MONITORING LEARNER INTERACTION WITH MULTIMEDIA CONTENT USING NATURAL LANGUAGE PROCESSING

BY

PETER N. MBURU

UNITED STATES INTERNATIONAL UNIVERSITY - AFRICA

SPRING 2019
MONITORING LEARNER INTERACTION WITH MULTIMEDIA CONTENT USING NATURAL LANGUAGE PROCESSING

BY

PETER N. MBURU

A Project Report Submitted to the School of Science and Technology in Partial Fulfillment of the Requirement for the Degree of Master of Science in Information Systems and Technology

UNITED STATES INTERNATIONAL UNIVERSITY - AFRICA

SPRING 2019
DECLARATION

I, the undersigned, declare that this is my original work and has not been submitted to any other college, institution or university other than the United States International University in Nairobi for academic credit.

Signed: _____________________ Date: ______________________
Peter N. Mburu (ID No 636900)

This project has been presented for examination with my approval as the appointed supervisor

Signed: _________________ Date: ______________________
Stanley Githinji, PhD

Signed: _________________ Date: ______________________
Dean, School of Science and Technology
ABSTRACT

E-learning has enhanced the way students think and learn over time. Different studies show that students appreciate facilities offered through the e-learning process. It has also proven to be a very useful tool by bringing education closer to the learner, hence, learner-centred. A point to note about e-learning is the ability to offer a wide range of information access, storage and education curriculum.

Institutions of higher learning moderate and harmonize this information between instructors and students. These institutions also advocate for different styles and types of content presentation. This study focused on three types of content namely: audio, textual and video content. However, monitoring learner-content interaction in open environments where each student has his/her own device posed a unique challenge to the instructors and the institutions at large.

The study also emphasized on investigating content items in asynchronous e-learning environment. It proposed the use of a monitoring tool to evaluate the level of content interaction as well as their dominance. The study developed an artefact that collected learner-content interaction data and reported to the respective instructor. Natural language processing was used for text extraction as well as pre-processing. It was then applied to scale through words and sentences that the learner had interacted with and provided a word count as a form of textual content interaction report to the corresponding course instructor.

Session-based interaction has been suggested in the study as a method of data collection in the level of content interaction. This was possible through the use of the percentage formula suggested in this study. The methodology, was design science and it revolved around development of an information system-based artefact.

A population of USIU-Africa students was suggested with a sample size of 50 random students, each taking 4 different lessons to provide a dataset of 200. The frame was between freshmen and senior students. Using a 95% confidence level and 50% population variance with error margin of 5, the study was confident that the provided dataset would produce an accuracy of 132.

A lab experiment was conducted to collect the data required for the study. This data provided the study with learner-content interaction levels. These levels were then used to determine content item dominance. The observation made in the study was that textual item dominated audio and video items.
The study recommended the use of more vibrant machine learning algorithms that adapts to the learner’s content item preferences. It also suggests the introduction of abstractive course content summary based on the learner’s level of interaction. Finally, adaptive learning was suggested for the purpose of automatic question generation based on the level of interaction.
ACKNOWLEDGMENT

First and foremost, I would like to thank God Almighty for granting me the opportunity to read and write all through my life. He is my endurance and my hope in this academic journey. I also acknowledge the guidance and mentorship of my supervisor, Dr. Stanley Githinji. He has been instrumental all through this project by critiquing the ideas that came across as well as challenging me with reading materials. For this, I thank you Prof.

Secondly, I acknowledge the care and blessings of Prof. Michael Darter. He has been influential since I began my higher education journey. I am grateful for your full support and I don’t take it for granted whatsoever. I also thank Ms. Vivien Prince for taking her time in identifying the potential in me and pushing me beyond limits. Dr. Wamuyu Kanyi, Dr. Jimmy Macharia and Dr. Justus Nyangwecha, you enlightened me on how research is done and the fundamentals of reading wide literature.

Not forgetting my classmate, Mr. Simon Mogaka and my friends, Mr. Benson Odede and Mr. Victor Mshindi who’s critics on the artefact opened my eyes. I am thankful. Mr. Dalton Ndirangu and Ms. Beatrice Owino, thank you for helping me collect data from the labs.

Lastly, my family has been a major pillar throughout my academic life. Dad you have been a rock that I rely on anytime I am down. You made it your life’s mission to educate me and advocate for the betterment of my life. Thank you for being a father, a ‘mother’ and a brother to me. My lady friend, Wawa, thank you for praying for me always and for proof reading this document.
DEDICATION

I dedicate this project to my Heavenly Father, The Almighty God by whom all strength come from. I also dedicate it to my great grandma, my father and my sister who have been there for me through thick and thin.

I also dedicate this project to the late Ms. Olivia Wamunyu Wakonyo. You were a true friend who brought out a lot of good in me and for that, may your soul Rest in Eternal Peace until we meet again.
TABLE OF CONTENTS

DECLARATION........................................................................................................ II

COPYRIGHT............................................................................................................. III

ABSTRACT ............................................................................................................... IV

ACKNOWLEDGMENT ............................................................................................... VI

DEDICATION.......................................................................................................... VII

LIST OF TABLES .................................................................................................... XI

LIST OF FIGURES .................................................................................................. XIII

LIST OF ABBREVIATIONS ...................................................................................... XVI

CHAPTER 1: INTRODUCTION .............................................................................. 1

1.1 BACKGROUND OF THE PROBLEM ............................................................... 1

1.2 STATEMENT OF THE PROBLEM .................................................................. 5

1.3 GENERAL OBJECTIVE.................................................................................... 6

1.4 SPECIFIC OBJECTIVES .................................................................................. 6

1.5 IMPORTANCE/SIGNIFICANCE OF THE STUDY ............................................ 6

1.6 SCOPE OF THE STUDY .................................................................................. 7

1.7 DEFINITION OF TERMS ................................................................................ 7

1.8 CHAPTER SUMMARY ..................................................................................... 8

CHAPTER 2: LITERATURE REVIEW .................................................................... 9

2.1 INTRODUCTION .............................................................................................. 9

2.2 THEORETICAL FOUNDATION ....................................................................... 9

2.3 INTERACTION MODELS IN E-LEARNING .................................................... 11

2.4 CONTENT ITEMS IN LEARNER-CONTENT INTERACTION ......................... 12

2.5 CONTENT INTERACTION MONITORING TECHNIQUES ............................... 14

2.6 EVALUATING LEARNER-CONTENT INTERACTION ...................................... 18
CHAPTER 3: METHODOLOGY .............................................................. 21
  3.1 INTRODUCTION ........................................................................ 21
  3.2 RESEARCH DESIGN .................................................................. 21
  3.3 RESEARCH PROCESS ............................................................... 22
  3.4 POPULATION AND SAMPLING DESIGN .................................... 22
  3.5 DATA COLLECTION METHODS ................................................ 25
  3.6 RESEARCH PROCEDURES ...................................................... 25
  3.7 DATA ANALYSIS METHODS ................................................... 27
  3.8 CHAPTER SUMMARY ............................................................. 27

CHAPTER 4: DESIGN & IMPLEMENTATION ......................................... 28
  4.1 INTRODUCTION ........................................................................ 28
  4.2 SYSTEM REQUIREMENTS ...................................................... 28
  4.3 MODELLING AND DESIGN ..................................................... 31
  4.4 TESTING .................................................................................. 40
  4.5 PROOF OF CONCEPT ............................................................. 43
  4.6 SYSTEM ARCHITECTURE ........................................................ 51
  4.7 CHAPTER SUMMARY ............................................................. 54

CHAPTER 5: RESULTS AND FINDINGS ............................................. 55
  5.1 INTRODUCTION ........................................................................ 55
  5.2 GENERAL INFORMATION ........................................................ 55
  5.3 CHAPTER SUMMARY ............................................................. 77

CHAPTER 6: DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS .... 78
  6.1 INTRODUCTION ........................................................................ 78
  6.2 SUMMARY .............................................................................. 78
LIST OF TABLES

Table 1: Wittgenstein's AND Logic Truth Table ................................................................. 18

Table 2: Sample size based on desired accuracy with confidence level 95% as extracted from Taherdoost (2017a) ................................................................................ 24

Table 3: System Functional Requirements ........................................................................ 29

Table 4: Functional Testing Test Case (Author's Table) .................................................... 41

Table 5: Video Content Interaction Report - Week 1 ...................................................... 56

