SMART MULTIMEDIA LEARNING SYSTEM FOR AUTOMATA THEORY

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In Partial Fulfillment of the Requirements for the Degree of

Master of Science

By

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CERTIFICATION

This is to certify that the thesis titled, Smart Multimedia Learning System (SMLS) for Automata Theory submitted to the school of postgraduate studies, African University of Science and Technology (AUST), Abuja, Nigeria for the award of the Master's degree is a record of original research carried out by *Rachel Chinye Sam-Oloyede in the Department of Computer Science.*

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A THESIS APPROVED BY THE COMPUTER SCIENCE DEPARTMENT

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ABSTRACT

Education is a vital ingredient for a sustainable economy where “knowledge is power”. M-learning initiatives can lessen the digital divide in education and promote a knowledge-based economy. The high saturation of mobile technology has made it imperative to have mobile applications that provide solutions in many aspects of the economy, including education. Smartphones/tablets have gradually become widely adopted mobile learning devices. In Science and Engineering, Automata Theory is a core subject that is abstract and mathematical in nature, which makes it difficult to teach and learn by educators and students respectively. This research is focused on the development of a Smart Multimedia Learning System (SMLS) that provides a multi-sensory learning experience for Automata Theory. The system provides a Finite State Automata (FSA) simulator, a real-time assessment and feedback mechanism for performance tracking. Moreover, SMLS has an integrated text-chat to support active and collaborative learning.

Keywords: learning, mobile learning, e-learning, multimedia, Android, automata, mobile, simulator, collaborative, active, Learning Management System, social media, interactive system, iterative development, FSA simulator, chat, real-time assessment, education, knowledge, quiz, video tutorial.

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DEDICATION

This research work is dedicated to the Most High GOD, who in His infinite grace and favour made it possible for me to study at this institution; and for seeing me through the entire period of my study.

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ABBREVIATIONS

MLS: Mobile Learning System

FSA: Finite State Automata

SDK: Software Development Kit

APK: Android Package Kit

SMLS: Smart Multimedia Learning System

AML: Automata Multimedia Learning

CHAPTER ONE
INTRODUCTION

Advancement in Technology has played a vital role in improving and evolving every facet of human living. The learning environment is not an exception, considering the improvement in the quality of educational content delivery; knowledge representations; overcoming time and distance constraints (Hamada, 2013); cost-effectiveness of e-learning; ease of learning; convenience of learning at individual pace; stimulating individual interests and intellectual curiosities (Hamada, 2013); and enhancing cognitive skills.

1.1 Background of the Study

Mobile learning and e-learning are current research topics in learning and education, and are vital ingredients for a sustainable economy. Education encompasses teaching, learning and training both formally and informally to empower people; in order to develop knowledge and skills for solving problems in the society. As the statement goes “Knowledge is power”; this is seen in the global economy shifting towards a knowledge-based economy, which depends more on intellectual capital than on natural resources for socio-economic development and global competitiveness (Powell & Snellman, 2004). Advanced technological skills and tools are products and services of a knowledge economy; hence, the need to develop educational aids or tools, that promote effective learning, cannot be over-emphasized.

The increasing global popularity of mobile devices provides the possibility of mobile learning and an increase in social interaction. Furthermore, as a result of the high saturation of smartphones and tablets, teaching and learning paradigms have experienced a significant shift (Hamada, 2013). Smartphones and tablets have gradually become widely adopted mobile learning devices, which could affect the adoption of sensing technologies (Hwang & Wu, 2014) for smart-active learning. A conventional teaching approach should be supported by motivation to learn besides the individual’s natural interest (McDevitt & Ormrod, 2013).

Mobile learning is the integration of multimedia and mobile communication technology for delivering educational contents to facilitate learning, and promote active and collaborative learning among, and not limited to, students and workers. Mobile learning helps to improve students' learning achievements, motivations and interests (Hwang & Wu, 2014). This research centres on building a mobile learning system for one of the fundamental topics in Computer Science, that is: "Automata Theory".

1.2 Problem Definition

Automata theory is a fundamental area of study in Computer Science and Engineering disciplines. It represents the logic of computation with which scientists and engineers are able to understand how machines compute functions and solve problems (Aziz, Cackler & Yung, 2004). As a result of its abstract and mathematical nature, it is difficult for educators to teach and for students to understand the concepts. According to Hamada (2008), engineering students prefer active and sensing learning styles. Furthermore, research has shown that people tend to remember 20% of what they see, 40% of what they see and hear, and about 75% of what they see, hear and do simultaneously (Neo & Neo, 2001). Hence, this research focuses on a Smart Multimedia Learning System (SMLS) for Automata Theory, deployable on mobile devices (predominately Android phones and tablets).

1.3 Aim and Objectives

This research adopts Smart Multimedia Learning System (SMLS) for Automata Theory for smart-interactive learning, with the aid of integrated interactive multimedia capabilities. The objectives are stated in measurable terms as follow:

- A multi-sensory learning experience for Automata Theory.
- System supports active and collaborative learning.
- System Implementation of a Finite State Automata (FSA) simulator.
- Educators can use the system to prepare quizzes and to track students' progress.

1.4 Technology and Tools

- Integrated Development Environment (IDE): Android Studio 2.3.3, an official IDE for developing applications exclusively for Android platform. It consists of an editor, Android SDK, debugging tools, compiler, emulator etc.
- Programming Language: Java provides the back-end engine of the mobile application. It is the core language in which Android applications are written.
- eXtensible Markup Language: XML is used to define the structures of the application's user interface.
- Cloud services such as YouTube and Firebase: YouTube provides access to a wealth of multimedia resources e.g. online videos. Firebase is a cross-platform solution that can store and share data between different users in real-time, as well as authenticate and authorize such users.
- Personal Computer: a laptop that provides the essential hardware and software specifications for the actual development.
- Android Device: an Android powered phone or tablet for instrumental testing and deployment.

1.5 Significance of the Thesis

Based on research findings, automata simulators for FSA, Turing machine (desktop applications) are available. However, there is a need for a mobile learning system that has more interactivity and smart-active learning for Automata Theory. This is a significant contribution since Android-based smartphones and tablets are affordable and widely used by students worldwide.

CHAPTER TWO
LITERATURE REVIEW

This chapter reviews the concepts of: multimedia technology, e-learning, m-learning, learning communities and learning management systems.

2.1 Introduction

There are several research works relating to technological-aided learning including; multimedia learning, e-learning, mobile learning, game learning and virtual reality learning. Overall, these forms of learning provide support to the traditional classroom pedagogical approach, and bring more effectiveness and efficiency into the learning environment. This chapter reviews; the concepts of some of these various forms of learning, which are similar but differ according to best practices, challenges and some critical key factors that are responsible for its successful diffusion.

2.2 Concept of Multimedia Technology

Multimedia is the combination of various digital media types such as text, images, sound and video, into an integrated multi-sensory interactive application or presentation to convey a message or information to learners (Neo & Neo, 2001). Multimedia technology is the underlying technology for all other forms of technological-aided learning. Furthermore, multimedia technology provides an effective and innovative teaching and learning strategy in a learning environment.

Multimedia technology creates a multi-sensory experience for learners and stimulates active participation in the learning process, as opposed to learners being passive participants in an educational content (traditional approach). Moreover, it enhances creativity, critical thinking, and analytical problem solving skills of the learner, providing them with a competitive edge (Hamada, 2013).

The learner has a control of the content and the flow of information. This enhances information retention, motivates a learner to become attentive to information presented and fast tracks learning time. Additionally, it benefits the learning experience, leading to an increased rate of learning.

2.3 Concept of E-Learning

E-learning refers to an electronic form of learning that is delivered using electronic devices such as computers via communication channels (Gutierrez, 2015).

E-learning enables virtual learning from any geographical location with a computer or mobile device and an Internet connection (Epignosis LLC, 2014). E-learning is not only limited to the education sector, it can positively improve the corporate, government and healthcare sectors.

The fundamental aspects of e-learning include organizational, technological, curriculum design, instructional design and e-learning course delivery (McPherson & Nunes, 2008). E-learning is not a mere technical exercise; it requires new pedagogical models in which tutors and learners need to be sufficiently prepared for, in order to create a successful e-learning environment. Tutors need appropriate online tutoring skills in order to explore and maximise the designed environment.

Furthermore, according to McPherson & Nunes (2008), the critical factors that affect the success of e-learning delivery in Higher Educations programme are: facilitator's attributes and experience for e-tutoring; implementing relevant delivery model, including compatible modes of communication, tutoring, evaluation and assessment; support and training for tutors and learners (e-tutoring and e-skills development respectively); and inspirational leadership involving the role of educational institutes' management to facilitate e-learning.

2.3.1 Benefits of E-Learning

In addition to the benefits of multimedia learning, e-learning stimulates; individual interest, intellectual curiosities and enhances the cognitive skills of learners (Hamada, 2013). The following are other benefits of e-learning:

- E-learning offers flexibility so that learners can learn at their own pace.
- It is relevant to the learner's environment and makes learning more fun and interesting.
- Overcomes geographical and time constraints; learning can take place anywhere and anytime.
- Cost effective as it is relatively more affordable than the traditional face-to-face learning, considering the cost of textbooks, printing course materials, presentations, transportation for both students and lecturers etc.
- Virtual and interactive learning uses interactive multimedia contents and resources to facilitate learning.
- Ease of learning adapted to suit individual learners, who have a unique style of learning. E-learning provides convenience in learning.
- Remote access and connection to 'virtual' classroom via communication technology, hence it removes distance barrier to learning.
- Access to unlimited online resources e.g. journals, databases, periodicals, online library repositories etc.

2.3.2 Drawbacks of E-Learning

- Difficulty in acquiring practical skills or hands-on-experience: This may require better supervision and physical interaction, which is not easy to achieve in an e-learning environment (Epignosis LLC, 2014).
- Isolation of learners: Learning is done virtually. Therefore, a learner may feel isolated.

- Health related concerns: This could include eyestrain, bad-posture, etc.; learners need to learn how to maintain good posture, and protect straining their eyes when using computer screens or smartphone screens etc.

2.3.3 Best Practices for Facilitating E-Learning

There are key elements that promote the successful adoption and diffusion of e-learning initiatives. These elements are necessary for the effectiveness of an e-learning environment, for example, supportive community, motivational activities and integration of links to unlimited available resources.

2.4 Learning Community

Collaboration and interaction are necessary among the learners and instructors, this would enhance the educational experience among the learners' community through discussion forums, chats, emails etc.

2.5 Learning Management Systems

Learning Management Systems (LMS) are typically e-learning software packages used to manage and deliver educational contents and resources to learners. There are commercial and open standard LMS packages. The popular ones include Blackboard, TrainNet and MOODLE. Typically, LMS comprises features for administration, assessment, content management and authoring, and course managements (Skea, 2011). The LMS provides interactive tools for learning, an example is the TrainNet, a commercial package, which contains tools such as text-chat, whiteboard (graphical tools with which an instructor can annotate, write and make illustrations on course materials), integrated email, and 'virtual raise hand' to get permission to speak or chat with an instructor.

2.5.1 Motivational Activities

A Learning Management System should integrate activities that promote interactivity, motivate learners to brainstorm and delve into a specific subject area, in order to gain in-depth knowledge.

2.6 Optimization of Vast Online Resources

A Learning Management System should take advantage of the vast online learning resources, and integrate up-to-date online study content that is capable of redirecting learners to current and adequate online materials.

2.7 Concept of M-Learning

The increasing popularity and saturation of mobile technology gives rise to building meaningful and relevant applications tailored to meet the needs of mobile users. Considering the convenient use and rapid adoption of mobile devices, it is pertinent and imperative to have mobile applications that provide solutions in different aspects including; Government, Education, Health, Social, Commerce, Communication sectors, etc.

Mobile devices are portable, handheld computer devices such as smartphones, PDAs, tablets, which are enabled to use a variety of communication technologies e.g. Wi-Fi, Bluetooth, GSM, modem etc.

Mobile learning is the delivery of educational knowledge and content on handheld computer devices via communication technologies. According to Keegan (2002), m-learning is the next generation of learning. There is a paradigm shift in learning from classroom learning (face-to-face) to distance learning and from e-learning to mobile learning. However, m-learning enables the integration of work, study and leisure in a significant way.

