Mobile Learning to promote Renewable Energy Education at the Secondary Education level in developing countries.

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Mobile Learning to promote Renewable Energy Education at the Secondary Education level in developing countries.

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Abstract. Education is a fundamental component in advancing society towards a cleaner and sustainable energy consumption route. To achieve and promote the Sustainable development Goals (SDG's) education will play a pivotal role in creating awareness and promotion of Renewable energy concepts amongst the general public. Malaysia and Bangladesh are two ambitious countries that has implemented various policies to harness energy from renewable sources but lacked to achieve their targets. This is mainly due to lack of RE education and interest and awareness amongst the public. Recent studies have shown a significant lack of RE curriculum specially in the secondary level of education in most of the developing countries. This lack of curriculum can directly impact the societal process to shift to a sustainable green energy future due to the lack of interest, awareness in students for RE career and importance. This gap of introducing RE education into the secondary education curriculum can be fulfilled by using Mobile Learning (M-Learning) methods and technologies as means to educate secondary schools students about RE. Both the countries have a population well equipped with smart devices and internet access thus equipping people with greater mobility, communication, and access to resources all over the world via the Internet, which can be used potentially to incorporate within the education sector as a mean for teaching and learning. Thus, this paper aims to highlight the educational strategies, theories and components that are associated with mobile learning and propose a mobile learning system that can be used to incorporate RE education in secondary education level in countries like Malaysia and Bangladesh.

Keywords: Renewable Energy Education, Mobile-learning, Sustainable Development Goals, Secondary Education, Developing countries.

1. Introduction

In the last decade, the world has shifted to a more technologically advanced society with a rapid increase of mobile technologies available and adopted by the public in the form of smart phones, tablets or PDAs (Personal Digital Assistant). This shift in technological advancement is no different in countries like Malaysia and Bangladesh where the former aims to be a fully-fledged developed country by 2024-28 and the latter aiming to be promoted to a developing country by 2026[1], [2]. As members of the United Nations both the countries in focus are part of the global Sustainable Developments Goals (SDGs) plan

set up in 2015. The SDGs consists of 17 interlinked global goals for a sustainable future for all and amongst them investment and transition to Renewable Energy (RE) sources for energy harness is a fundamental part of the SDGs. Like other countries Malaysia introduced various government policies to achieve the RE SDGs, like the 9th Malaysian Plan, Renewable Energy Act 2011 by which Malaysia aims to harness 30% of its energy needs from RE sources by 2030 and 50% by 2050 [3]. But in reality, Malaysia only managed to achieve only 2% of energy from RE sources. On the other hand, Bangladesh issued the Renewable Energy Policy in 2008 aiming to achieve 10% of its energy needs from RE sources by 2020, inviting public and private investment in RE ventures [4]. But this plan was well short of its initial target only achieving 3.5% by the end of 2020. The government issued a new plan of achieving 40% of energy from RE sources by 2041 but doubts have already risen about this if drastic measures are not taken [4], [5].

In both the countries the common factor in not achieving their respected goals was the lack of awareness, availability of knowledge on RE concepts amongst the general public [4], [6]. Education plays a pivotal role in creating and promoting awareness about various concepts that in turn helps drive the society to achieve their goals. Similarly, RE education is vital for a society to shift to clean and sustainable green energy from fossil fuels if they are implemented early in the secondary school level. Students can comprehend the RE technologies and their concept if implemented in the early stages and gain motivation and interest to pursue higher education and career in this sector [7], [8]. Thus, with the latest technological advancement available inboth the countries and the lack of RE awareness and education, this paper aims to highlight the educational strategies, theories that are associated with mobile learning (M-learning) and how they canbe used to incorporate RE education in secondary education level in both the countries.