Table 6: Average Count of Video Interaction - Week 1 .................................................... 57

Table 7: Video Content Interaction Report - Week 2 ...................................................... 57

Table 8: Average Count of Video Interaction - Week 2 .................................................... 58

Table 9: Video Content Interaction Report - Week 3 ...................................................... 59

Table 10: Average Count of Video Interaction - Week 3 ................................................ 59

Table 11: Video Content Interaction Report - Week 4 .................................................... 60

Table 12: Average Count of Video Interaction - Week 4 ................................................ 61

Table 13: Audio Content Interaction Report - Week 1 .................................................... 61

Table 14: Average Count of Audio Interaction - Week 1 ................................................ 62

Table 15: Audio Content Interaction Report - Week 2 .................................................... 62

Table 16: Average Count of Audio Interaction - Week 2 ................................................ 63

Table 17: Audio Content Interaction Report - Week 3 .................................................... 63

Table 18: Average Count of Audio Interaction - Week 3 ................................................ 64

Table 19: Audio Content Interaction Report - Week 4 .................................................... 64

Table 20: Average Count of Audio Interaction - Week 4 ................................................ 65

Table 21: Text Content Interaction Report - Week 1 ...................................................... 66

Table 22: Average Count of Text Interaction - Week 1 ................................................... 67

Table 23: Text Content Interaction Report - Week 2 ...................................................... 68

Table 24: Average Count of Text Interaction - Week 2 ................................................... 69
Table 25: Text Content Interaction Report - Week 3 ................................................................. 69
Table 26: Average Count of Text Interaction - Week 3 ............................................................ 70
Table 27: Text Content Interaction Report - Week 4 ................................................................. 71
Table 28: Average Count of Text Interaction - Week 4 ............................................................ 71
Table 29: Week 1 Content Item average and standard deviation .............................................. 72
Table 30: Content Items Anova Single Factor - week 1 ............................................................. 72
Table 31: Week 2 Content Item average and standard deviation .............................................. 73
Table 32: Content Items Anova Single Factor - Week 2 ............................................................. 73
Table 33: Week 3 Content Item average and standard deviation .............................................. 73
Table 34: Content Items Anova Single Factor - Week 3 ............................................................. 74
Table 35: Week 4 Content Item average and standard deviation .............................................. 74
Table 36: Content Items Anova Single Factor - Week 4 ............................................................. 75
Table 37: Linear Regression Statistics Showing Content Item Relationship ......................... 75
Table 38: Students’ Access Matrix ......................................................................................... 112
Table 39: Instructor’s Access Matrix ....................................................................................... 112
Table 40: Admin Access Matrix .............................................................................................. 113
LIST OF FIGURES

Figure 1: LRS data flow diagram adapted from Wang (2017) .......................... 16
Figure 2: xAPI learning activity statement (Nouira, Cheniti-Belcadhi, & Braham, 2018). 16
Figure 3: Conceptual Model (Author's own illustration) .................................. 19
Figure 4: Research process (Author's own illustration) ..................................... 22
Figure 5: Basic Sampling Techniques (Sarstedt et al., 2018) .............................. 23
Figure 6: Software Quality model for Agile Non-Functional Requirements (Younas et al., 2017) .................................................................................. 31
Figure 7: Data Model (Author's Illustration) ...................................................... 32
Figure 8: Kruchten 4+1 view model (S. Singh et al., 2016) ................................. 33
Figure 9: Use Case Diagram and Key (Author's Illustration) ............................... 34
Figure 10: Class Diagram and Key (Author's illustration) ................................... 35
Figure 11: Component Diagram and Key (Author's Illustration) .......................... 37
Figure 12: Activity Diagram and Key (Author's Illustration) ............................... 38
Figure 13: Deployment Diagram and Key (Author's Illustration) ......................... 39
Figure 14: Performance Testing done at https://app.loadimpact.com ................. 43
Figure 15: Admin Course Management .............................................................. 44
Figure 16: Admin Add User ............................................................................... 44
Figure 17: Admin User Management .................................................................. 44
Figure 18: Instructor Course View ...................................................................... 45
Figure 19: Instructor Week View ....................................................................... 45
Figure 20: Instructor Weekly Content Upload .................................................. 46
Figure 21: Instructor Audio Upload View .......................................................... 46
Figure 22: Instructor Text Upload View ............................................................ 46
Figure 23: Instructor Video Upload View .......................................................... 47
Figure 24: Instructor Reports View ................................................................... 47
Figure 25: Student Login View.................................................................................................................. 48
Figure 26: Student Course List View................................................................................................................. 48
Figure 27: Student Course Weeks View............................................................................................................. 49
Figure 28: Student Course Weekly View ........................................................................................................... 49
Figure 29: Student Audio Content View .......................................................................................................... 49
Figure 30: Student Text Content View ............................................................................................................. 50
Figure 31: Student Video Content View .......................................................................................................... 50
Figure 32: System Architecture (Author's Illustration) ...................................................................................... 51
Figure 33: Week 1 Video Interaction Analysis.................................................................................................. 56
Figure 34: Week 2 Video Interaction Analysis.................................................................................................. 58
Figure 35: Week 3 Video Interaction Analysis.................................................................................................. 59
Figure 36: Week 4 Video Interaction Analysis.................................................................................................. 60
Figure 37: Week 1 Audio Interaction Analysis.................................................................................................. 61
Figure 38: Week 2 Audio Interaction Analysis.................................................................................................. 63
Figure 39: Week 3 Audio Interaction Analysis.................................................................................................. 64
Figure 40: Week 4 Audio Interaction Analysis.................................................................................................. 65
Figure 41: Week 1 Text Content Analysis........................................................................................................ 67
Figure 42: Week 2 Text Content Analysis........................................................................................................ 68
Figure 43: Week 3 Text Content Analysis........................................................................................................ 70
Figure 44: Week 4 Text Content Analysis........................................................................................................ 71
Figure 45: Linear Regression Scatter Graph..................................................................................................... 76
Figure 46: Text Interaction Array ...................................................................................................................... 80
Figure 47: Text API Response without Calculations........................................................................................ 81
Figure 48: API GET Response .......................................................................................................................... 81
Figure 49: Artefact Dependencies ..................................................................................................................... 99
Figure 50: Export and Import of Routes ........................................................................................................... 100
Figure 51: Firebase Database Configuration .......................................................... 101
Figure 52: Firebase Configuration ........................................................................ 102
Figure 53: User Login JS Code ............................................................................ 103
Figure 54: Audio Upload JS Code ........................................................................ 104
Figure 55: Text Upload JS Code ........................................................................... 105
Figure 56: Video Upload JS Code .......................................................................... 106
Figure 57: Reports JS Code .................................................................................. 107
Figure 58: Python Text Processing API ................................................................. 108
Figure 59: Firebase Database ............................................................................... 109
Figure 60: Cloudinary CDN Content Storage ..................................................... 110
Figure 61: Principles of Microeconomics MIT Open Courseware ....................... 111
LIST OF ABBREVIATIONS

AI - Artificial Intelligence
API - Application Programming Interface
AQG - Automatic Question Generation / Generator
DOM - Document Object Model
IR - Information Retrieval
IS - Information Systems
JS - JavaScript
MVA - Minimum Viable Artefact
NLP - Natural Language Processing
OOP - Object Oriented Programming
POS - Parts of Speech
UML - Unified Modelling Language
UID - Unique Identifier
UUID - Universally Unique Identifier
CHAPTER 1: INTRODUCTION

1.1 Background of the Problem

E-learning is a unique endeavour supported by digital electronic tools and media (Basak, Wotto, & Bélanger, 2018). It allows learners to study at their own convenient time and place, therefore utilizing computer network technologies, primarily over the internet, as a mode of information delivery. J. Hammad, Hariadi, Purnomo, and Jabari (2018), elaborates that e-learning has been one of the interesting research fields over the last few years, and it is rapidly being adopted by many people, organizations, companies, and universities. Additionally, e-learning utilizes the applications such as web-based learning, computer-based learning, virtual classrooms, and digital collaboration for content delivery (Basak et al., 2018).

Advances in communication and technology have also influenced the way learning content is delivered to the student by bridging the geographical gap using tools that make the learners feel as though they are inside the classroom (J. Hammad et al., 2018). In e-learning, different kinds of study materials are shared to facilitate learning. PDFs, word documents, slideshows, and video are some of these materials. Others include, online virtual classes that engage learners in an active participation and interaction by asking questions using voice and chatting tools (Adesuyi, Obolo, Oloja, & Badeji-Ajisafe, 2018).