2.7.1 Impact of Mobile Technology on Education

Mobile technology drives many innovations, promotes socio-economic development, improves learning and offers several benefits, (in addition to the benefits provided by e-learning) including personalised education, real-time assessments and innovative practices (West, 2015). Furthermore, m-learning brings about efficient and effective learning (Shippee & Keengwe, 2014; Adeboye, 2016).

2.7.2 Efficient Learning

In terms of efficient learning, mobile technology provides; easy communication, fast access to unlimited resources, no geographical restriction, ease and comfort of having all course materials on a portable device and straightforward feedback from instructors. All these make studying more practical for learners. Furthermore, instructors can prepare lecture slides, notes, videos and upload to an LMS. This is beneficial in many ways, for example, students can get their course materials on their smartphones and re-watch lecture videos at their leisure.

2.7.3 Active and Collaborative Learning

Active and collaborative learning refers to a learning environment in which learners are actively engaged in learning and knowledge sharing, which is promoted through social interactions enhancing effective learning and learner's motivation.

Active and collaborative learning can be enriched by the creative use of mobile technology in order to increase productivity and to realise better results. Some of the ways to achieve active and collaborative learning are; chat or online discussion forums, live quizzing tools for formative assessment, quality audio feedback, creating videos and providing links to further resources.

2.7.4 Real-time Assessment

M-learning improves learning, engages learners and educators, enables instantaneous assessment and feedback for students, and provides better tracking of individual students' achievements. Furthermore, m-learning assesses appropriate actions that can be taken with respect to motivating or to strengthening a specific area of weakness for each student.

2.7.5 Learning through Social Networks

The social network plays a vital role in education, it facilitates collaborative learning, which involves gathering and sharing knowledge; therefore, increasing knowledge acquisition. According to West (2015), a previous research demonstrated that students, who collaborate through social media achieve better results than those who do not. Researchers believe that social media promotes achievement and knowledge acquisition.

2.8 Personalized Learning

In any learning environment, diverse students have varied backgrounds, interests and learn in different ways. M-learning applications enable customised content for individual learners, so that a learner has personal control and flow of the educational content; allowing them to study at an individual pace. Moreover, it offers vast resources and information at the fingertips. This invariably allows for in-depth exploration of interests and the use of multi-sensory learning experiences, e.g. textual, visual and auditory.

2.9 Bridging the Digital Divide in Learning

The digital divide is represented by the margin between a traditional classroom and a high-tech modern classroom. There are learning institutions that are disadvantaged and stuck to the conservative style of learning, while some classrooms use modern digital tools for learning. The digital divide refers to the inequality in access to technology skills and tools in institutions, which are required for learners to have a competitive edge and advantageous exposure to knowledge.

Shippee & Keengwe (2014) emphasised that "E-learning programs and websites provide anywhere, any time learning for those with Internet access, making strides towards closing the digital divide with a narrow bridge of opportunity".

However, the ubiquity of mobile technology lessens the digital divide and broadens opportunity via mobile learning (Shippee & Keengwe, 2014). A leap to bridge the digital divide in an institution is to get technology into the hands of the students, using easily available devices (Tustin, 2016). Mobile learning provides individuals, communities and countries learning opportunities, where learning is otherwise challenging and difficult (Traxler, 2009). From a global perspective, m-learning rapidly builds bridges of information providing easy access to various communities (Shippee & Keengwe, 2014).

On the other hand, Brotman (2016), highlighted that the digital divide exists in the usage of digital educational content in the classroom, where there is a substantial separation between active and passive uses of digital/ online content and tools in the classroom. Hence, there is an emphasis on the need for active use of educational content.

2.10 Critical Success Factors in M-Learning

Cochrane (2012) identified key elements that cause m-learning initiatives to fail; these include, non-establishment of supportive learning community, lack of course assessment integration, and a lack of difference in pedagogical approach, from the traditional teacher-directed (or 'instructivism') approach. Critical to the success of fostering new pedagogies, which are student-directed and supported by technology, in higher education programmes, is lecturer's professional development and sustained collaborative support between educational technology stewards or researchers and course lectures, which are mandatory.

On the other hand, Shippee & Keengwe (2014), expressed that the value placed on any innovation affects its successful diffusion. Therefore, the utilization and personal adoption by an educational community (such as administrators, teachers, student and parents) places high value on trending mobile technology.

2.11 Challenges of M-Learning

The use of technology to enhance learning is challenging and requires a complex blend of technological, pedagogical and organisational components. It may have to deal with issues such as contradictory demands and conflicting needs (McPherson & Nunes, 2008).

There are a vast number of resources available globally, however, the information gotten can be a fact or an opinion. The instantaneous availability of the source of information does not equate to its reliability, which is a subject of concern. Therefore, critical analysis of information must be a component to m-learning (Shippee & Keengwe, 2014).

CHAPTER THREE
RESEARCH METHODOLOGY

In this chapter, various software development methodologies are highlighted. The phases of an iterative model, Software Development Life Cycle (SDLC) methodology that is adopted, is explained in detail.

3.1 Introduction

Software Development Methodology (SDM) is a framework that provides standard procedures, techniques, tools and documentation aids for engineering software products. This helps to formalize how software is built and to make software development more predictable and efficient. There are four main activities that occur in any software development process; namely, software specification, software design and implementation, software validation and software evolution (Sommerville, 2011).

There are two main categories of SDM; plan-driven methodology and agile methodology, which is more applicable in this context due to the nature of the project. The Smart Multimedia Learning System (SMLS) is not a critical system, the objectives are clear and the system does not require an extensive documentation. Moreover, the agile methodology focuses on short iterations and lightweight processes. There are various existing agile methodologies used in the software industry including Extreme Programming, Feature Driven Development (FDD), Adaptive Software Development (ASD), Rapid Application Development (RAD) and Scrum. The software project requires an iterative and incremental development approach for fast and efficient deliverables. The suitable methodology for the software development is the iterative model SDLC.

3.2 Iterative Model SDLC

The standard procedures for software development are carried out to ensure that the system is built correctly. The software development is broken into smaller chunks of more manageable units of the entire system that have no functional dependencies; this allows for a simple implementation of a subset of the system requirements. The process can require continuous review to identify further requirements that would enhance the system functionalities until the system build is complete. The life cycle of the development approach is described in Figure 3.1 below.

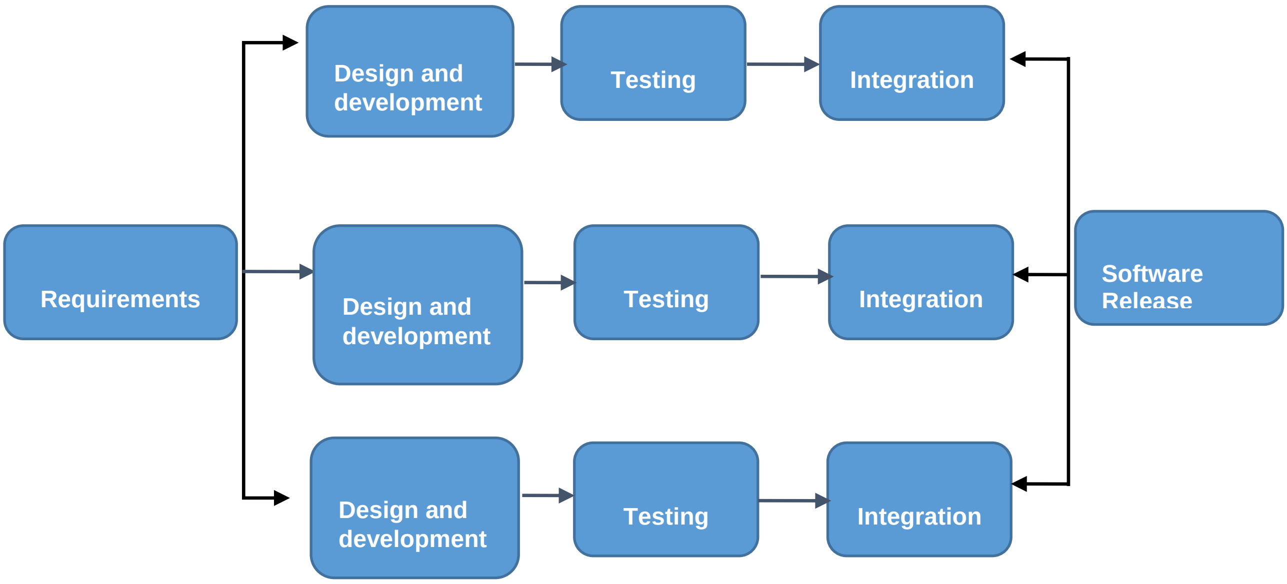


Figure 3.1: Iterative Model SDLC (tutorialspoint, 2017)

3.3 Requirements Identification

The Smart Multimedia Learning System (SMLS) is a mobile learning system deployable on mobile devices, usually Android devices, as Android software development is an object-oriented programming environment. The requirements are the clear objectives, which are identified based on the needs of mobile users that intend to use the SMLS as an efficient, active and collaborative learning environment. The user requirements can be engineered and modelled using applicable Unified Modelling Language (UML) tools, such as a use-case diagram; the user requirements, from a mobile client perspective, are described in Figure 3.2 below.

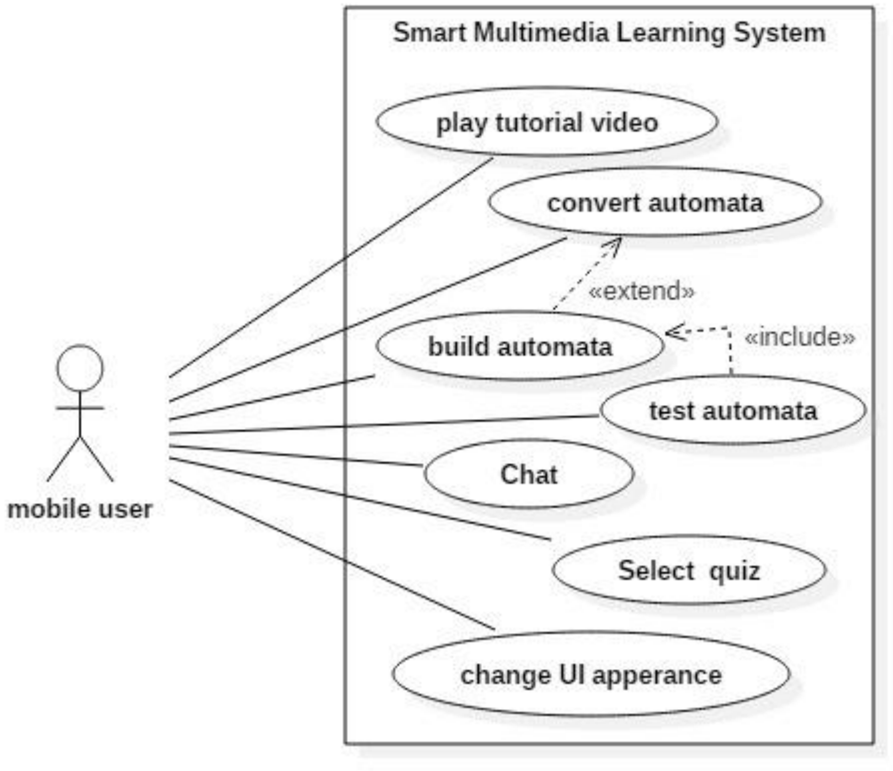


Figure 3.2: Use-case Diagram of SMLS

3.4 Software Design

The software design provides the architecture of the system that is being developed. It is the system blueprint, which can be modelled using UML modelling tools such as activity diagrams, state-machine diagrams, class diagrams, component diagrams etc. It defines the boundary, structure and behaviour of the system under development. Moreover, it helps to identify the entities, objects, components and their interactions.

3.5 Software Implementation

Android studio is an integrated environment for developing Android applications. The SMLS project requires an Android Software Development Kit (Android SDK), which provides debugging tools, virtual mobile device emulator, compilers, editors, graphical tools etc. needed for the development process. It also provides an integrated XML for designing an interactive user interface (UI) which serves as the front-end engine. Java is the main programming language of Android and provides the back-end engine that interacts with the front-end UI. The minimum target Android device chosen is Version 4.1 for backward compatibility, in order to accommodate about 97% of active Android users on the Google play store.