1.1. Mobile learning in Malaysia

The rapid advancement in mobile technologies seen throughout the world in the last decade is impacting the educational sector in a positive way, with M-learning exhibiting immense potential of learning and effective teaching, thanks to the advantages mobile technologies have with them like portability, participatory learning, ease of communication and availability [9]. According to Statista 2022, 88.79% of the total population of Malaysia use smartphones [10] and the Department of Statistics Malaysia published a report showcasing 96.85 of the population have internet access [11]. Amongst the population that uses smartphones 13.5% belongs to age group 15-19 and 24.5% comprises of the age group 20-24 (refer to Figure 1), thus highlighting a high number of secondary school students and tertiary level students owns smartphones that can be used for mobile learning in their respected institutions [12].

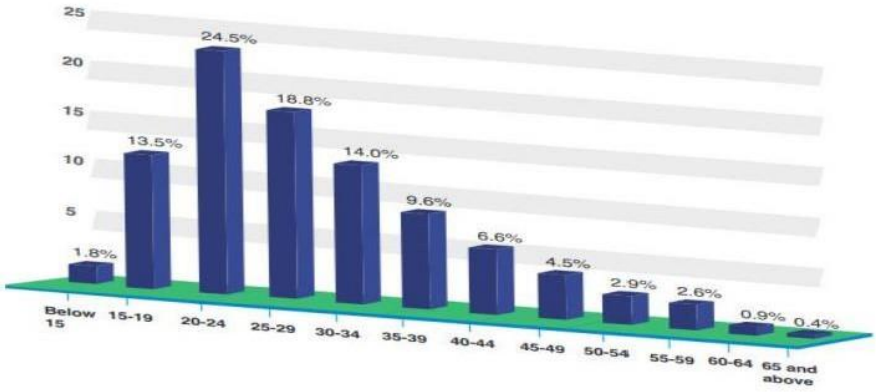

Figure 1: Percentage of Smartphone Users by Age Category [12]

Government intervention to implement M-learning in the educational spectrum of Malaysia is critical to bring about the success it is capable of bringing. The government with the help of dedicated policies that can enable M-learning in various institutes across different states can help students access good quality education and increase their technological literacy [3],[7]. The Malaysian government has already implemented various policies like “National Higher Education Strategic Plan” beyond 2020, which emphasizes on the usage of ICT and mobile technologies as means to offer effective learning and teaching in higher education institutions in Malaysia, and also the “Bring your own device” (BYOD)

policy where teachersand students bring their own portable and use the institutions network system to convey teaching and learning [13]. These policies have seen a positive impact in providing quality education to all especially in the rural areas with help of remote learning. But the setback is the lack of effortgiven to implement these policies in the secondary level of education [13] which if implemented can help create awareness, interest and motivation for these students to pursue higher education and career [14], [15] in necessary areas like the RE sector which is in need of better-quality workforce and innovation.

1.2. Mobile learning in Bangladesh

With the advancement in technological innovation and the current digital age the educational sector has seen massive changes in their strategies to incorporate the 21st Century skills characteristics. In the current educational trend across the world students are expected to master the 21st century skills like knowledge construction, skilled communications, collaborations with peers, technological literacy to name a few, as they are seen as necessity characteristic requirement in modern workforce [16]. Thus, alongside Malaysia and other countries Bangladesh also implemented policies to promote M-learning and ensuring the students are equipped with these skills and characteristics required in the modern workforce industry. The government of Bangladesh implemented the National Information and Communication Science policy in 2009, which emphasizes the use of digital and mobile technologies for ICT based education across primary to tertiary level of education. This policy is part of the greater national goal of "Digital Bangladesh: dreams and reality". Bangladesh being one of the fastest smartphone mobile penetration countries in theworld, with 47% of its total mobile phone users owns a smartphone [17]. Around one million of the smartphone users falls in the age group of 18-25, and a possible significant number can be found in the15-18 age group, thus encompassing a huge number of secondary and tertiary level of students that canimplement M-learning for effective learning and teaching methods [18]. Under the aforementioned policies the government has taken great steps in providing M-learning infrastructure like free wi-fi in all public universities, so that teachers and students can use the network to implement M- learning [18], [19]. But similar to Malaysia, there is a lack of effort and infrastructure present in the secondary level of education. This is because the policies currently implemented cater to the higher education spectrum and less policies are implemented in the secondary education [3],[4],[6]. Thus, this paper aims to highlight the importance of using M-learning to provide quality education for all including students in the remote areas of the country and in turn use M-learning to promote RE education amongst the secondary school students.