Some of the advantages of e-learning include: raising standards and widening participation in lifelong learning, enhancing instructor’s quality and reach of their teaching (Adesuyi et al., 2018). The study of J. Hammad et al. (2018), suggests that in e-learning, there are no boundaries, and or restrictions, therefore location and time of learning is independent. It also suggests that it is more fun due to the dissemination of multimedia content delivered through different methodologies and technologies. Lastly, it is cost effective compared to traditional learning that uses materials like textbooks which are not easily updated.

El-Seoud et al. (2014), builds their argument around e-learning disadvantages and shows how the incorporation of technology in learning processes does not necessarily guarantee motivation of students. In fact, online instructions have resulted in the student teacher relationship becoming less personal. Hence, this less interpersonal relationship creates a vacuum for the students. However, to address this issue, various e-learning tools have been suggested based on their goals, scope, adopted strategies, etc. They include: Learning Management System (LMS), Virtual Learning Environment (VLE) and Adaptive e-Learning Systems (R. Hammad, 2018).
1.1.1. Types of E-Learning

i. Web-based

This type of e-learning is one of the most significant innovation for education delivery and has emerged as an imperative of modern education systems. It is characterized by its ubiquitous nature (Oyefolahan & Abdallah, 2014). It flexibly delivers education content through the use of internet to support individual learning or organizational performance goals (Katoua, AL-Lozi, & Alrowwad, 2016). With the advances in technology and communication channels, many universities are providing their academic content through web-based e-learning (Oyefolahan & Abdallah, 2014). According to Katoua et al. (2016), web-based learning fits into three categories namely:

a) Self-paced independent study - which focuses on the individual learner whereby their motivation comes from within and the study schedule depends on the learner’s pace (Basak et al., 2018).

b) Asynchronous interactive - whereby learning mostly occurs through digital media (Bates, 2015).

c) Synchronous - concerned with students attending live lectures via computer media and asking questions via communication platforms (Katoua et al., 2016).

Katoua et al.’s (2016) study also indicates some advantages of this type of e-learning. It states that: It is self-paced, it has access to global materials and resources, it encourages development of knowledge using latest web technologies, it is robust and lastly it is ubiquitous. A few drawbacks to note here may include: lack of framework to encourage students to learn, absence of learning atmospheres and lastly, leaners with low self-drive and low self-motivation may fall behind because of poor study habits. This study used web-based e-learning to learn and understand learner-content interaction. It also developed a web-based tool for monitoring the above mentioned.

ii. Computer - based

Azhari and Ming (2015), views this type as a mode of e-learning where activities are done through a personal computer without the use of internet connection. Their study also indicates that the method of content delivery is offline and may be through compact disks [CD’s], digital video disks [DVD’s], USB sticks or even “online” assuming that the connection has nothing to do with the ongoing learning activities. This type is utilized in areas with little to no internet connectivity.
iii. Virtual classrooms

Virtual classrooms happen in environments by which learning takes place via virtual cyberspace. Learners and instructors are brought together by means of virtualized classes amongst other methods (Agarana, 2015). In virtual classrooms, leaners interact with the content in real time. Some of these classrooms include: shared whiteboard, video conferencing, etc. (J. Chen, 2016). It is also argued that; virtual classrooms are set-up in synchronous teaching.

iv. Digital Collaboration

Digital collaboration is assisted through web-based learning. This process allows students and experts as well as peers to share content on secluded digital forums (Kumar Basak et al., 2018). Some examples of digital collaboration forums may include: Reddit, Stack Overflow, GitHub, etc.

1.1.2. E-Learning Tools

i. Learning Management Systems

Also known as LMS, they are web-based delivery applications that are used by universities and institutions of higher learning to deliver course, course content and offer distance learning as well as managing the education process (Katoua et al., 2016). In the study of J. Chen (2016), learning management systems provide automated mechanisms that make the course delivery and management of learning process more convenient and effective. For example, some LMSs can automatically notify the learners of the performance of the learning activities they have attended. According to R. Hammad (2018), learning management systems capabilities can be classified into six categories namely: module delivery, interaction, assessment, teaching and learning, content management or administration.

A good example of such systems include Moodle and Blackboard which according to Katoua et al. (2016), have established their dominance amongst the others.

ii. Virtual Learning Environments

J. Chen (2016), defined virtual learning environment as an emerging tool for distance learning that focuses more on the management of learning process rather than management of learning tasks. Some of the pedagogical tools designed for virtual learning environments allow for remote communication, online collaboration and tracking of learner’s learning process. It is arguably said that VLEs provide instructional content that can be specifically tailored to meet different
learner profiles (Battou, Baz, & Mammass, 2017). The importance of the use of VLE is that, it can accommodate the needs of each student and support the development of students as a whole (Rosmansyah & Ashaury, 2017).

This study produced a web-based tool in the form of virtual learning environment that simulated, evaluated and collected learner-content interaction data.

iii. Adaptive e-Learning Systems
J. Hammad et al. (2018), viewed adaptive e-leaning systems as a new approach which effectively adapted the learning materials and all linkage structures to users related to their knowledge and behaviour. Cognitive processes were used to help understand how the learner’s brain work thus allowing them to learn in their own style. This indeed made learning personal and engaging (Kumar Basak et al., 2018).

According to J. Hammad et al. (2018), adaptive learning can be divided into four parts:

a) Adaptive content aggregation: - In this style teaching and learning provides students with different content depending on simulations.

b) Adaptive presentation: - Here presentations are adapted by prerequisite, additional, or comparative explanations.

c) Adaptive navigation: - Navigations presented within the pages can be adapted to achieve several adaptation goals.

d) Adaptive collaboration support: - This method helps learners collaborate with peers and or instructors based on the system’s knowledge about the learner.

1.1.3. Communication Techniques Used in E-Learning

i. Synchronous Learning

This mode of e-learning communication, allows learners and instructors to share information in real time. It makes use of tools like instant messaging and video conferencing (J. Hammad et al., 2018).

ii. Asynchronous Learning

Asynchronous technologies enable participants to access information or communicate at different points of time, usually at the time and place of choice of the participant. All recorded media are asynchronous (Bates, 2015). It is also known as self-paced learning in that, various
Digital media technologies are employed to enable the learner-centric learning process (J. Chen, 2016).

However, one of the drawbacks of this type of e-learning is that the students don't have direct interaction with other students and teachers. Thus, it leads to no direct communication (J. Hammad et al., 2018). This study intends to build a web-based virtual learning tool that is embedded in asynchronous communication for the purpose of bridging between learner, content and instructor.

1.1.4. Uses of Natural Language Processing in E-Learning

Hirschberg and Manning (2015), defines natural language processing as a process that employs computational techniques for the purpose of learning, understanding, and producing human language content. Also known as computational linguistics, NLP, constantly deals with learning, understanding, and producing human language content.

Alhawiti's (2014), study shows how natural language processing is an effective tool for assisting students in the process of scientific learning. It has over fifty-year history in the discipline of scientific studies, with initial work beginning as early as 1960’s (Litman, 2016). Natural language processing began with automatically scoring student texts as well as developing text-based dialogue tutoring systems, while later work also included spoken language technologies.

Natural language has been used in different e-learning setups. For example, in schools of medicine, it is used to assess medical trainees through pre-defined competencies (Denny et al., 2015). With the addition of machine learning algorithms, natural language processing has been used in educational content mining, essay ranking, etc. (Melnikov, Botov, & Klenin, 2017). A study conducted by Bhaduri (2017), shows how natural language processing is used to extract and analyse large volumes of textual data from engineering education for the purpose of teaching.

This study uses natural language processing to extract all textual data that a learner interacted with during the learning process. Tokenization was applied for the purpose of interaction analysis.

1.2 Statement of the Problem

The ubiquity of e-learning offers 100% mandate to self-paced students due to its asynchronous nature (Natarajan, 2015). Hence, the existence of a number of e-learning platforms for this
purpose (J. Hammad et al., 2018). However, none of them are able to provide a mechanism of accurately monitoring learner-content interaction. In light to this issue, key challenges are listed below. First, there are very few empirical studies that examine the role of learner-content interaction with reference to successful course outcomes. That is because a lot of research is dedicated to reciprocal interpersonal interaction, i.e. learner–learner and learner–instructor interaction (Xiao, 2017). Secondly, the e-learning artefacts that exist do not provide a mechanism for accurately reporting the level of content interaction that the learner reaches (J. Chen, 2016).