3.6 Software Testing

The SMLS Android application is an incremental development as the functional units of the system are developed incrementally and iteratively. There are two options available for testing incremental builds; a virtual mobile device (emulator) and an actual smartphone that is enabled for development and debugging. Unit testing is required, when the test passes, the builds are integrated and the system is tested as a whole (system testing) to ensure that new increments do not cause a defect or errors in the software system, which is still under development.

3.6.1 Correctness Testing

This test is performed to ensure that the software is built correctly i.e. it performs the exact functionalities that the system is built for in the first place. The system specifications have to be evaluated.

3.6.2 Reliability Testing

The reliability test ensures that the system has no errors, bugs or defects and that the system is built efficiently.

3.7 Software Integration

This is the stage whereby all the individually tested software builds or components that are evaluated to meet the system specifications, are aggregated or combined into a whole system.

3.8 Software Release

A software release package is an application that can be installed and run on users' devices. At this stage, the system development is complete, stable, evaluated to meet the learners' expectations and ready for deployment. An Android software release package comprises a debug APK file, compiled source code, resources, manifest file etc. Furthermore, the Android system provides a self-signed certificate; any Android applications for release are signed digitally with the application's developer certificate, using cryptographic keys. The application must have an icon and may include an end-users license agreement.

CHAPTER FOUR
SYSTEM DESIGN, DEVELOPMENT AND TESTING

This chapter describes the implementation of the major functional components of the Smart Multimedia Learning System (SMLS) based on the system specifications. These sub-functional units of the system are developed incrementally, tested and integrated as a complete build.

4.1 System Specifications

The major functionalities of the learning system are; an interactive multimedia content, automata simulator, collaborative learning platform for the community of learners and a real-time assessment for performance tracking. A detailed description of the system functionalities is given in measurable terms below:

- Easy navigation to the main functional components of the system.
- Customisable look and feel UI based on user's preference.
- Multiple links to multimedia educational contents on different areas of Automata Theory.
- Selection of multiple choice real-time assessments from a range of quiz sections.
- Login interface to participate in a discussion forum of learners' community using registered email accounts.
- User interface (UI) to build and test the correctness of an automata.

4.2 System Design

The dynamic aspects of the system are described with the aid of an activity diagram, refer to Figure 4.1, which provides a detailed pictorial description of the sequential and concurrent activities that occur in the SMLS. The SMLS activity starts once the mobile learner taps or clicks the mobile application icon on a smartphone.

The SMLS then provides two navigation options; the navigation menu and navigation view, on the home screen. All processes come to a halt whenever the user clicks and acknowledges an exit menu option.

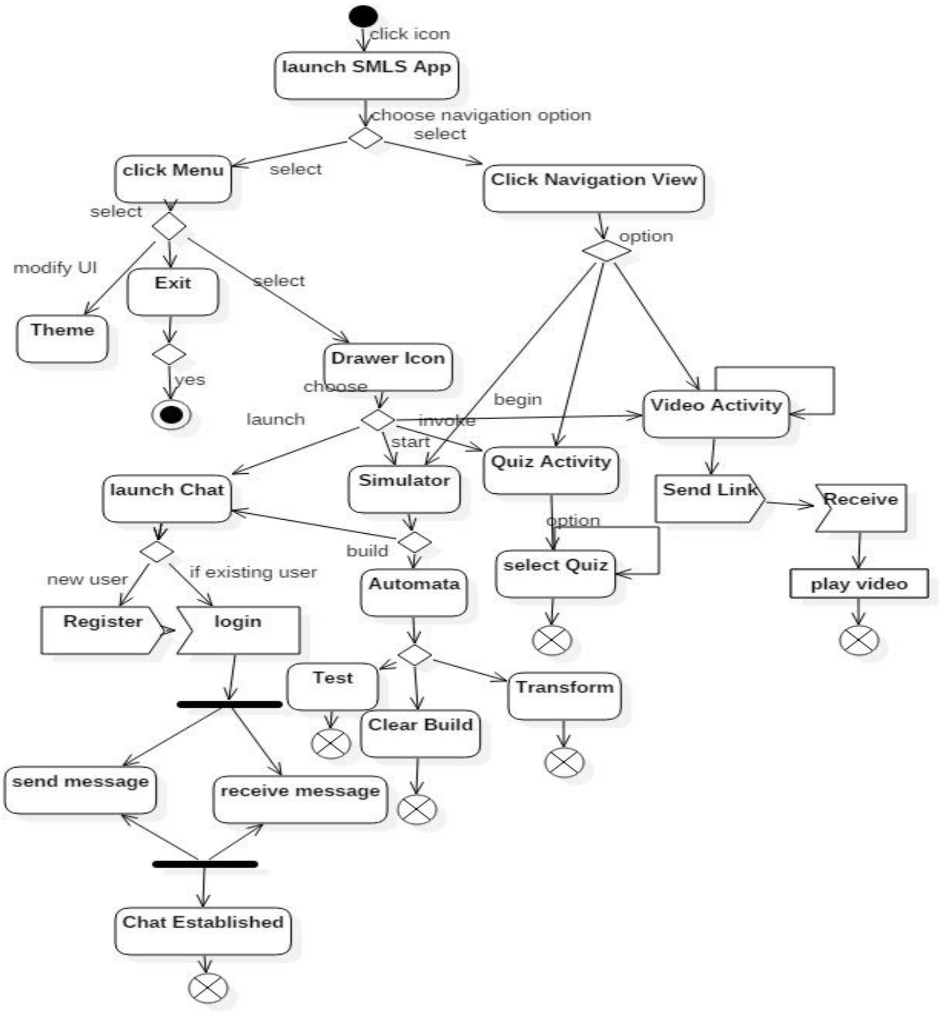


Figure 4.1: SMLS Activity Diagram

4.3 System Implementation and Testing

The Android framework provides flexibility in managing the application's user interface (UI). The application UI can be designed by declaring it within an XML or instantiated at run time. The XML layout defines the visual structures for the UI of an activity or app widget. Typically, relative layout is used and set to dynamic height and width of contents, unless otherwise defined. There are other variety of layouts used, such as linear and grid layouts.

The Android widgets used to create interactive UI components include buttons for automata states, radio buttons that are used in quiz activity, image views, text fields etc. Android studio 2.3.3 is the version used for the mobile application development, refer to Figure 4.5.

4.3.1 Home Screen

The home screen is the main activity that provides smooth navigation to other functional components of the SMLS. Figure 4.2 below shows the SMLS launch icon on an Android device. The SMLS main activity starts once a mobile user taps on the icon. The home screen is created by a call method, onCreate (Bundle savedStateInstances), passing in an object bundle as the parameter, and uses the activity_main.xml to define the application UI. Likewise, all the other activities defined by a java class have a corresponding pre-defined XML layout that is used to define the structure of the UI.

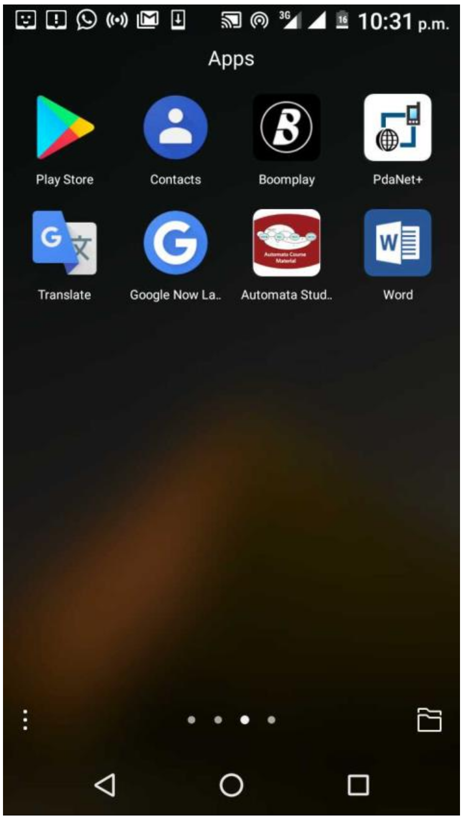


Figure 4.2: SMLS Launch Icon

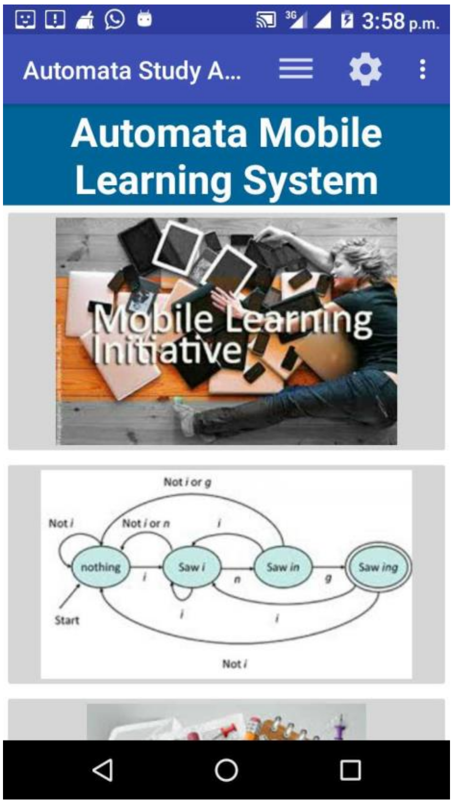
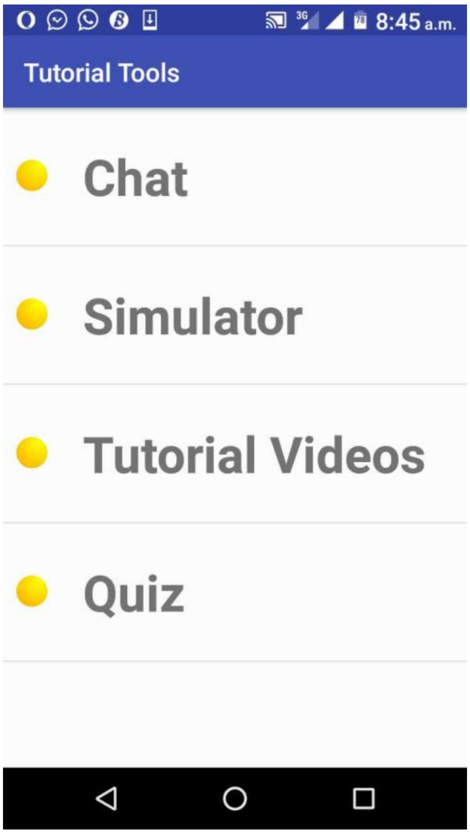


Figure 4.3: SMLS Home Screen



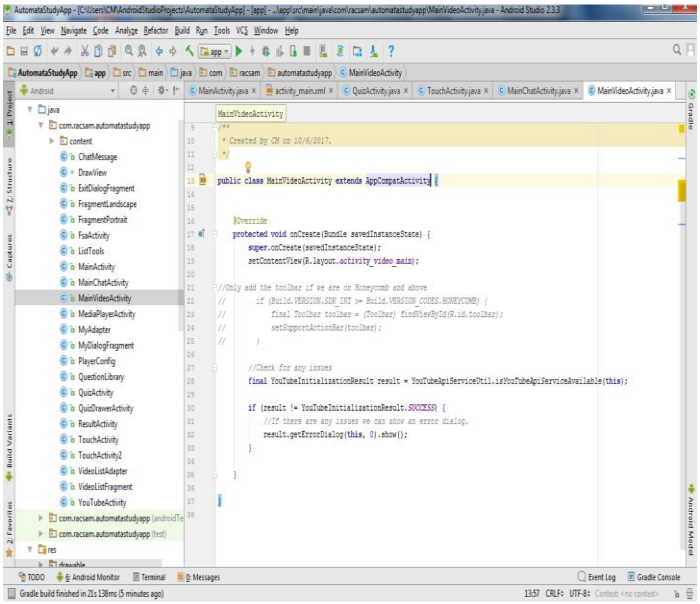


Figure 4.4: SMLS Navigation Option

Figure 4.5: SMLS Development

4.3.2 Navigation Links

The SMLS provides easy navigation options using menu, refer to Figure 4.4, and image views that give a pictorial description, refer to Figure 4.3, of the use of the application. This approach makes the UI more interactive and it is easier to learn the basic functionalities of the SMLS.

4.3.3 Customisable Application UI

The SMLS supports a user-defined or customisable UI, whereby a user can change the look and feel of the system based on individual's preference, as shown in Figures 4.6 and 4.7.

