENGES

The ASM platform supports truly context-aware study management services, which provides freedom and enhanced learning experiences to students. More, it aims at facilitating teachers' work, thus it is important to discuss the opportunities from teachers' perspective. The opportunities from the student's and the teacher's perspectives are summarized and discussed in Table 1 and Table 2, respectively.

Table 1: Opportunities from the student's perspective.

Opportunity	Description
Freedom	The student is free to plan and implement their studies in a personalized manner.
Portability	Technical portability is enabled with ubiquitous technologies. Content of the orientation game is portable as a story. The lectures are accessible ubiquitously.
Increased motivation	The ASM platform aims to be an all-in-one study management service where the student may join a lecture from anywhere (remote presence), gain ownership through customization of the service, and instantly communicate with peers and teachers. These are likely to increase student motivation.
Informal and formal contexts	The platform supports both formal (e.g. ordinary courses) and informal (e.g. virtual campus tour) learning opportunities
Adaptable content	Services are adapted to match the student's profile
Quizzes	Each week the student receives a quiz, which is based on their profile (e.g. competence level, previous performance) to facilitate learning
Performance	The student can follow his / her progress
Suggestion	The student receives recommendations from the platform (e.g. courses to take)
Human touch	The platform provides a combination of face-to-face and remote teaching/learning. Emotional engagement of the stakeholders is a key factor in the platform development.

Table 2: Opportunities from the teacher's perspective.

Opportunity	Description
Freedom	The ASM platform provides freedom to teachers in many ways: 1) it frees teachers from some parts of the orientation week; 2) Teachers are able to upload and provide the lectures notes at their convenience; 3) Compulsory presence become optional for students, thus making the classroom more manageable; 4) System records and manages students' progress and performance, hence, less manual students' performance assessment.
Portability	The ASM platform enables teachers to follow students' performance, progress, and presence at any time and any place. Furthermore, through the ASM platform, teachers may offer lectures regardless of time and place.
Increased motivation	The ASM platform aims to be an all-in-one study management service where the teacher may provide lectures from anywhere (remote presence), gain ownership through customization of the service, and instantly communicate with students. Teachers receive visual feedback on students' performance and are therefore able to improve the course further.
Informal and formal contexts	The platform supports both formal (e.g. ordinary courses) and informal (e.g. virtual campus tour) learning opportunities. Hence teachers may utilize their preferred pedagogical approaches for course implementation.
Adaptable content	The platform features are provided as services. These services are compatible and adaptable with the existing Learning Managements System (LMS) when required. Additionally, the platform services are adapted to match the student's profile
Quizzes	Teachers can create a quiz bank from which the system picks quizzes to the student based on their profile (e.g. competence level, previous performance) to facilitate learning. Teachers receive update on the students' performance on quizzes.
Performance	The teachers can follow students' progress and accordingly adjust the course content and quizzes to gain the better results.
Suggestion	The teacher receives recommendations from the system (e.g. additional content or suitable pedagogical approaches to use)
Human touch	The ASM platform provides a combination of face-to-face and remote teaching and learning. Emotional engagement of the stakeholders is among the key factors in the platform development

There remains challenges to be solved in the development process, as Table 3 illustrates.

Table 3: Development challenges.

Challenge	Description
Content creation and sharing	Development of an easy-to-use and feature-rich content editing system is challenging in terms of resources. To alleviate this, an existing content framework could be adopted.
Novelty effect	Novelty of VR technology and freedom of participation in classroom is likely to motivate students and teachers but it will not last forever.
Encouraging performance indicator	Continuous performance evaluation may result in disappointment for students who are not doing well in the classroom. Moreover, teachers ignore the indicators in a long run.
Usability and user experience	The concept is a unique experience for students and teachers. Adaptation to the new learning and teaching environment in the beginning can be challenging.
Heterogeneous components	The current prototype components were implemented separately. It is a technical challenge to combine these in a seamless way whilst supporting extensibility.
Human touch	To make a system that engages the students emotionally in an efficient manner is a challenging task.

5 CONCLUSION

The potential of technology is not being fully utilized in educational processes. In contemporary classroom and lecture setups, the participation in the lecture is still often compulsory, and students have to follow dictated degree program curricula and study paths. The existing tools such as Moodle mainly help for durable content management and does not provide students with freedom to personalize their studies. The aim of this study was to develop an adaptive study management platform that efficiently utilizes various technologies to such freedom to students. The motivation is to overcome traditional educational constraints, such as place, time and connectivity. The platform supports students, teachers and§ educational institutes from the time that the student receives an acceptance letter up to their graduation ceremony. The platform enables the student to take part in a lecture at any time any place. Furthermore, it helps the student personalize their study path and courses based on their individual profile and performance.

The ASM platform enables the teacher to follow up the student's performance records and activities in each lecture. The current prototype comprises a main mobile learning application for students and teachers, and an orientation game for students.

The proposed concept is a demonstration of changing requirements for learning and teaching environments. Consequently, education must be aligned with students' expectations. Smart devices have become parts of our lives, and utilizing these devices in learning processes is a pedagogical asset. Learning happens on the student's own device in a familiar environment. Soon any device can be transformed into a learning platform that interacts with the surroundings for pedagogical purposes.

In the following months, we aim to implement a phase 3 prototype of the ASM platform with adaptation features using data mining (e.g. machine learning algorithms). Afterwards, we plan to evaluate the implemented prototype components in the BITe degree program. This evaluation will help us assess the students' performance and evaluate the impact of the ASM platform on their learning processes.

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