This study was an attempt to develop a web-based learner-content-interaction monitoring tool for asynchronous e-learning, that accurately monitored interaction levels of three content items namely: video, audio and textual content. The study also used natural language processing for text extraction in an effort to monitor levels of interaction in the textual content. The data produced hereby, was used for measuring the dominance of content items over each other.

1.3 General Objective

This study investigated content items in asynchronous e-learning environment and used a monitoring tool to evaluate the level of interaction as well as which ones are dominant over others.

1.4 Specific Objectives

1.4.1 To investigate the influence of content items in learner-content interaction.
1.4.2 To develop a framework and a tool for monitoring learner-content interaction using NLP.
1.4.3 To evaluate the level and dominance of learner-content interactions in the tool developed.

1.5 Importance/Significance of the Study

The purpose of this study was to close the gap identified in the problem statement by developing a tool that would help monitor accurate learner-content interactions. Secondly, it would help inform instructors and administrators of institutions of higher learning on the levels of interaction based on subject particularity. Lastly, it would assist instructors understand the dominance of content items based on analysis done hence, determining content type that students preferred.
1.6 Scope of the Study

The scope of this study was to develop a web-based asynchronous virtual learning environment with two types of users namely: instructor and student. Instructor modules contained login, content upload and reporting module while student module had login, subject explore and content interaction.

In order to embed the learner-content monitoring tool, the study used open source video and audio JavaScript libraries for monitoring video and audio content respectively. It also used open source text processing libraries in a python programming environment to create the NLP API for text pre-processing in textual content monitoring. Lastly, the entire tool was simulated for demo purposes.

1.7 Definition of Terms

1.7.1 Composition Relationship
A part-of relationship in which parts belong to only one whole object, and the parts live and die with the whole object (Valacich & George, 2017).

1.7.2 Dataset
A dataset is a knowledge base composed of different domains of data either questions, words, sentences or articles (Ankit Kumar, Luo, & Xu, 2018).

1.7.3 E-Learner
This is a person who is learning a skill in an online setup either by remote connection, synchronous or asynchronous (Vijayalakshmi, Venkatachalapathy, & Ohmprakash, 2017).

1.7.4 Machine Learning
It is a branch of Artificial Intelligence that provides the machine with the ability to automatically learn and adapt to new stimuli based on a particular model. It usually doesn’t not involve explicit programming (Melnikov et al., 2017).

1.7.5 Pedagogy
This is the dynamic relationship between learning, teaching and culture and includes teachers’ beliefs about these aspects and a consideration of the context in which learning and teaching takes place (Livingston, Schweisfurth, Brace, & Nash, 2017).
1.7.6 Self-Paced Learning

This is the kind of learning that incorporates the learner’s initiative to read at their own convenient time and place without any interventions (Khamparia & Pandey, 2017).

1.8 Chapter Summary

In this chapter, the topic of the matter was introduced. The chapter went ahead to look at some of the background aspects affecting the topic of study. E-learning was discussed with the various uses of it being laid out. The chapter has discussed the importance of using e-learning, its types, tools, as well as communication techniques used in e-learning.

In addition, natural language processing was introduced and some of its uses in education also discussed. Key aspects in the study were laid out in the problem statement carefully outlining literature that informs them.

Lastly, the scope of the study and its importance were defined with some of the technologies needed in order to successfully create an artefact for demonstration and data collection purposes.
CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In this chapter, interaction equivalency theorem and cognitive theory of multimedia learning will be discussed and the gaps they address established. These theories will also act as a leeway for the entire study guiding it through the various e-learning models. These e-learning models will then be discussed further, describing the usage of each.

Content items in learner-content interaction will be discussed as well. NLP text extraction will be introduced as a method of text pre-processing in monitoring and reporting learner-content interaction with regards to textual data. A content interaction and monitoring algorithm will be introduced as one of the techniques used in content interaction monitoring. Audio and video content monitoring techniques will be discussed as well as the general content interaction evaluation method.

Finally, the conceptual model of the study will show the clear relationships between the artefact being discussed and the factors to be examined and their desired results.

2.2 Theoretical Foundation

Grant and Osanloo (2014), view a theoretical framework as a blueprint of a particular study where the philosophical, epistemological, methodological, and analytical structure is established. It serves as a guide of the study and informs the researcher of the direction of study. It also constructs a coherent explanation of certain phenomena and relationships.

This study was informed by a number of theories that developed the integral part of its arguments. These theories were discussed below.

2.2.1 Interaction Equivalency Theorem

This theory states that deep and meaningful formal learning is supported as long as one of the three forms of interaction (student–teacher; student-student; student-content) is at a high level. The other two may be offered at minimal levels, or even eliminated, without degrading the educational experience. High levels of more than one of these three modes will likely provide a more satisfying educational experience, though these experiences may not be as cost or time
effective as less interactive learning sequences (Rodríguez & Armellini, 2014, 2015; Xiao, 2017).

This theory is based on a classical study conducted by Anderson in 2003. Modern literature has made attempts of improving and reviewing it with evidence ranging from Rodríguez and Armellini (2015) to Xiao (2017). Both their studies identify the gap addressed by this theory. They state that meaningful learning would occur if any one type of interaction can be maximized and high levels of more than one type of interaction are likely to provide more satisfactory educational experiences. However, Xiao's (2017) study is sceptical about these findings and goes on to address that the substitutivity of either one of the interaction styles does not necessarily guarantee learner satisfaction.

Rodríguez and Armellini (2015), also believe that for online students, different interaction types are not considered to be equivalent or interchangeable. Therefore, all three are important for students’ academic achievement.

Using this theory, the study supposed that high levels of learner-content interaction would provide effective educational experience to the learner. On the same argument, Nieuwoudt's (2018) findings informed this study that increasing learner-content interaction and learner-instructor interaction would have a satisfactory and meaningful learning experience.

2.2.2 Cognitive Theory of Multimedia Learning

This theory is based on three principles as specified by Muhammad (2018). These principles state that learners have separate processing channels for pictures and words, they also have limited capacity of working memory for information processing and lastly, they need appropriate cognitive processing for meaningful learning to occur. The theory originated from conventional studies conducted by Mayer in 2009. Her study hypothesised that external factors affect design of multimedia instructions (Knörzer, Brünken, & Park, 2016).

Schrader and Rapp (2016), views the gap addressed in the theory as valuable in terms of cognitive load when a learner interacts with a static image and written text versus a moving image with narration. These principles indeed inform this study by examining content item dominance. Findings from Jiang, Renandya, and Zhang (2017) indicated that instructional design is affected by how the human mind works and how it processes information presented in a multimedia environment. Those findings positively affected this study through their examination of the various content items.
2.3 Interaction Models in E-Learning

The study of Haron, Natrah Aziz, and Harun (2017), defines interaction as reciprocal communications in which at least two objects and two actions are required. Their study shows how this is crucial to the achievement of goals in e-learning. They further indicate how learning success comes from frequent interactions with key stakeholders of e-learning.

Classically, interaction models originate from two conventional theories namely: Moore’s theory of transactional distance and Anderson’s interaction equivalency theorem. The latter is an enhancement of Moore’s theory (Alhih, Ossiannilsson, & Berigel, 2017). Both theories view interaction in three states namely: learner-learner interaction, learner-content interaction and learner-instructor interaction.

Findings from Alhih, Ossiannilsson, and Berigel's (2017) study indicate how interaction plays a crucial role for educational activities in e-learning mediums. That is because it is a route for success in e-learning courses as well as learners’ motivation. Alamri and Tyler-Wood (2017), reiterates that several online interactive tools, as well as strategies, can easily be used to facilitate interactive debates, computer-based simulations, role-playing activities, case studies, group projects, Internet-based research, experiments, problem-solving scenarios, peer reviews of classwork, online reflective journals or blogs, electronic field trips, guest lecturers, reports, presentations, and discussions.

2.3.1 Learner-Learner Interaction

Haron et al. (2017), views this as a two-way reciprocal communication between two or more learners. In order to be academically successful, online learners need to belong to an interactive community of learners (Nieuwoutd, 2018). Discussion forums form an integral part of this type of interaction online. In the study of Abuhassna and Yahaya (2018), it is implied that this kind of interaction may also appear in the form of group discussion, group projects, etc. It promotes learning via sharing of knowledge and learner collaboration.