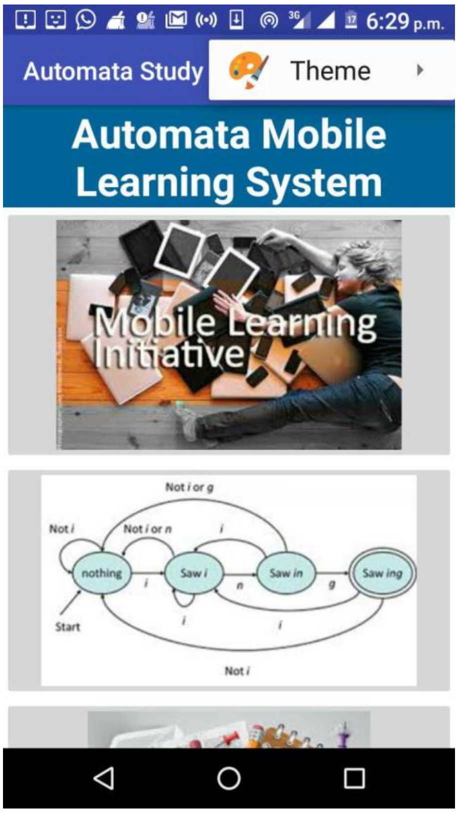


Figure 4.6: UI Theme Setting

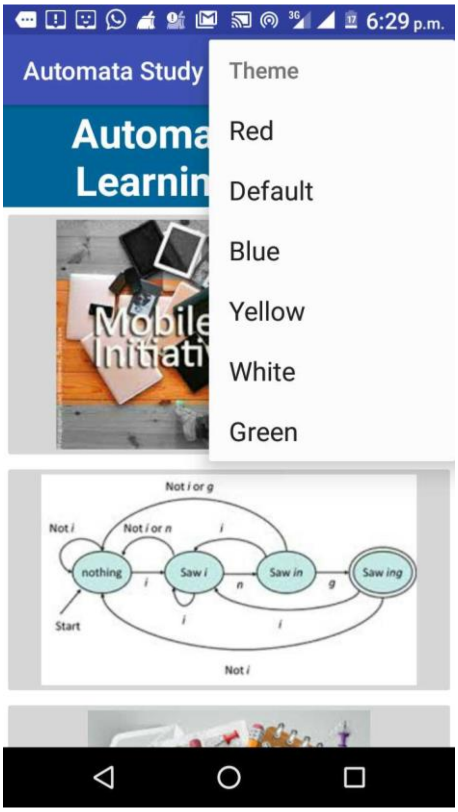
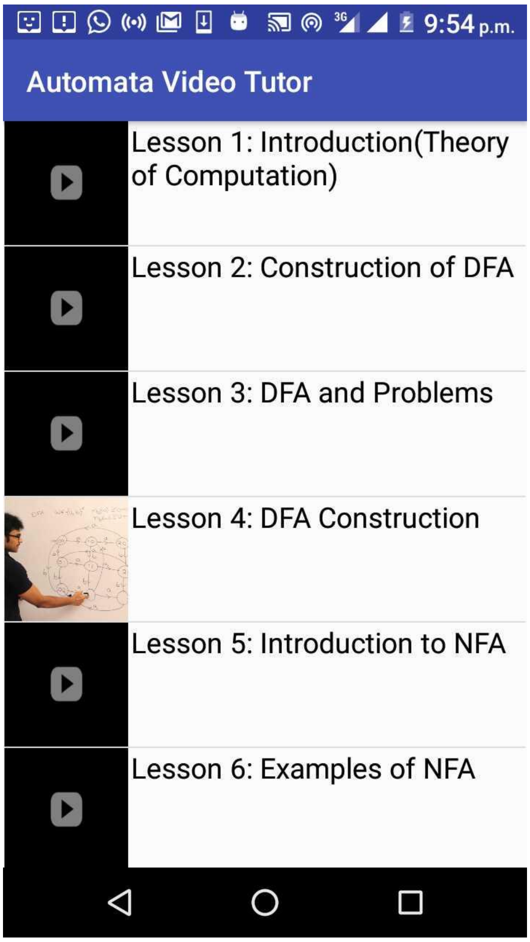


Figure 4.7: Customisable User Interface

4.3.4 Multimedia Interactive Learning Feature

The SMLS provides links to all related multimedia educational contents for learning Automata Theory, refer to Figure 4.8. The multimedia contents are segmented into various topics under the theory of computations. The mobile learners can then personalize their learning by making selections of their topics of interest from a range of video tutorials as shown in Figures 4.9 – 4.16.



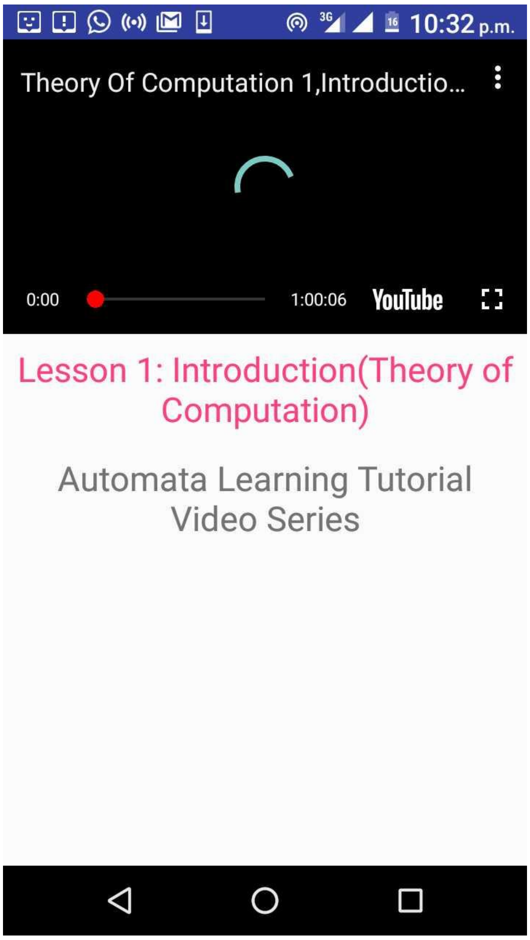


Figure 4.8: Automata Multimedia Learning **Figure 4.9: AML Lesson One**

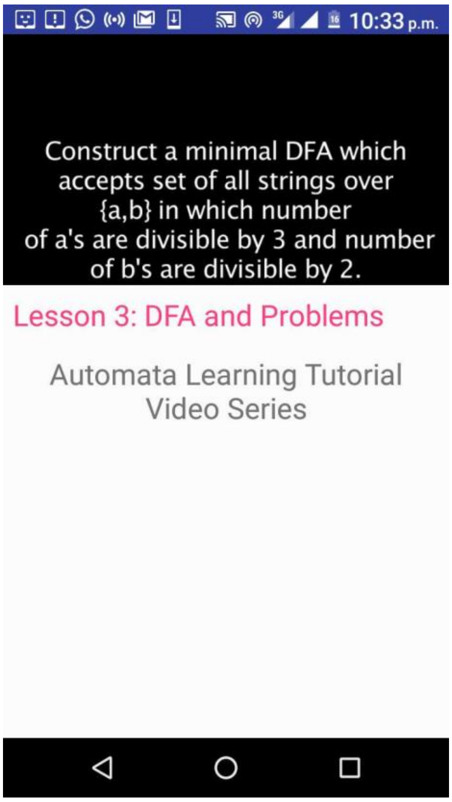


Figure 4.10: AML Lesson Two

Figure 4.11: AML Lesson Three

Figure 4.12: AML Lesson Four

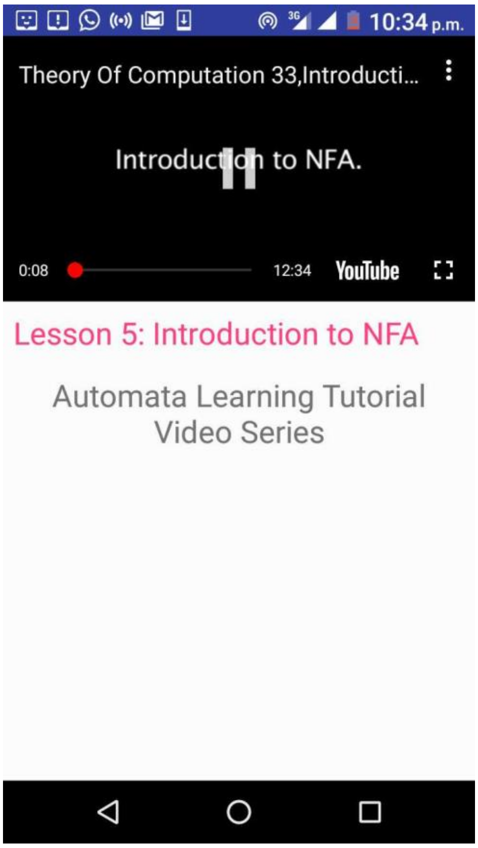


Figure 4.13: AML Lesson Five

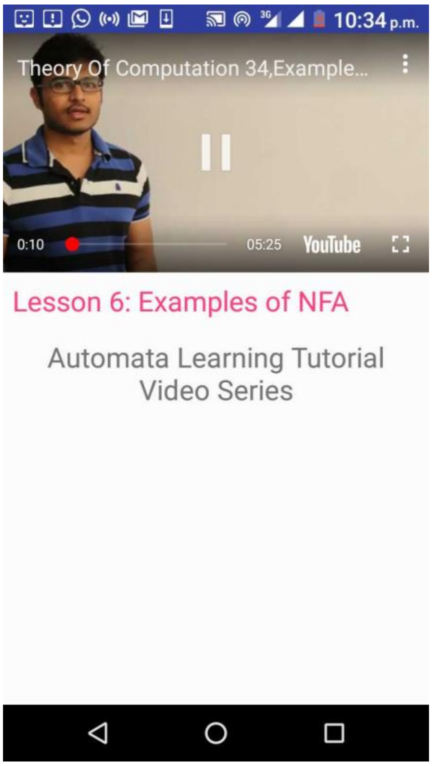


Figure 4.14: AML Lesson Six

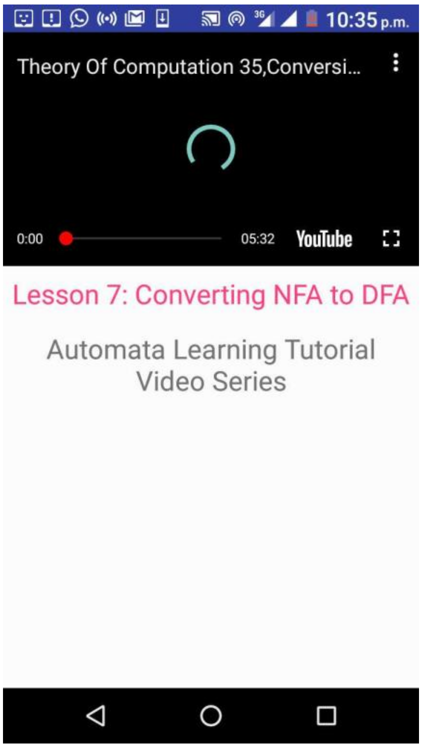


Figure. 4.15: AML Lesson Seven

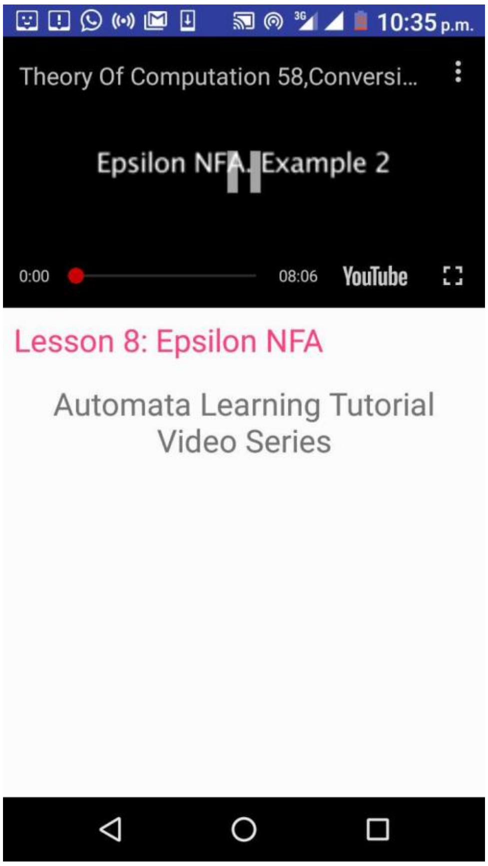
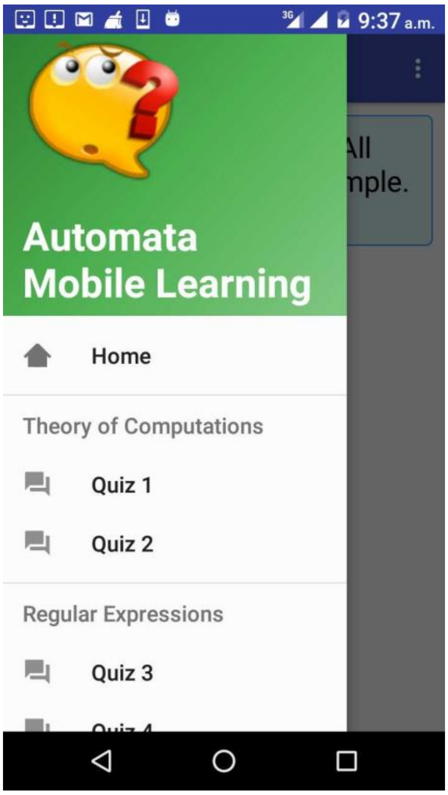