2. Mobile learning characteristics and educational theories related to M-learning

Mobile learning has been defined by Crompton, Berge and Muilenberg in their book *"A Historical Overview Of M-Learning"* as *"the process of learning across multiple contexts, through social and content interactions, using personal electronic devices"*. The term "context" in the definition means that m-learning is self-directed and spontaneous meaning learning can be done by an individual by his or herself or by directions of others in a spontaneous learning environment [20]. Thus, based on the definition m-learning can be divided into elements that forms the basis of this learning method. The elements include the learner which is more student centered based on the 21st century learning and teaching model, where the learner need to have access to the information at any time and are able to self-evaluate their learning as individuals or in collaboration with peers. In m-learning the learner is at the center of the process and all other elements revolve around them. The other elements are teacher who are apart from being only providers of information needs to collaborate with students and supervise them as a moderator or consultant using modern mobile technologies to acquire knowledge [21]. Content is another element in M-learning which needs to be designed and developed in various multimedia formats ranging from animation graphics, interactive videos, quizzes, or interactive games to allow learners to quickly absorb the information using the technologies [21], [22]. Environment is another element of M-learning that must be designed in a way to promote positive learning experience, either in the form fully online, face-to-face, or mixed mode. Depending on the mode, the learners should always have access to the information required and have the ability to communicate and collaborate with fellow students and teachers to achieve their learning goals [21], [22]. And lastly assessment is the last element

of M-learning that enables teachers to monitor and analyze the learners' performances using online exams, online discussions and creating database logs to evaluate the students' progress. M-learning emphasizes on the ability of students to self-evaluate their progress by conducting online tasks, quizzes and discussions and getting feedback instantly via the application, website or devices they are using [23].

2.1. Characteristics of M-learning

To implement M-learning model and develop a learning system in the form of website or application, the characteristic of the model needs to be followed and kept in mind while designing the system. The core characteristics allows the learners to experience an efficient learning environment with ease of access to required knowledge at any time and place [24]. The core characteristics are Ubiquitous and Portability which allows learners to access information from anywhere without a fixed geographical location and also allows learners to use portable wireless devices to perform learning tasks and activities anytime from anywhere. Blended is another characteristic that allows instructors to use various teaching methods and strategies to provide the necessary learning outcomes for the learners. With the technology present the model allows for blended learning which is beneficial to conduct a mixture of face-to-face and online learning process [21], [25], [26]. Interactiveand Collaborative are two characteristics that allows learners to interact with the system to gain knowledge and also enables them to communicate with fellow peers and teachers in a social construct to complete tasks and get feedback instantly creating a collaborative learning environment [23], [27]. Instantaneous and Private information are the last two fundamental characteristics as they provide the learners with safe and secure learning environment where they can get private feedback on their progress and can access all the contents in the system at any time or place [21],[27]. These characteristics are fundamental in providing a successful learning environment for the learners and this paper uses these characteristics to come up with the design of a M-learning system forRenewable Energy education.