On the other hand, live chats and virtual classrooms form important elements that increase learner-learner interaction in synchronous e-learning (Alhih et al., 2017). It is believed that this type of interaction is desirable to learners where the exposure space is big and information provided is credible. To some learners it provides opportunities for participating in more effective learning relationships as well as activities (Haron et al., 2017).
2.3.2 Learner-Instructor Interaction

The study of Alamri and Tyler-Wood (2017) defines learner-instructor interaction as a common method of communication whereby it occurs in either synchronous or asynchronous e-learning. Real time interaction occurs in synchronous e-learning in the form of video streams, audio streams or chats. Whereas discussion boards and emails are used for asynchronous.

Additionally, Abuhassna and Yahaya (2018), believes that this form of interaction may increase learner’s understanding of the course by asking questions related to course exercises. Although, learner-content interaction is seen as a success for the student, it poses an immediate challenge for self-paced learners who according to Nyandara and Lijie (2017), face limited interaction between them and their instructors.

2.3.3 Learner-Content Interaction

The review conducted by Špilka (2015), denotes learner content interaction as a process of intellectually interacting with content therefore resulting to changes in the learner’s understanding, the learner’s perspective, or the cognitive structures of the learner’s mind.

It is arguably said that currently, learners time is consumed in the interaction with educational content. Nieuwoudt’s (2018) argument of learner-content interaction is based on the extent to which it engages these learners.

This study adopted learner-content interaction for the purpose of monitoring every step of interaction that learners engaged with in the content items. Combining this model with interaction equivalency theory, this study was able to carefully connect between learner-content interaction, instructor-learner interaction and multimedia content items.

2.4 Content Items in Learner-Content Interaction

The transformation of e-learning content styles has seen it come from traditional media like books, figures and written material into online readily available interactive forms. As such, this introduction has positively affected learners enabling the delivery of interactive content as well as enabling these learners to adapt to different learning styles (Alsadhan, Alhomod, & Shafi, 2014). Made Rajendra and Made Sudana (2018), echoes that the presence of interactions and interactivity in technology based instructional materials have become synonymous with enhanced learning.
The enrichment of various forms of technologies have affected the different styles and types of learning content. For example, in asynchronous web-based virtual learning environments, interactive content may include text, sound, still images, audio, video, and graphics. Instructors tend to combine either or use them independently (Khamparia & Pandey, 2017). This study examined the three main content items as used in asynchronous e-learning because they were considered important factors in interaction (Alhih et al., 2017).

i. Audio Content Items
According to Cho, Cosimini, and Espinoza (2017), the use of audio recordings in asynchronous learning dates back to early 1968. Their study indicates that audio content is also referred to as audio-podcast in today’s e-learning setup. Audio podcasts have been integrated across the globe by a number of higher education institutions. This has seen the incorporation of both on-campus and e-learning modules (Drew, 2017).

Drew’s (2017) study demonstrates how audio contents affect self-paced learners. They are widely seen as positive learning tools that can have the tangible benefit of bringing instructors and learners together, often across long distances. Ray (2014), introduces the three types of audio content in e-learning as: narration, music and sound effect. Of these three, narration has more effect to the learner.

Narration audio can be elaborative (audio summaries of on-screen text), paraphrasing, verbatim (reading exact words on-screen) and descriptive (audio descriptions of content on-screen). Cho et al.’s (2017) reveals how these content types are used for teaching distant medical learners and practitioners.

ii. Textual Content Items
Textual content can be used as stand-alone or added graphics to appeal and communicate the message to the learner effectively (Mayer, 2017). This content can in the form of PowerPoints, pdf or word documents (Balaji, Al-Mahri, & Malathi, 2016). In the study of Vijayalakshmi, Venkatachalapathy, and Ohmprakash (2017), it is stated that the effectiveness of textual content is measured by the subject of learning.

Some learners tend to remember more when content is presented to them in the form of text and images accompanied with infographics (Kifor, 2017). In the case of web-based e-learning environments, the text and graphics should be kept next to each other on the same screen (Bezhovski & Poorani, 2016).


iii. Video Content Items

Videos are viewed as content items with moving pictures. It may or may not have sound (Vijayalakshmi et al., 2017). According to Mayer (2017), video content may contain: motion graphics e.g. animation accompanied with onscreen text or simulations that include spoken text. Kifor (2017), believes that video-based learning has brought a new dimension in e-learning and allows both the development of practical skills as well as the demonstration or presentation of various phenomena.

The Sage report produced by Carmichael, Reid, and Karpicke (2017), indicates how video content provides great benefits to instructors and learners, stimulating stronger course performance in many contexts, and affecting learners’ motivations, confidence and attitudes positively. The report highlights that long videos can be divided into concise podcast segments for easier understanding of content.

2.5 Content Interaction Monitoring Techniques

In an e-learning environment, monitoring can be termed as the observation on any interaction a learner produces within the learning process (J. Chen, 2016). A study done by Estacio and Raga Jr (2017), shows that interaction monitoring can be done using activity logs produced by an e-learning system. These activities might be enormous and may require data mining for analysis purposes. For web-based e-learning environments, data scrapping and web crawling has been used before to try and capture learner’s and instructor’s actions as they use the e-learning system (Corbi & Burgos, 2014). Chen's (2016), study proves that the effectiveness of a monitoring mechanism is measured by its capability to instantly provide feedback to the instructors and eventually enhance the learners’ engagement in learning activities.

i. Use of Session Data Analytics

Session data analytics is the process of selecting, collecting, analysing, and reporting session data about learners and their interactions with online learning resources to improve teaching and learning (Bodily, Graham, & Bush, 2017). Studies conducted by Estacio and Raga Jr (2017) denote that session data analytics in e-learning environments are used to track learner’s behavioural patterns.

Agnihotri, Aghababian, Mojarad, Riedesel, and Essa (2015), investigates learners’ login behaviour from a web-based e-learning system. Their study shows that the various times of interactivity based on login activity, directly affects their assignment scores. In order for them
to understand these phenomena, their study uses machine learning-based clustering techniques to group learners based on their attempts, scores, and logins.

Web-based session data can also be used to monitor learners’ interaction with content items. For example, studies conducted by Wen and Rose (2014), provided evidence of content interaction by collecting the following session data: (1) Time information, including hour of the day, day period, day of the week and course week. (2) Device used during the current session. The device can be desktop, tablet or mobile. (3) Length of the session. This information was then plotted on an N-gram model to calculate the probability of the occurrence of specific behavioural patterns. Chen's (2016) study also indicates that analytics can be used to collect user behavioural data regarding pausing and resuming videos, and navigating between points during playback.

This study used session data to capture a learner interaction with the course content. This data was used to calculate the percentage of interaction for that given session. Results obtained were directly reported to the respective instructor. Sessions were also used to store the content type that the learners preferred per lesson. This data provided calculations of the dominance of content items.

ii. **Use of Google Web Analytics**

The study of Romanowski and Konak (2016) specifies that Google web analytics is a versatile tool that performs quantitative measures on website traffic. These quantitative data measured is based on user data, session data, traffic sources, platform or device used to access site, page tracking, content grouping, site speed, social interactions, app tracking, event tracking, and many more.

According to Vecchione, Brown, Allen, and Baschnagel (2016), the usefulness of Google analytics is that it displays graphically a user path, from the source, through the various pages, and where along their paths they exited. Google analytics is also able to give real-time event reports (Farney, 2016). Unfortunately, this study did not use Google web analytics for any purposes.

iii. **Use of Experience API (xAPI)**

Experience application programming interface, also known as Tin Can API is used in e-learning to capture data in a consistent format about a learner or group of learners’ activities from many
technologies (Lim, 2015). In xAPI, learning experiences are recorded in a Learning Record Store (LRS).

The study of Wang (2017) indicates that an LRS can be independent or embedded in a Learning Management System. That is demonstrated using the diagram below.

**Figure 1: LRS data flow diagram adapted from Wang (2017)**

Experience APIs work based on statements in the form of “I did this” (noun, verb and object) that are recorded to or retrieved from a Learning Record Store (LRS) (Manso-Vazquez, Caeiro-Rodriguez, & Llamas-Nistal, 2015). It is stated that xAPI statements are JSON based objects comprising of a set of defined elements: UUID, actor, verb, object, context, result, timestamp, extensions, attachments, authority, stored and version.