Figure 4.16: AML Lesson Eight

4.3.5 Real-Time Assessment Feature

The real-time assessment feature provides multiple quiz sections related to the topics in Automata Theory from which a mobile learner can make a choice, see Figure 4.17. Each quiz section comprises a series of five questions. A mobile learner can start a quiz by clicking on a start button, shown in Figure 4.18, the learner can only proceed to the next question using Next button click, if an answer is selected by clicking a radio button. As the learner progresses in the quiz, the score of the previous questions answered is displayed on the screen, see in Figures 4.19 – 4.23. At the end of the quiz, the system evaluates and rates the mobile learner based on the performance, refer to Figure 4.24.



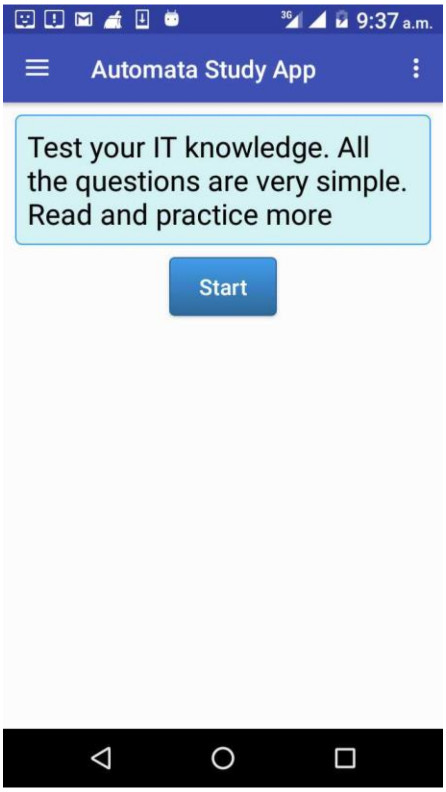
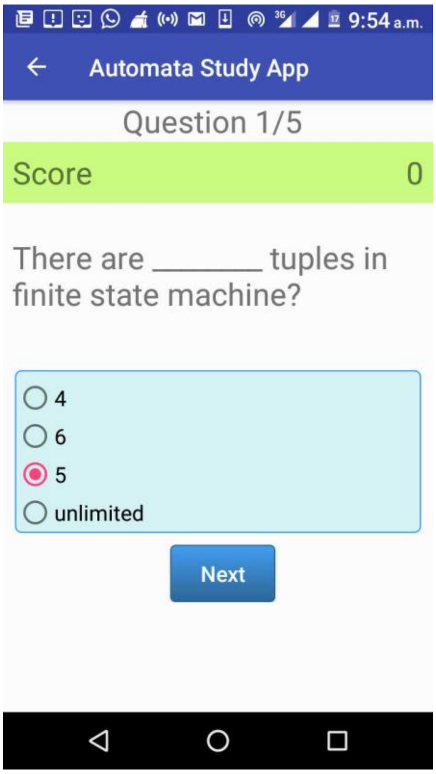


Figure 4.17: Quiz Activity Home Screen

Figure 4.18: Quiz Activity Launcher



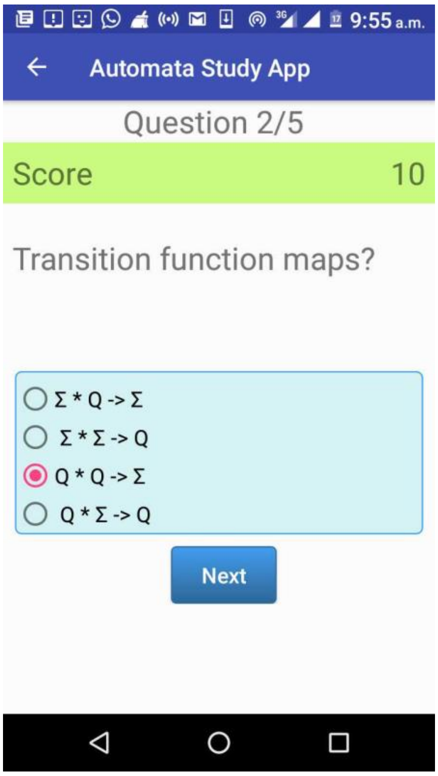


Figure 4.19: Quiz Section Question 1

Figure 4.20: Quiz Section Question 2

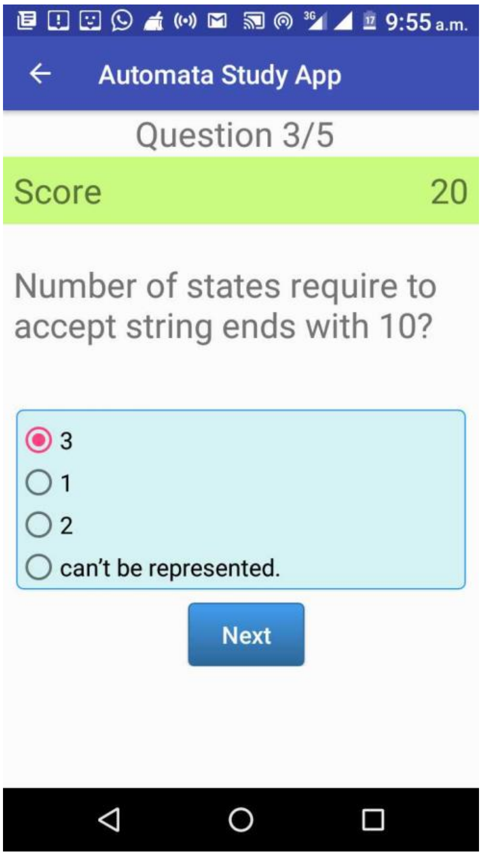


Figure 4.21: Quiz Section Question 3

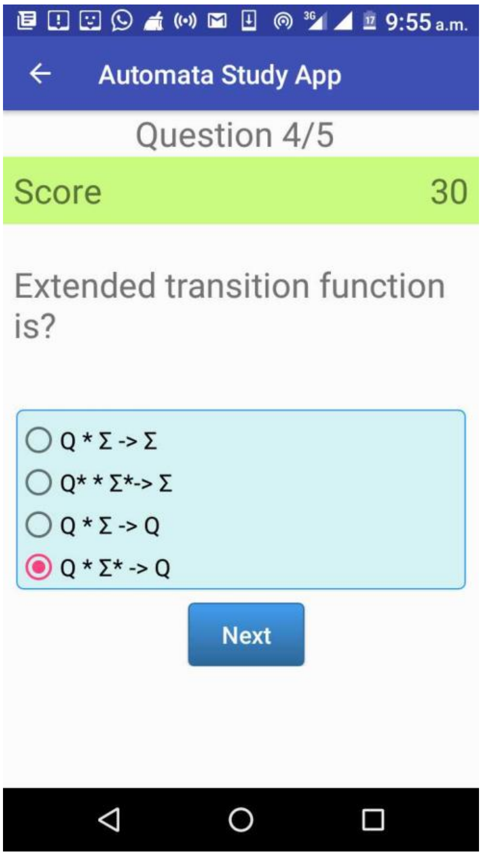


Figure 4.22: Quiz Section Question 4

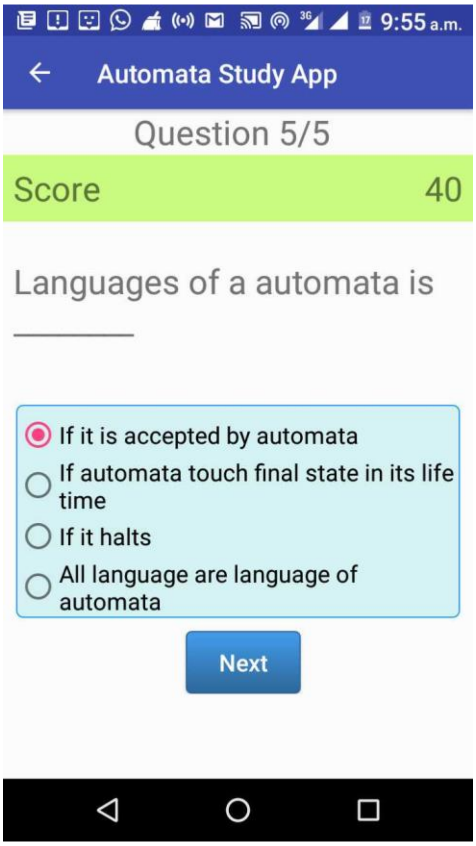


Figure 4.23: Quiz Section Question 5

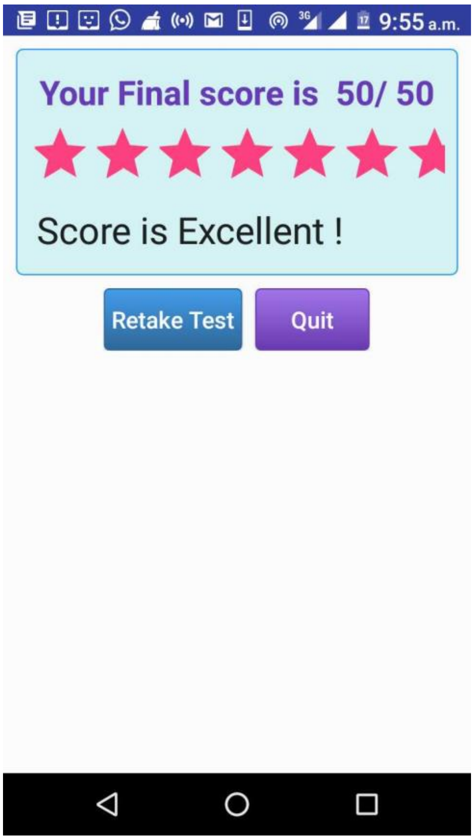


Figure 4.24: Assessment Report

The real-time assessment feature enables the learners to test their understanding and to know their areas of strengths and weaknesses using a feedback mechanism that generates a report evaluating the learner based on their performances, see Figure 4.25. A mobile learner can also retake a test by clicking on the Retake button or simply quit after a test is done, in order to try out other quizzes.

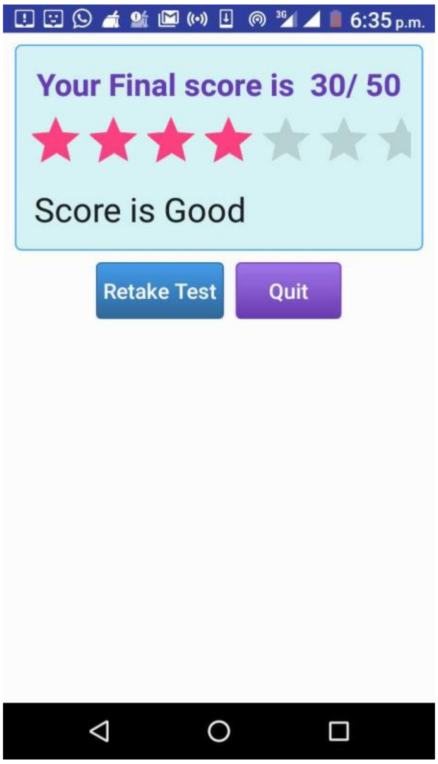


Figure 4.25: Feedback Report Generation

4.3.6 Chat Activity Feature

The chat feature promotes collaborative learning among the community of learners; this system component is enabled by a Google firebase application. A mobile learner can only use this feature by registering with an existing email account, see Figures 4.26 and 4.27. Firebase keeps track of all user accounts and provides a management console for system administration, refer to Figure 4.30. Also, it provides the system administrator the privilege to disable or delete an account, when it is necessary.