2.2. Educational learning theories related to M-learning:

The way each learner gains knowledge varies differently from person to person, thus many researchers across the world conducted research to understand the different ways learners gain knowledge. Based on these researches they came up with learning theories that can be implemented alongside educational teaching methods and strategies to provide efficient learning opportunities to learners. Similarly, M-learning methods also corresponds with some of these learning theories to makeit a more efficient learning method [28]. The learning theories that form the core basis of M-learning are Constructivism which is credited to John Dewey as being the founding philosopher. And Social Constructivism founded by Lev Vygotsky [29].Constructivism theory states that leaners acquire knowledge themselves based on their past experiences.The key features of this theory are that the learning process should be active where the learners aregiven meaningful activities requiring high level of processing. The knowledge that the learners gain should be constructed by the learners themselves and the teacher should be more like a facilitator or moderator, giving interactive instructions to encourage the learners. The learners must be motivated to be involved in collaboration and cooperative learning making the learners work with fellow peers and instructors to gain real-life experiences and perform metacognitive skills to execute the given tasks. The theories firmly states that learners should be at the center of the learning process, and they shouldindulge in meaningful interaction to promote high-level of social learning process [30]. Also, social constructivism's core belief is that knowledge is developed by learners through social interactions withpeers and instructors. Vygotsky proposed the concept of "Scaffolding" in his theory which is a process where students are supported by teachers, peers, or adults to gain knowledge about new concepts through meaningful social interactions. Both the theories emphasizes mostly on collaborative learning where learners gain knowledge working in groups [28], [30], [31]. These are justtwo of the many learning theories that can be applied to M-learning and in this paper these two theoriesare the basis on which the M-learning system for Renewable Energy education was designed.

3. Proposed design of the M-learning system for RE education

With the current availability and usage of mobile devices, like laptops and smartphones, web applications have gained immense popularity amongst the users. Web applications are different from websites, where websites can only be used by using a browser on the laptop and mobile phones, web applications can be used by browsers in the laptop and also as a mobile application in smartphones making it more dynamic and easier to for developers to make constant updates and allow users smooth and efficient user experiences [32]. The proposed design of the M-learning system for RE education is a web application with this network architecture designed in such a way that allows users portability and also security from external attacks. The personnel responsible for maintaining and providing updatesto the users will be stationed at the institutions' offices protected by a firewall from malicious attacks and the data components will be stored in a registered online server so that the system is accessible by the users via their laptops or smart devices at any time (refer to Figure 2).

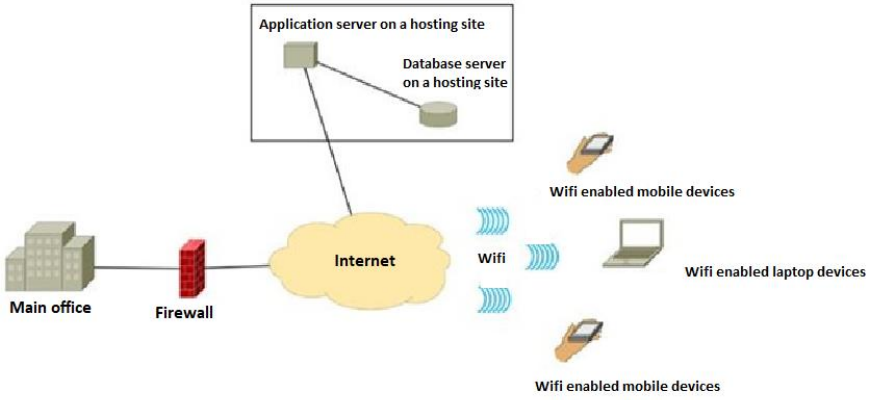

Figure 2: Network Architecture Diagram for the proposed M-learning system.

The system's functionalities are divided into three categories based on the three different types of users that will be using the system. The first is "Admin" who is responsible for approving registration of teachers by checking the credentials provided during registration. He or she is also able to see all the contents and discussion present in the system and make necessary changes to remove any harmful contents or discussion languages. The admin will generally be a member of the institution's staff thus he or she also has the ability to upload comments or post notices on behalf of the institution if required. Second type of user are the teachers, who are able to register and login to the system once their registration is approved. They can upload contents which can be in the form of multimediaslides, videos, or articles. The contents preferred to be in the form of a combination of texts, images, graphics alongside animation or interactive videos are widely accepted to be a better form of deliveringinformation to the modern generation who are more used to this type of media in their daily lives [33], [34]. The teachers can create quizzes for the student to take part in and upload assignments or activitiesto assess the student's progress. They can also engage in the discussion forum alongside students in discussing issues and providing guidance to the students. Finally, the third type of users are the studentswho can access all the uploaded contents, engage in the various threads in the discussion forum with fellow peers and instructors and participate in the online quiz and activities to enhance their knowledge and also get real time feedback on their assessment from the quiz scores (refer to Figure 3).