**Figure 2: xAPI learning activity statement (Nouira, Cheniti-Belcadhi, & Braham, 2018).**

With a few modifications, this study adapted the content reporting format from the xAPI activity statement. Data collected by the content monitoring tool was formatted and reported to the instructor in a more comprehensive format. The proposed NLP was used to scale through textual content that the student interacted with. The sum of words as well as percentage of interaction was sent to the instructor’s dashboard in the form of a table.
2.5.1 Automatic NLP Text Extraction for Content Monitoring

Text extraction is the automatic selection of all words that describe the contents of a document (Hasan & Sanyal, 2017). According to Bharti, Babu, and Pradhan (2017), text extraction is a subset of text mining where large quantities of words are obtained to form high quality information.

A good example, of word/text extraction is in the process of automatic summarization, through which fluent summary is produced while preserving key information content and overall meaning (Allahyari, Pouriyeh, et al., 2017). In order to extract text from a document, it is first broken down into manageable blocks which according to Ajith, Ajay, Prakash, and Ramesh (2017), are structure-independent.

Many text mining algorithms use natural language processing techniques for the purpose of linguistic analysis (Allahyari, Trippe, et al., 2017). These techniques involve the use of text pre-processing. In a study conducted by Lourdusamy and Abraham (2018), it is stated that text pre-processing is the cleaning of text in order to detect and eradicate anomalies.

In this study, tokenization is used as a pre-processing technique to scale through all textual content and segment it into meaningful elements. These elements are constituted of words and symbols. The total elements in one lecture are then counted and saved.

However, the total elements obtained in the document do not give any accurate information about textual interaction. Hence, this study proposes the addition of event-based algorithm triggered by time and user interaction. According to Basin and Klaedtke (2018), events have a distinguishing feature in that they happen at single points.

Supposed that slide index $I$ is contained in total slide indices $T$, in that $I \in T$. And extracted data index $E$ is contained in total extracted data indices $Y$, in that $E \in Y$. Then after every thirty seconds of reading (active content interaction), a click of the button “next” (an event triggered by time and user interaction) sends the previous slide index to the NLP word counter. Thus, $I-1$. The intersection of the slide index with the extracted data index, $I \cap E$, triggers a count of that particular index’s data.

Therefore, total text interaction data, $tD = \sum_{1 \leq I \leq T} (I - 1 \cap E)$
This phenomenon uses Boolean AND logic. This can be verified using a simplified Ludwig Wittgenstein’s logic table as reviewed by Russell (2015). The table states that, using AND logics, two variables p and q will produce a true result, r when both of them are true.

Table 1: Wittgenstein’s AND Logic Truth Table

<table>
<thead>
<tr>
<th>p</th>
<th>Q</th>
<th>r = p ( \land ) q</th>
</tr>
</thead>
<tbody>
<tr>
<td>True</td>
<td>True</td>
<td>True</td>
</tr>
<tr>
<td>True</td>
<td>False</td>
<td>False</td>
</tr>
<tr>
<td>False</td>
<td>True</td>
<td>False</td>
</tr>
<tr>
<td>False</td>
<td>False</td>
<td>False</td>
</tr>
</tbody>
</table>

See chapter 6, for proof of algorithm execution.

2.5.2 Automatic Audio and Video Content Monitoring

In this study, audio and video content monitoring were treated using the same approach. The study used video JavaScript library developed by Brightcove (2015), under the Apache open-source licence.

Amongst the many capabilities, the library has a timeupdate event listener that is able to capture seeking time and parallelly compare it to the current system clock. This principle collected the actual audio and video interaction time. It also borrowed the Boolean logic described in table 1 above.

2.6 Evaluating Learner-Content Interaction

According to Rodriguez (2014), learner-content interaction is gauged through surveys that are issued to the learner at the end of the course. These surveys measure level of effectiveness of the course. Others measure time spent during learner-content interaction against their performance in that particular course. A phenomenon referred to as evaluation of the impact of interaction in instructional contexts (Einfeld, 2014).

The approach taken by this study in evaluating learner-content interaction is statistical due to the nature of content items and the use of machine learning. Therefore, a formula has been suggested to help in calculating percentage of interaction in all the content items. A keen point to note is that the content monitoring tool collects session-based data in real time usage.
Supposed a one-time session is denoted by $S_1$ and the consequent session denoted by $S_2$, then we can say that the $n^{th}$ session is denoted by $S_n$, where $n$ is an arbitrary number. In order to calculate the percentage of interaction in one session, we define number of units of interaction (either words read in textual content or minutes watched in video and or heard in audio content) as $C_{during}$. Whereas, the total number of units of interaction in the particular content as $C_{total}$.

Percentage of interaction in session $S_1$, will be $\% S_1 = 100 \times \left( \frac{C_{during}}{C_{total}} \right)$ therefore, the $n^{th}$ session $S_n$, will be $\% S_n = 100 \times \left( \frac{C_{during}}{C_{total}} \right)$. To calculate the total percentage of interaction over time on the same content in different sessions, we will say that, $\%_{total} = \sum_{i=1}^{n} \% S_i$.

The assumptions made for this formula were that:

i. The learner interacts with content but does not finish it in one session.
ii. The learner interacts with the same content twice or more and every time the formula updates to latest results.
iii. If the learner interacts with the content once and are able to finish the one-time session interaction percentage is reported.

2.7 Conceptual Model

![Conceptual Model](Author's own illustration)
The conceptual model above shows the relationship between learner-content interaction and the content monitoring tool. Each content item is linked to its respective monitor and together, they produce the end results. In this case, level of interaction and dominance of content. Asynchronous virtual environment has been used to represent the web-based platform.

2.8 Summary

This chapter presented two theories that guided the literature of the study. The theories indicated the use of multimedia content in asynchronous e-learning as well as their effect of learner-content interaction. The various interaction models discussed showed their relationships with the theories.

Three content items were discussed in this study. A text monitoring algorithm was also suggested as well as a JavaScript library that would help in audio and video monitoring. Lastly, a session-wise content interaction formula was recognized in this chapter as well as the conceptual model for the study.
CHAPTER 3: METHODOLOGY

3.1 Introduction

A methodology provides a piece of research with its philosophy, the values and assumptions which drive the rationale for the investigation as well as the standards that will be utilized for the interpretation information and the drawing of conclusions (Almalki, 2016).

This chapter introduces the nature of the research and how data is collected. The chapter also goes into details of the population and samples that will be used in the research as well as the methods of data collection. The study design is elaborated well and analysis methods discussed.

3.2 Research Design

According to Creswell (2014), a research design leans on the types of inquiry within qualitative, quantitative, and mixed methods approaches that provide specific direction for procedures in a research study.

This study is a design science research that focuses on developing a software system, for the purposes of collecting data and testing the objectives. It is open to a variety of processes and it may be the least concerned with design process rigor (Peffers, Tuunanen, & Niehaves, 2018).

Iivari and Kuutti (2017), argue that different literature works have proven that design science research is two-way, in that, it is expected to generate valuable knowledge for a particular cause as well as serve a particular practitioner. This study creates an e-learning artefact that is capable of serving a particular cause in institutions of higher learning as well as being a model for generating knowledge.
3.3 Research Process

![Research process diagram]

**Figure 4: Research process (Author's own illustration)**

This flow diagram illustrates the process of research that is undertaken in this study. It begins with problem definition. Then objectives of this study are aligned with the problem at hand. These objectives together, form the literature of the study that helps in gap analysis as well as benchmarking based on what has been done before. The gap identified in this study was the core business in development of the artefact. This artefact collected data that was analysed and interpreted therefore providing a base for discussions.

3.4 Population and Sampling Design

3.4.1 Population

Rahi (2017) defines population as all people or items that one wishes to understand. In this study, the population consisted of United States International University - Africa students. The reason for picking university student population is because they were directly affected by the tool because it was assumed that they use e-learning on a daily basis, as well as their availability.

3.4.2 Sampling Design

Sampling is the process of selecting a statistically representative sample of individuals from the population of interest (Majid, 2018). His study believes that sampling is important in selecting participants because not everyone can be included from the population of interest. Sampling is directly influenced by the sample frame (Etikan & Bala, 2017). This is further discussed below.
3.4.2.1 Sampling Frame

Martínez-Mesa, González-Chica, Duquia, Bonamigo, and Bastos (2016) define sample frame as the group of individuals that can be selected from the target population given the sampling process used in the study. This study was keen on the following group of students: freshmen, sophomores, juniors, and seniors. They formed the integral part of the population and stood equal chances of being picked by the sampling technique.