The registered users can post comments or texts on the discussion learners' forum; and these posts are synchronised. However, the system restricts users from sending blank messages, see Figure 4.29. The users' names, messages and the time of post are captured and displayed on the chat screen, shown in Figure 4.28.

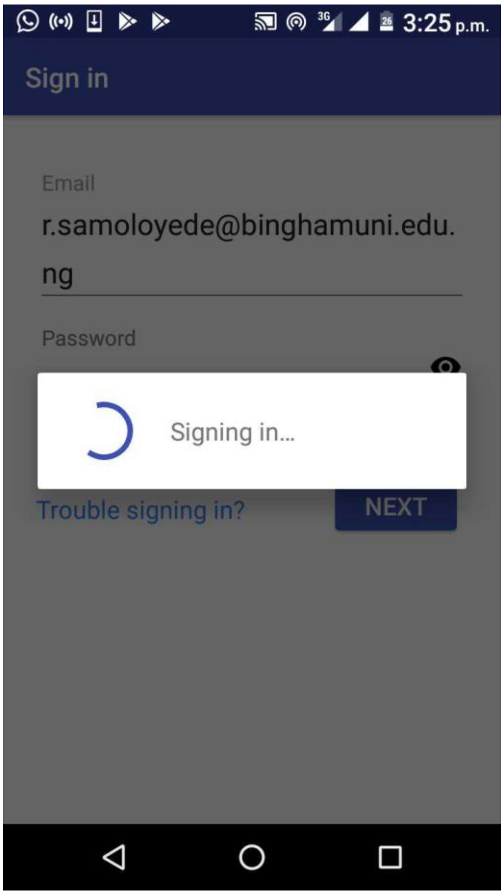


Figure 4.26: Chat Activity Login I

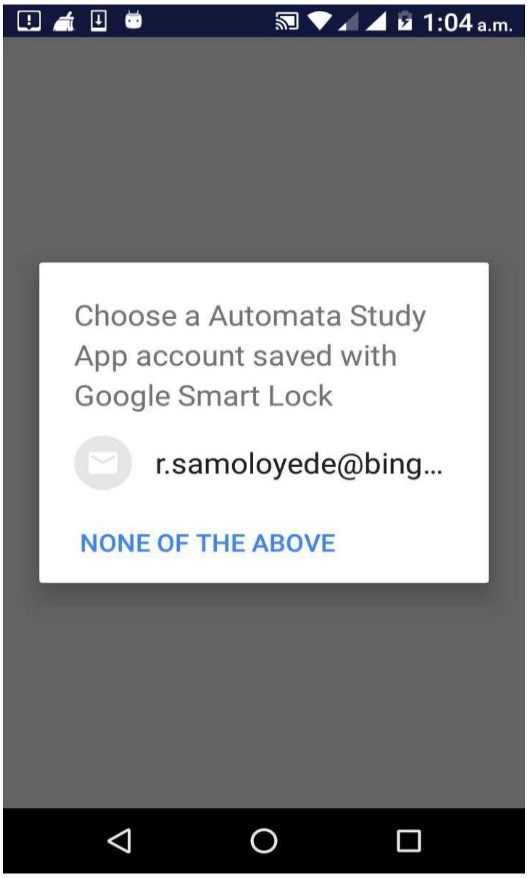


Figure 4.27: Chat Activity Login II

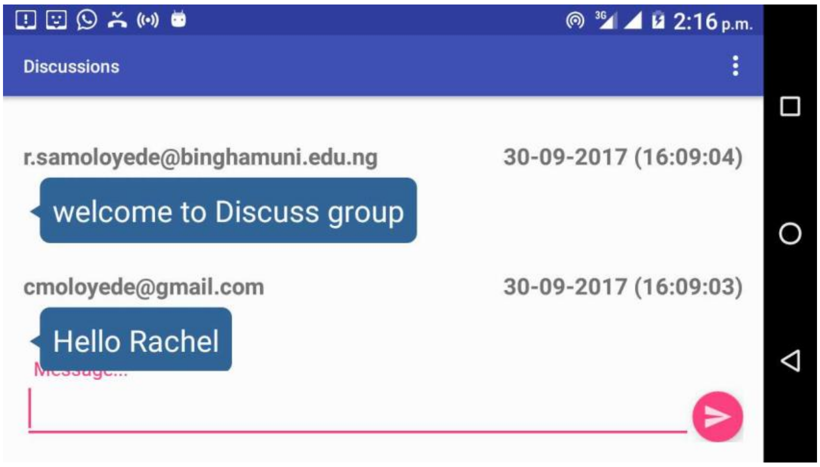


Figure 4.28: Discussion Forum

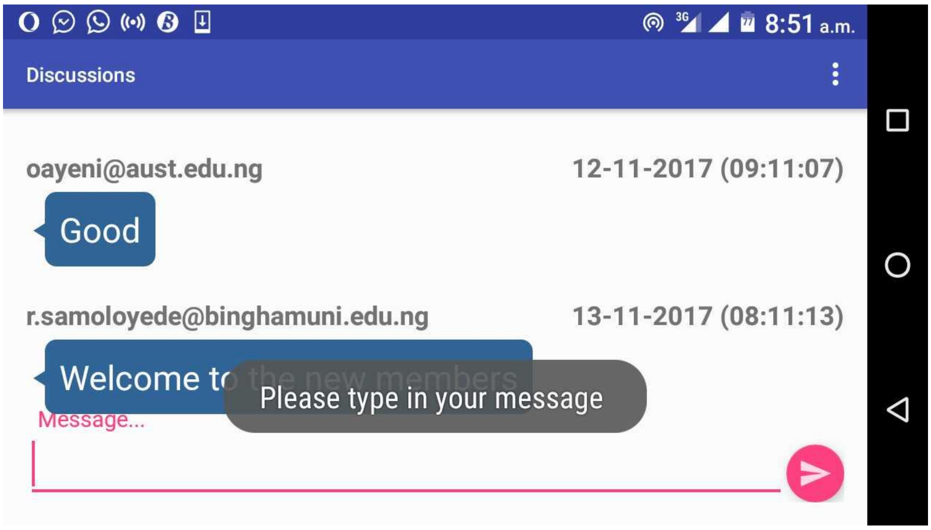


Figure 4.29: Data Integrity Check

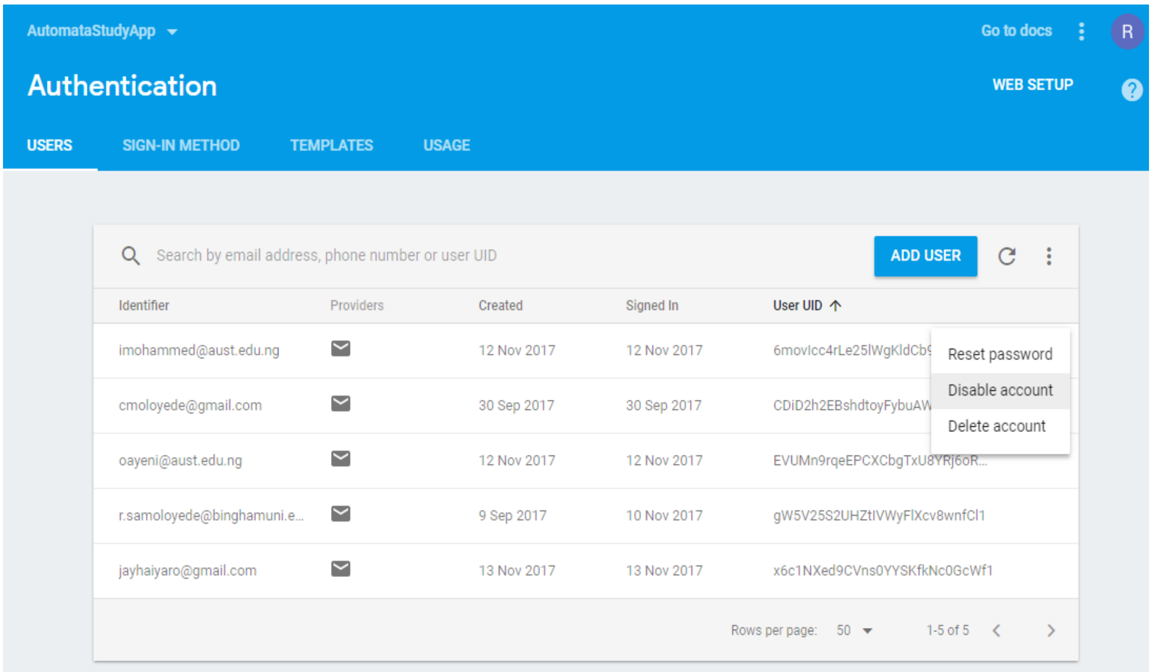


Figure 4.30: Chat Activity Management Console

4.3.7 Automata Simulator

The SMLS provides an Android automata simulator for building a Finite State Automata (FSA), such as deterministic finite automata (DFA), non-deterministic finite automata (NFA) etc. In principle, a FSA must have exactly one initial state or start state, which is created by default when a user launches the simulator.

The start state cannot be deleted by any delete or clear action by default, see Figure 4.32. A mobile learner can add any number of intermediate states using the simulator tools at the top corner of the screen, see Figure 4.33.

Technically, a FSA can have any number of finite states, therefore, the finite state add tool can be used to add any number of finite states. Moreover, as the states are added to the screen, the state ‘ids’ are set incrementally and the states are named respectively. Any state can be deleted, except the initial state, refer to Figures 4.31 and 4.34; however, all states can be renamed.

The transition is enabled between two states at a time and is triggered by clicking the transition add tool. When two states are selected; the buttons are highlighted, and an input string edit box appears at the bottom of the screen, to enable the user to enter a valid input. Then the simulator draws a transition between the selected states. The green check and red cancel buttons are used by the SMLS simulator to display whether the automata accepts or rejects an input string, which a learner enters respectively, see Figures 4.35 – 4.38.