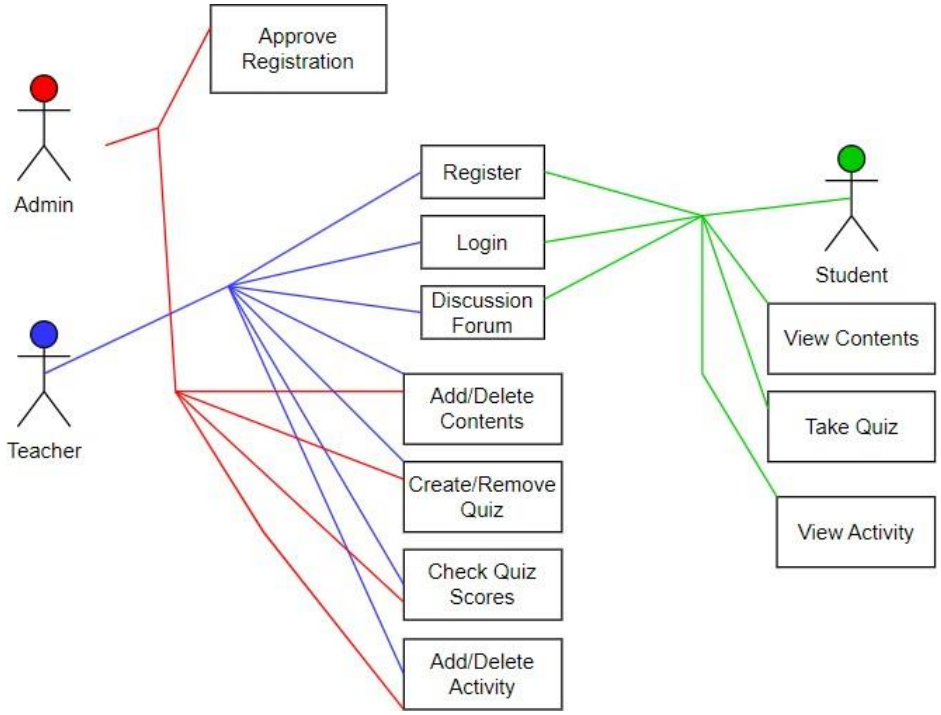

Figure 3: Functionalities of the proposed system

4. Discussion

The proposed M-learning system was designed keeping in mind all the characteristics of M-learning and all the educational strategies and theories that are closely associated with M-learning, to give the learners a positive environment to gain knowledge. Since the core characteristics of M-learning includes Ubiquitous and Portability, the network architecture of the system is designed in such a way that the system is always kept online and accessible to the users via any portable device at any time. The system being proposed as a web application rather than just a website allows more flexibility to the users to use it anytime from laptops or PCs via browsers or as mobile applications in their Android, iOS or Google operating system devices (refer to Figure 2). The functionality named "Discussion forum" (refer to Figure 3) allows students and teachers tohave communication with each other via posts and comments method at any time, allowing collaborative learning amongst fellow students. This functionality encompasses two of the core characteristics of M-learning "Interactive" and "Collaborative" and keeps in mind the educational theory of Constructivismand Social constructivism, where students form social interactions with each other and also with instructors to gain knowledge. Instantaneous and Private are two other characteristics of M-learning thatheavily influenced the proposed system's design. With various studies showing great success in implementing "Anytime, anywhere learning" which allows students in remote areas to high quality education [35], [36], this system also allows its users to access the contents at any time and any place instantly and provides security of their data. Blended is the last characteristic of M-learning that the proposed system adheres to encouraging and allowing teachers to conduct both face-to-face and onlinemethods of teaching. The teachers are allowed to upload digital contents in the system and teach them in class and later allow students to do additional reading on the contents at home and take part in quizzes