3.4.2.2 Sampling Technique

Sampling technique is the identification of the specific process by which entities of a sample frame are to be selected (Majid, 2018). Taherdoost (2016), indicates that sampling techniques can be divided into two types: probability (random) sampling and non-probability (non-random) sampling.

There are three characteristics that make probability sampling distinctive. These are: Randomness of selecting objects from the sample frame, each potential sampling unit has a known probability of being selected for the sample and lastly, is possible to identify all potential samples of a given size that can be drawn from the population before the actual selection process starts (Sarstedt, Bengart, Shaltoni, & Lehmann, 2018).

Contrary to probability sampling, non-probability sampling does not use randomization in selecting a sample from the population of interest (Etikan, 2016).

Figure 5: Basic Sampling Techniques (Sarstedt et al., 2018)
This study uses simple random sampling where the sample is picked at random from the population. They stand an equal chance of being picked (Etikan & Bala, 2017). This also provides unbiasedness (Majid, 2018).

3.4.2.3 Sample Size

Majid (2018) views sample size as a way of choosing the number of statistical representative sample from the population such that the inferences and study findings from the sample represent real associations in that population.

This study follows the formula used in Taherdoost's (2017a) study which is shown below.

\[
n = \frac{P(100−P)Z^2}{E^2}, \text{ Where: } n \text{ is the required sample size,}
\]

\[P\] is the percentage occurrence of a state or condition (50%),

\[E\] is the percentage maximum error required (5%)

\[Z\] is the value corresponding to level of confidence required (for confidence level 95% \(Z\) value is 1.96)

Therefore, value \(n\) is shown on the distribution table below.

Table 2: Sample size based on desired accuracy with confidence level 95% as extracted from Taherdoost (2017a)
This study will use a sample size of fifty students.

### 3.5 Data Collection Methods

According to Paradis, O’Brien, Nimmon, Bandiera, and Martimianakis (2016), data collection methods are important, because the information collected is used in explanations and analysis of the methodology by the researcher. There are two types of data collection methods namely: primary and secondary. Primary data collection is first hand and direct while in secondary data collection, data is obtained from other sources that are informed by the primary data (Kita, 2018).

In this study, data was primarily collected through a controlled lab experiment. The data instrument was the tool itself.

### 3.6 Research Procedures

Human lab experiments have become an established method for gathering behavioural, perception, and even neurophysiological data from users interacting with information technology (IT) in a controlled environment (Jung, Adam, Dorner, & Hariharan, 2017). The research procedures involved in this step by step study are discussed below.
i. **Experimental setup**

Before the procedure began, the experiment was setup and the environment prepared. In this case, the artefact was installed on a cloud server and user (both students and instructor) accounts were created too. On the same, the student accounts were linked to various course content where content was to be uploaded. The learning content was prepared and uploaded in the respective instructor modules.

Additionally, a username and password matrix was kept in order to avoid repetition of login credentials and maintain authentication integrity.

ii. **Briefing and consent**

The artefact generated basic terms and conditions that were required to make the participants understand the experiment. Where necessary, oral elaboration was done. Once the participants read and understood these terms, they were prompted to accept them.

It is important to note that participation was voluntary and anyone could opt out of the experiment before it began.

iii. **Participants instructions**

Once the participants agreed to the terms set forward by the experiment, they were taken on a step by step instructions as to how they were supposed to use the artefact and what was expected of them. Having in mind that the experiment was controlled, the participants were required to act on their normal behaviour as though they were interacting with content on the virtual learning environment.

They were also briefed that the content provided in the artefact was generic and would not in any way test their knowledge on a particular academic subject. That avoided knowledge biasedness therefore allowing any student to participate. Other instructions included,

a) When they joined a particular course in the artefact, they would be required to select the desired content item. There were four lessons each having three content items to choose from.

b) They were supposed to interact with all the courses’ four lessons as they usually did in their normal study states. i.e. according to their desired mode of studying.
iv. Participation period

The whole experiment took thirty minutes per session i.e. One-time login only. Within the thirty minutes all the fifty students interacted with all the four lessons.

v. Debriefing

After exercise, the participants were debriefed and awarded with snacks for motivation.

vi. Data extraction and analysis

Once all the participants were done conducting the experiments, data in the form of weekly reports was collected from the respective instructor module, extracted and stored for analysis purposes.

3.7 Data Analysis Methods

Kita (2018), defines data analysis as the process of transforming raw data into usable information. This study will use data obtained from the artefact to show dominance of interaction between the three content items. It will also show level of interaction in all the three content types.

The data obtained was plotted on Microsoft Excel for statistical analysis. Graphs were used to show the analysed information.

3.8 Chapter Summary

This chapter presented research design, the target population, sampling techniques, sampling frame as well as the sampling size. A design science approach was used and the research process shown. A controlled lab experiment approach was deployed in order to collect data.

This chapter proposed a sample size of fifty students for the purpose of a controlled lab experiment. It also proposed four lessons in one course in order to collect substantial analysis data. The chapter showed how the experiment was conducted, clearly stating how each step was done.
CHAPTER 4: DESIGN & IMPLEMENTATION

4.1 Introduction

This chapter presents requirement elicitation by identifying functional and non-functional requirements. These requirements are then grouped and analysed according to their similarities. The analysed requirements are later represented using UML models.

Kruchten’s 4+1 view model of software architecture is also introduced and the various views discussed in-depth. The data model of the artefact has also been illustrated in a UML diagram and used to explain data connections and communications across the artefact.

Lastly, the system architecture, the technology used for the implementation of this artefact as well as the testing techniques will be discussed. Proof of concept will be illustrated using web screenshots.

4.2 System Requirements

System requirements involves a careful study of existing systems either manual or computerized, in order to help in the development of a proposed system (Valacich & George, 2017). It is derived from requirements engineering, which is a branch of software engineering (Pacheco, Garcia, & Reyes, 2018).

Wu, Pa, Abdullah, Rahman, and Tee’s (2016) study indicates that this rigorous process involves four phases, namely requirements elicitation, requirements documentation, requirements validation and verification, and requirements management. Raw requirements from various viewpoints constitute the elicitation phase, whereas requirements analysis include examining high level requirements.

There are several existing e-learning applications where this artefact draws some inventiveness from. These are Blackboard (Blackboard, 2018), Moodle (Moodle, 2018) and OpenEdx (OpenEdx, 2018). Details of the artefact’s requirements are discussed below.

4.2.1 Functional Requirements

Functional requirements point towards the product services (Sunner & Bajaj, 2016). They also specify particular functionalities to be performed by the proposed software application (Khan &
Khan, 2017). These definitions are termed as system behaviours (Vermeulen & Ravesteyn, 2017).

Valacich and George (2017), define functionality as the tasks a software application can perform as well as the compulsory, critical and anticipated system features.

The artefact proposed in this study was a minimal viable product that mimicked a web-based Virtual Learning Environment. Details are discussed on the table below.

**Table 3: System Functional Requirements**

<table>
<thead>
<tr>
<th>Category</th>
<th>Functional requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration</td>
<td>1. The system should have a super admin user.</td>
</tr>
<tr>
<td></td>
<td>2. The super admin should be able to create user i.e. students and instructors.</td>
</tr>
<tr>
<td></td>
<td>3. The super admin should be able to create courses i.e. course and description.</td>
</tr>
<tr>
<td></td>
<td>4. The super admin should be able to link these users with their respective courses.</td>
</tr>
<tr>
<td>Authentication and authorization</td>
<td>1. The system should support basic authentication using username (Email) and password.</td>
</tr>
<tr>
<td></td>
<td>2. The system should be able to distinguish between users i.e. instructor and student upon login.</td>
</tr>
<tr>
<td>Content</td>
<td>1. The system should allow the instructor to create virtual course content and publish them.</td>
</tr>
<tr>
<td></td>
<td>2. The system should allow grouping of related course content.</td>
</tr>
<tr>
<td>Communication</td>
<td>The system should be able to provide for asynchronous connection between the user requests and the database responses.</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Data</td>
<td>The system should be able to upload content in multiple data versions. i.e. pdf, mp3 and mp4.</td>
</tr>
<tr>
<td>Report generation</td>
<td>3. The system should allow registered students to access content respectively.</td>
</tr>
<tr>
<td></td>
<td>1. The system should be able to provide user reports based on weekly lessons.</td>
</tr>
<tr>
<td></td>
<td>2. The system should generate content interaction reports based on percentage of interaction (for all the content types), time spent (for video and audio content), number of words read (for textual content).</td>
</tr>
<tr>
<td></td>
<td>3. The system should be able to provide data analytics based on content type.</td>
</tr>
</tbody>
</table>

Table 3 above shows the functional requirements that were proposed during the initial project setup.