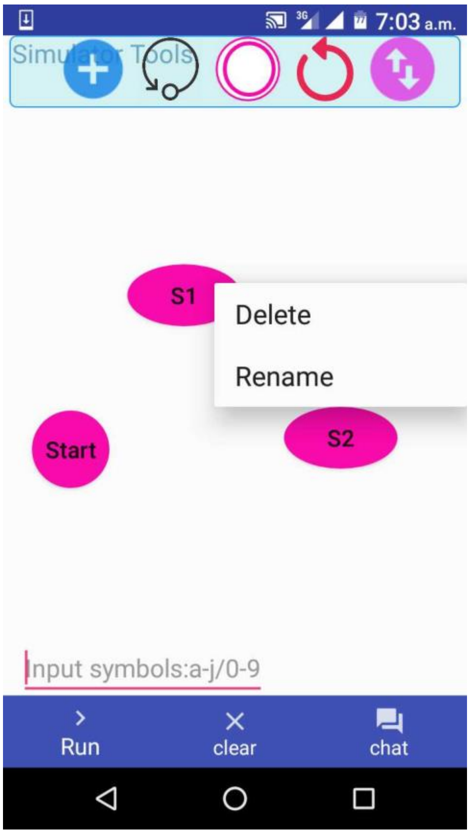


Figure 4.31: FSA Modification

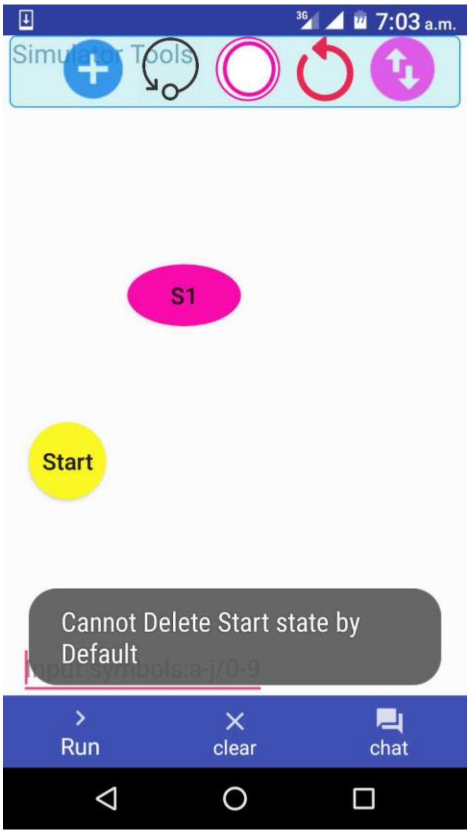


Figure 4.32: Default Initial State

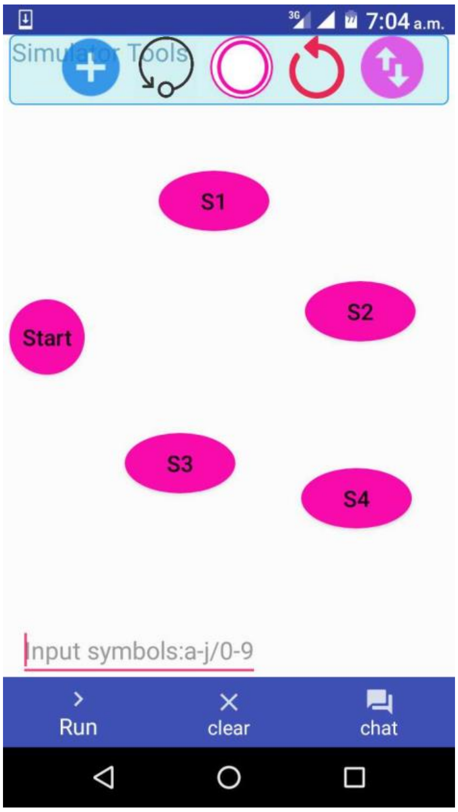


Figure 4.33: Multiple States Creation

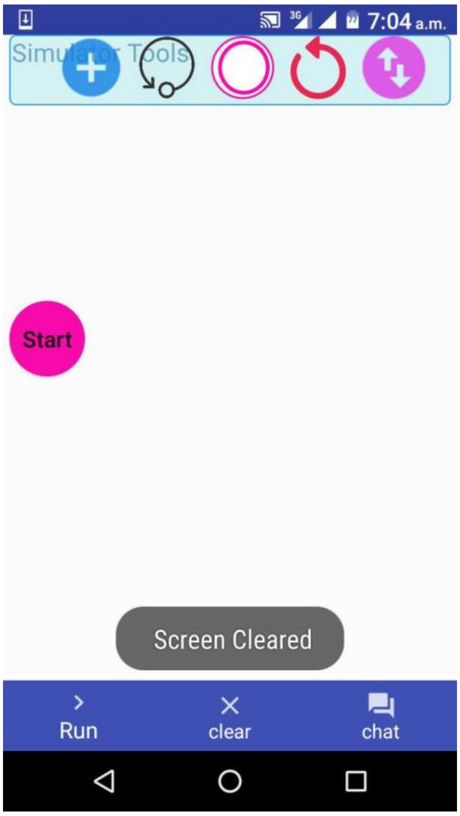


Figure 4.34: Simulator Screen Clearing

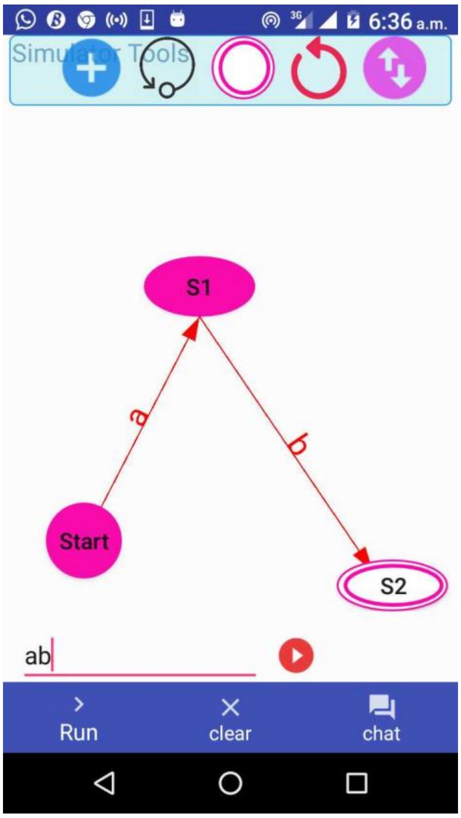


Figure 4.35: FSA Acceptance Test I

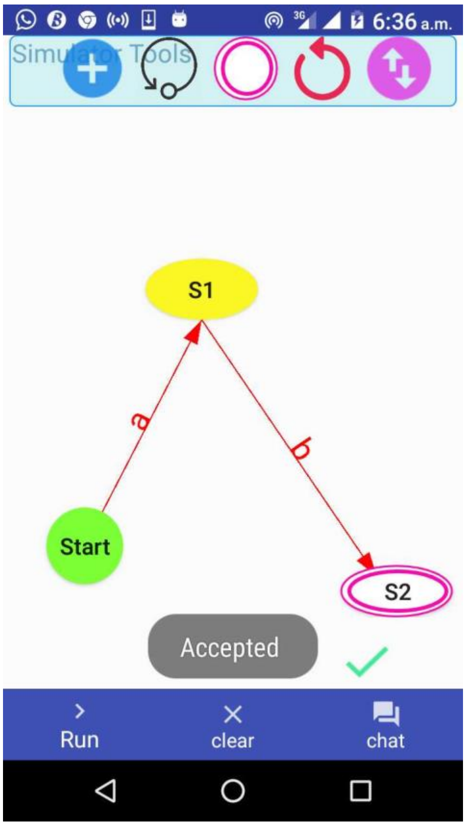


Figure 4.36: Automaton Acceptance

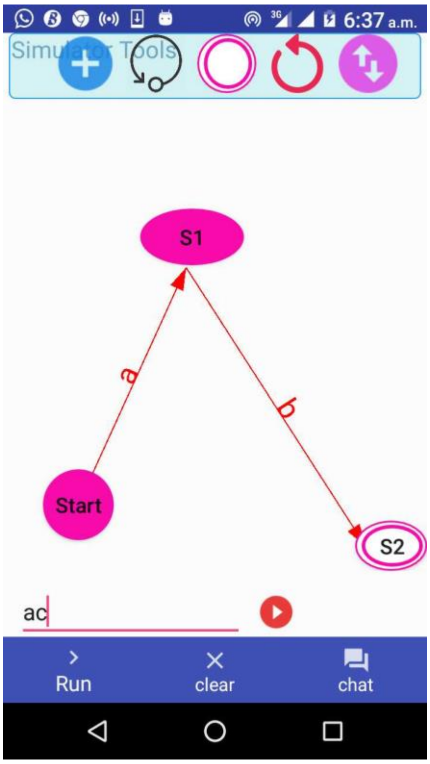


Figure 4.37: FSA Acceptance Test II

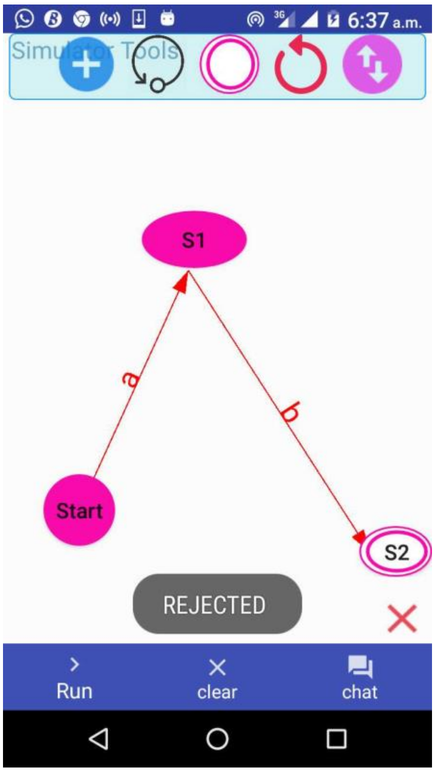


Figure 4.38: Automaton Rejection

4.3.8 Typical Scenario

Assuming a mobile learner wants to research on a topic in automata that deals with constructing a deterministic finite state automata (DFA), the learner can choose from the list of multimedia contents provided. Another option is to ask the community chat forum for recommendations, by posting a question using the chat feature of the SMLS. Any member of the community of learners can respond and guide accordingly. The respondent may recommend an interactive multimedia content among the list of videos provided by the SMLS or give additional information from his or her wealth of experience.

On the other hand, a mobile learner who desires to evaluate himself or herself on a subject area of Automata Theory can select from a range of quizzes, which are sectioned accordingly. Additionally, a student learning automata simulation can make use of the SMLS automata simulator to build and test an automaton on his or her mobile device anywhere and anytime.

Overall, SMLS can be used to actively and collaboratively learn and acquire hands-on-experience of Automata Theory.

CHAPTER FIVE

EVALUATION, RECOMMENDATION AND CONCLUSION

This chapter describes the system's evaluation based on learner's interaction with the mobile application built for learning Automata Theory and includes some recommendations, deduced from the evaluation survey carried out among Computer Science students who have taken the course.

5.1 System Evaluation

The Smart Multimedia Learning System's (SMLS) evaluation based on some learner's experience and interaction is depicted with the aid of a pie chart. At the time of this report, thirty-nine responses were realised. An online survey form was used to gather information, which demonstrated, to an extent, that the SMLS meets the learners' requirements. A series of five questions were asked and the learners were given three answer options; "Yes", "No" and "Maybe". From the responses, many learners found it impressive to have a mobile application tool to learn Automata Theory and simulate an automaton, more so, they could learn at their convenience. SMLS could provide motivation and learning-aid support to many learners who are struggling with the core subject, "Automata Theory". The survey was used to determine the learners experience in terms of; ease of use of the mobile application, interactivity, feedback, motivation and its usefulness as a tool for learning.

5.2 Ease of Use

Do you find it easy to learn to interact with the app?

39 responses

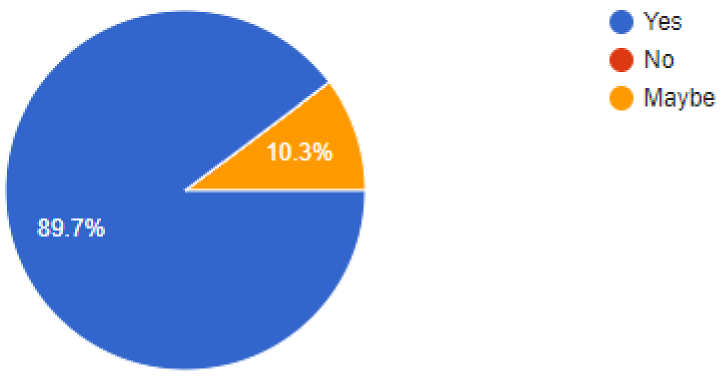


Figure 5.1: Ease of Use Pie Chart

5.3 Multimedia Content Interactivity

Do you find the multimedia content interactive?

39 responses

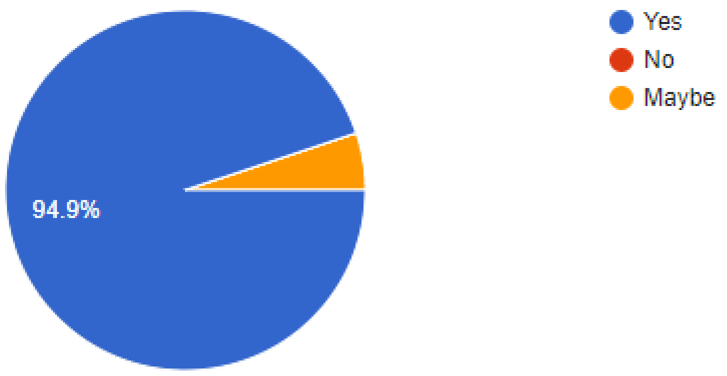


Figure 5.2: Multimedia Content Interactivity Pie Chart

5.4 Real-time Assessment Activity

The quiz activity is used for real time assessment. Is it interactive and does it provide a proper feedback?