online. The students are allowed to take quizzes at any time and the result of the quiz will be given instantly providing instantaneous assessments of their progress, which gives motivation and encouragement to students on achieving their educational goals. Also, teachers can upload activities to be done in group or individually which students can do at their own time and upload to the system for assessment. Formative assessment (providing feedbacks to learners on current performances) [37] can be given by instructors via the discussion forum to students in the form of private or group discussions with students. And summative assessment (providing feedback on the learning process at the end of a task or activity) [37], [38] can be provided by instructors to the learners in the form of activity marks or also from total quiz scores. The functionalities of the admin to approve registration and the authority to remove any contents and posts and comments is given to maintain security and integrity of the overall system.

Another important aspect of the system that needs to be addressed is the type of content like digital media (multimedia slides, videos, animations) that needs tobe uploaded for the students to use and learn. With advance technological environment the current generation are well equipped to absorb information from digital media like animations, videos, or image-based slides. Studies have shown digital media impacts positively on the student's information retentionand performance if equipped with metacognitive and motivational prompts from the instructors [39], [40]. Thus, the proposed system allows teachers to upload slides on the topics of RE and its concepts and technologies, in the form of text as well as images or graphics, videos either as interactive or animations and also extra readings in the form of articles, multimedia forms of books or documents. Thecontent of the system should be multimedia and digital based for the overall system to succeed in achieving its goal of RE education.

4.1. Suggestions for Teachers and Policy makers

Teachers play a pivotal role in implementing M-learning. Apart from being providers of information in M-learning setting teachers needs to play active part in providing instructions and motivational prompts regularly to the students. This encourages the students to complete their tasks and necessary activities. For the proposed system teachers are needed to have regular interaction with the students using the discussion forum. The teachers also need to encourage the students to use the functionality to regularly communicate and collaborate with fellow students and teachers. Teachers also need to provide regular prompts and tasks/activities using the system so that the students are part of an active learning environment. Teachers also need to provide assessments individually to the studentsto create more motivation and guidance to learn the RE concepts.

In previous research, M-learning has shown positive impact on students' knowledge, motivation and awareness on particular subjects. According to a study conducted in secondary schools in Greece, using mobile learning method of instruction students have shown to display increase in interest, knowledge in science subject and physics experiments [41]. In various countries researchers have conducted experiments to investigate the impact of using M-learning methods for particular subjects like science, geography, physics and have gotten positive results in increasing students' knowledge, awareness about the topics and also their motivation to pursue further education on the selected subjects [41], [42]. Thus, policy makers in both the countries, Malaysiaand Bangladesh, should implement drastic measures to make M-learning for RE education accessible for all the students in secondary schools, so that the future prospective students can be encouraged to pursue higher education and career in the RE fields [43]. Policy makers should implement teacher's training and increase teachers' technological literacy [13] to make it easier and effective for them to usethe M-learning technologies and establish secure network infrastructure in schools to allow students to use the network to conduct their tasks using the system [44], [45].

5. Conclusion

Malaysia and Bangladesh, both have high ambitions to achieve a sustainable green energy future for their citizens but are lacking awareness, education, and motivation amongst their public to achieve their desired RE goals. To overcome these hurdles, educating and creating awareness and interest amongst the public has become fundamental for both the countries, specially to produce future generations of people interested in pursuing careers in RE sectors and generate more technologically advanced workforce, to achieve their long term RE goals. Thus, with both the countries having vast number of students who are technologically well adapted, implementing M-learning methods to educate these

students on RE concepts and practices will come a long way in achieving each country's respected RE goals, with the help of proper intervention from the policy makers in conducting teacher's training on technological literacy and also developing network infrastructures for the students to securely use them for their educational goals.

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