39 responses

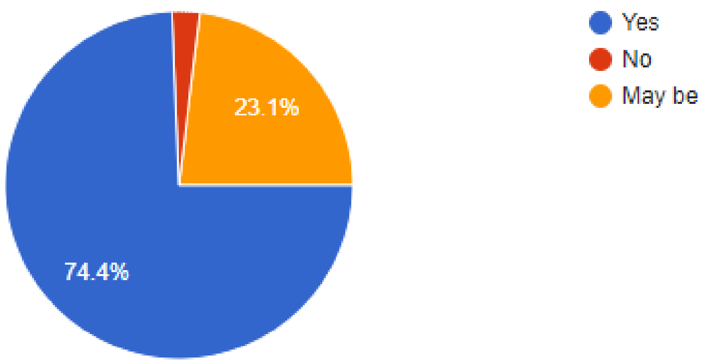


Figure 5.3: Real-time Assessment Pie Chart

5.5 Collaborative Learning Evaluation

The chat feature helps learners communicate and share knowledge. Do you think this feature augments Learning?

39 responses

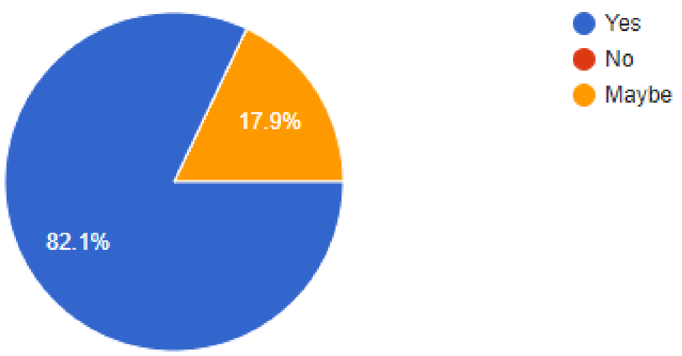


Figure 5.4: Collaborative Learning Evaluation Pie Chart

5.6 Automata Simulator Users Experience

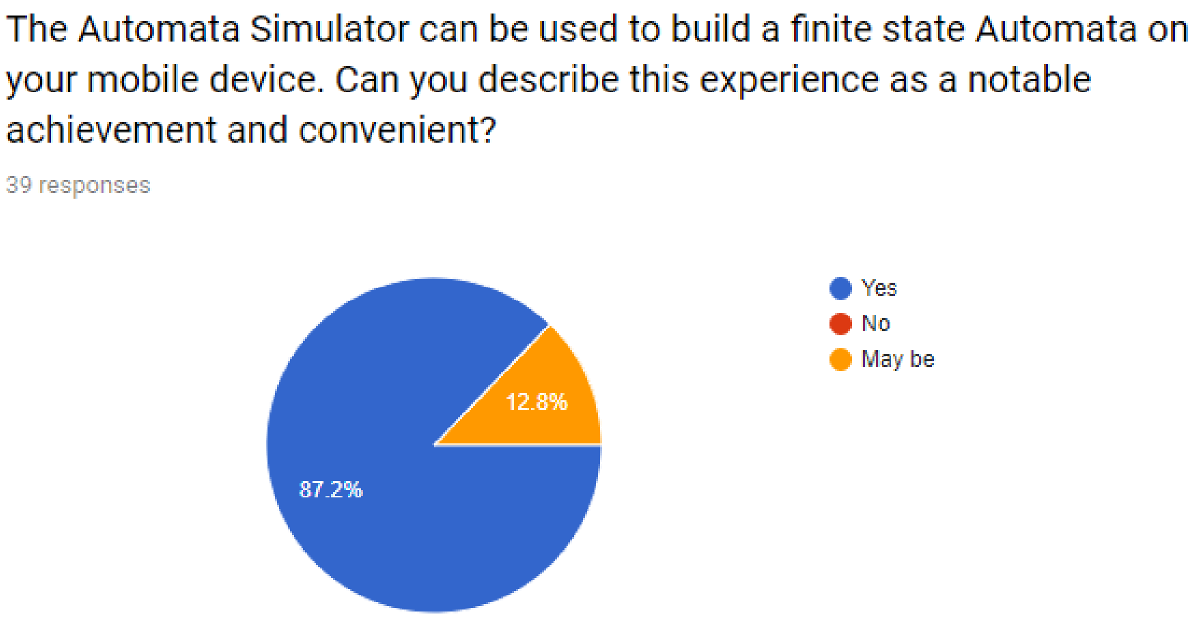


Figure 5.5: Automata Simulator Users Experience Pie Chart

5.7 Motivation

The evaluation of motivation among learners of which the majority of them have not taken the course, shows that the level of motivation increased with the provision of the mobile learning application. The Smart Multimedia Learning System APK was distributed to some learners to make use of the application on their individual mobile devices. The respondents were asked two questions, as shown in Figures 5.6 and 5.7 respectively. The result of the evaluation shows an increase in motivation of learners.

If Automata course was an elective course, would you choose to study it? And, do you recommend other students to study it?

28 responses

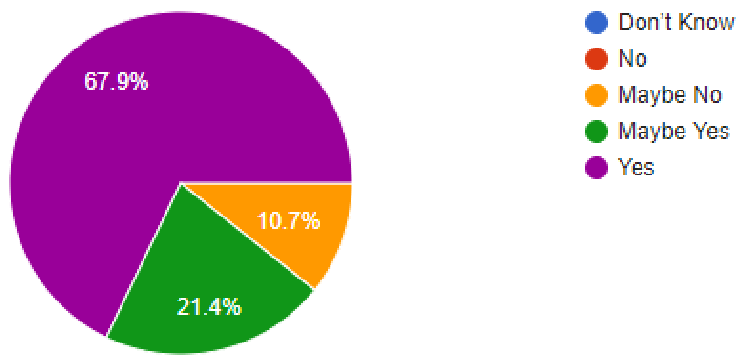


Figure 5.6: Automata Course Study Choice

With the provision of a mobile learning app like the Automata Study App will you like to study the course? Also, will you recommend other students to study it?

28 responses

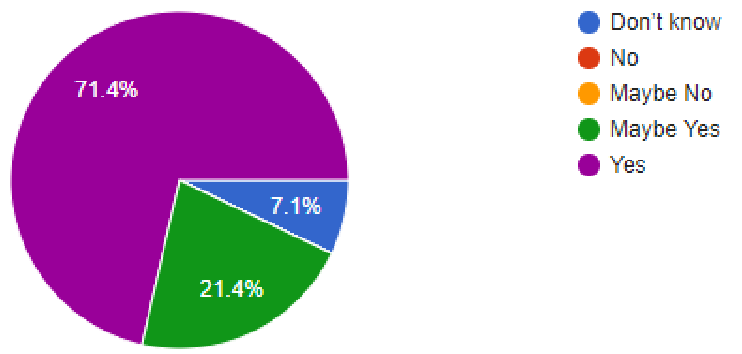


Figure 5.7: Motivation of Automata Learners

5.8 Recommendations

The SMLS can be adapted for other smartphones and mobile devices using other operating systems. A mobile sensing mechanism can be integrated into the SMLS to provide smart-active learning. The system could use facial recognition to determine the learner's mood and make appropriate decisions that will enhance the learning process. For instance, based on the criteria for evaluating learners, the system could recommend specific activities to aid learning such as; refer the learner to a specific multimedia content that teaches a particular area where a learner lacks understanding. Hence, for future works the system can be used as a recommender system for learning using facial recognition.

5.9 Conclusion

Majority of the respondents report that the SMLS provides a platform for active and collaborative learning. The success of any mobile learning application greatly relies on its adoption. Hence, it is important that educators, institutions and the learners' community adopt a functional mobile learning system to improve and make learning effective. Many researchers have advocated that a 'bring your own device' (BYOD) is a good measure, which will lessen the digital divide in education. Learners have easy access to these devices, basically handheld devices. Hence, there is need to promote mobile learning in any learning environment.

REFERENCES

Adeboye, D. (2016). *5 Effective Uses Of Mobile Technology In The Classroom - eLearning Industry*. Retrieved from https://elearningindustry.com/5-uses-mobile-technology-in-the-classroom

Aziz, A. D., Cackler, Jo., & Yung, R. (2004). *Basics of Automata Theory*. Retrieved from https://cs.stanford.edu/people/eroberts/courses/soco/projects/2004-05/automata-theory/basics.html

Brotman, S. N. (2016). The Real Digital Divide. *The Economist*. Retrieved from https://www.brookings.edu/blog/techtank/2016/01/28/the-real-digital-divide-in-educational-technology/

Cochrane, T. (2012). Secrets of mlearning failures: Confronting reality. *Research in Learning Technology*, *20*(SUPPL), 123–134. https://doi.org/10.3402/rlt.v20i0.19186

Epignosis LLC. (2014). *e-learning Concepts, Trends, Applications*. Book, 5. Retrieved from http://www.talentlms.com/elearning/elearning-101-jan2014-v1.1.pdf

Gutierrez, K. (2015). *Understanding The Difference Between eLearning and mLearning*. Retrieved from http://info.shiftelearning.com/blog/difference-between-elearning-and-mlearning

Hamada, M. (2008). An Integrated Virtual Environment for Active and Collaborative e-Learning in Theory of Computation. *IEEE Transactions on Learning Technologies*, *1*(2), 117–130. https://doi.org/10.1109/TLT.2008.3

Hamada, M. (2013). *E-learning: New technology, applications and future trends*. *E-Learning: New Technology, Applications and Future Trends*. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-84892919329&partnerID=tZOtx3y1

Hwang, G.-J., & Wu, P.-H. (2014). Applications, impacts and trends of mobile technology-enhanced learning: a review of 2008-2012 publications in selected SSCI journals. *International Journal of Mobile Learning and Organisation*, *8*(2), 83–95. https://doi.org/10.1504/IJMLO.2014.062346

Keegan, D. (2002). The Future of Learning: From eLearning to mLearning. *2014 37th International Convention on Information and Communication Technology, Electronics and Microelectronics, MIPRO 2014 - Proceedings*, (ISSN-1435-9340), 616–622.

https://doi.org/10.1109/MIPRO.2014.6859641

McDevitt, T., & Ormrod, J. (2013). Child Development and Education. *J. Amer. Psychoanal. Assn.*, *57*(4), 871–879.

McPherson, M. A., & Nunes, J. M. (2008). Critical issues for e-learning delivery: What may seem obvious is not always put into practice. *Journal of Computer Assisted Learning*, *24*(5), 433–445. https://doi.org/10.1111/j.1365-2729.2008.00281.x

Neo, M., & Neo, K. T. K. (2001). Innovative teaching : Using multimedia in a problem-based learning environment. *Educational Technology & Society*, *4*(4), 19–31. Retrieved from http://www.ifets.info/journals/4_4/neo.html

Powell, W. W., & Snellman, K. (2004). The Knowledge Economy. *Annual Review of Sociology*, *30*(1), 199–220. https://doi.org/10.1146/annurev.soc.29.010202.100037

Shippee, M., & Keengwe, J. (2014). mLearning: Anytime, anywhere learning transcending the boundaries of the educational box. *Education and Information Technologies*, *19*(1), 103–113. https://doi.org/10.1007/s10639-012-9211-2

Skea, J. (2011). Structure of presentation p. *Policy*, (December), 16–18. Retrieved from https://www.slideshare.net/parthacharya/learning-management-system-9806345?from_action=save

Sommerville, I. (2011). *Software Engineering*. *Software Engineering*. https://doi.org/10.1111/j.1365-2362.2005.01463.x

Traxler, J. (2009). Learning in a Mobile Age. *International Journal of Mobile and Blended Learning*, *1*(1), 1–12. https://doi.org/10.4018/jmbl.2009010101

Tustin, R. (2016). Bridging the Digital Divide in Education through Professional Development. Retrieved October 23, 2017, from http://study.com/academy/lesson/bridging-the-digital-divide-in-education.html

tutorialspoint. (2017). SDLC - RAD Model. Retrieved October 31, 2017, from https://www.tutorialspoint.com/sdlc/sdlc_rad_model.htm

West, D. M. (2015). Connected learning: How mobile technology can improve education. *Centre for Technology Education at Brookings*, December, 1–8.