**4.2.2 Non-Functional Requirements**

Non-functional requirements define the required properties of any software as they are essential conditions to be met for functional requirements to get implemented and used properly (Gupta, Lohia, Çetinkaya, & Kim, 2017). They are emergent because they depict the principles under which the system works (Sunner & Bajaj, 2016; Vermeulen & Ravesteyn, 2017).

This study adapted some of the agile non-functional software quality model as suggested by Younas, Jawawi, Ghani, and Kazmi (2017) as seen in figure 6 below. These qualities include: device portability, modifiability and accessibility.
4.3 Modelling and Design

Modelling and design occurs immediately after system requirement analysis, and it is used to represent both logical and physical system specifications (Valacich & George, 2017). Usually system design decides how the system will function, in-terms of the hardware, software, and network infrastructure. It also generates the user interface, forms, and reports, as well as the precise programs, databases, and files that will be required (Cosmas, Christiana, Jeremiah, & Ikechukwu, 2018).

4.3.1 Data Model

According to Lungu and Mihalache (2016), data modeling defines and analyses data requirements needed in business processes deployed in companies. In order for data to be used for referencing purposes, it has to be stored. The developed artefact, used a NoSQL database.
The data model below was used to describe the various data paths and communications that were used in the artefact. There were five key contexts that interacted directly or indirectly with various data stores in the database. Login and user management interacted with users’ data store to fetch and store user data while it also extended sessions to the session data store. These sessions were required for the content interaction report.

![Data Model](image)

**Figure 7: Data Model (Author's Illustration)**

Course management and content management, required courses data store to facilitate creation of courses as well as their content. Content interaction required session data store in order to log active user sessions as well as get stored user sessions. It also fetched and pushed data to the content interaction report datastore.

Additionally, course datastore connected to a remote CDN (Cloud Delivery Network) for the purpose of referencing to the right course material as uploaded by the instructor.

### 4.3.2 System Model

System modeling is presented using Unified Modeling Language (Zheng, Feng, & Zhao, 2014). According to Kim (2018), a UML provides the expressive notations for diagrams so that it
denotes the different viewpoints of a target system. In order to model and design the various viewpoints of the artefact, this study adapts Kruchten’s 4+1 architectural view (Imran, Alghamdi, & Ahmad, 2016).

According to Singh, Chaurasia, and Gaikwad (2016), the 4+1 architectural view consists of logical view, development view, process view, physical view and scenario view. This is represented by the model below.

![Kruchten 4+1 view model](image)

**Figure 8: Kruchten 4+1 view model (S. Singh et al., 2016)**

Additionally, this study discussed the data model of the artefact.

### 4.3.2.1. Scenario View

According to Makkar and Sikka (2017), a scenario view connects all the four views (logical, development, process and physical view) to represent the main functionalities of a system. This is depicted using a use case diagram (S. Singh et al., 2016). Use case diagrams are used to model the interaction between the system and the actors (Kurniawan, 2014).

The diagram below represents a use case for the developed artefact. The main actors were identified as admin, instructor, student and NLP tool. For any of the actors to use the system, they must be authenticated by the login use case (a pre-condition).
The admin actor interacted with the manage users use case which included features of creating users (students and instructors). The same actor could also manage course by creating the course and linking the users to their respective course. All other actors were dependent to this action.

The instructor actor interacted with the use case manage learning content, which provided them with creation of audio, text and video content. It also provided interaction report use case, which was a dependent use case.

The student actor interacted with the use content use case, which provided them with content created by the instructor. They could choose any one of the content items provided. This use case was linked to interaction generation use case which was a “background” monitoring feature in the system. Text interaction monitoring was done actively but separately by use of the NLP tool actor on the background.
Singh et al. (2016) define logical view as an abstraction that illustrates the functional requirements of the system by modeling. It is documented using data structure and functional structure dimensions (Omrani, Faraahi, & Robatmili, 2015). It consists of classes, interfaces and collaborations. UML provides class diagrams as well as object diagrams to support this (Makkar & Sikka, 2017). This study used a class diagram to illustrate the artefact’s functional requirements using object-oriented techniques.

Figure 10: Class Diagram and Key (Author’s illustration)
The class diagram illustrated above consists of classes, attributes, operations (methods) and the relationships between them. It is noted that the user class generalizes its attributes to the three subclasses namely, SuperAdmin, Student and Instructor. Additionally, these subclasses form their own unique operations. A session class is also formed to capture session-based attributes for each student upon login.

It is also shown that, there is a composition relationship whereby, all attributes of the class ContentInteraction cannot survive by their own without the class Course. This class formed the integral part of content interaction monitoring.

Lastly, multiplicity between the classes was shown in order to elaborate the number of objects of each class that took part in the general relationship. The key was used as a legend to guide in the interpretation process of the diagram.

4.3.2.3. Development View

According to Omrani et al. (2015), a development view is used to describe the architecture that supports software development. It is guided by code-line structures and their dependencies. Makkar and Sikka (2017) elaborates that component diagrams are used to support development view.

Component diagrams represent the interactions of services, their interfaces, and any dependencies between system components (Anjum & Budgen, 2017). They give information about these interfaces as offered by the services. The component diagram used in this study showed the artefact’s required interfaces as shown on the illustration below.

The initial interface was a web login client that allowed users to access their specific dashboard upon login. The admin dashboard provided user and course access layers respectively, where CRUD (Create, Read, Update, Delete) operations took place by the help of the CRUD services.

On the other hand, the instructor’s dashboard was able to provide them with the course access layer specifically the course content creator. In this component they were able to create content in three forms namely, audio, video and text. They were also offered with a content reporting layer where student-content interaction was viewed. This content reporting layer was provided services to by the course access layer.
Lastly, the web login client provided students with a dashboard that gave access to the course and course content. The student chose the course content item they liked to use. Through the usage of these course content items, is where content interaction monitoring took place. A component diagram key was also provided in the diagram in order to guide in the interpretation process.

Figure 11: Component Diagram and Key (Author's Illustration)

4.3.2.4. Process View

The study conducted by Makkar and Sikka (2017) indicates that a process view is used to show the flow of a program. Therefore, all the elements used in both logical and development view are considered in order to support this perspective. In process view, the behaviour of the system
is modelled rather than the structure. This is represented using activity diagrams (S. Singh et al., 2016).

The activity diagram below was modelled to show a workflow-oriented perspective by capturing both functional and behavioural aspects (Anjum & Budgen, 2017). The various modular behaviours were depicted in the diagram whereby, activities, states and their transitions were observed.

The activity initial node was used to mark the beginning of the whole process. The decision point was used to distinguish between the admin and the other users upon login. To define the level of users, swimlanes were used; each having their own activities.

The relationship between one swimlane and another was connected using object flow connectors. The admin swimlane contained user and course management activities which were broken down to creation and editing respectively. Activity forks were been used to split and join communication paths.

In order for the student and the instructor to access a course they ought to be linked to it by the admin as shown in the diagram. The student accessed courses per week as created by the instructor and was able to use the content. From the diagram it was shown that the student could choose a content path which in-turn captured content interaction.

Figure 12: Activity Diagram and Key (Author's Illustration)
In order to capture the textual content per page, a wait time of thirty seconds was applied to avoid seeking (fast forwarding). The same (seeking) applied to the video and audio content. The instructor was able to view a report of the captured content interaction through object connectors.

### 4.3.2.5. Physical View

A physical view represents the distribution framework of software components on the physical nodes, computer or processor to be used. It uses deployment diagrams to describe these structural elements (Kurniawan, 2014). Omrani et al. (2015), argues that a deployment diagram is used to express the non-functional requirements of the system. The deployment diagram below illustrates the execution environments of the various hardware and software needed to support the artefact.

![Deployment Diagram](image)

**Figure 13: Deployment Diagram and Key (Author's Illustration)**

In order for the artefact to work, a personal computer with a web browser was required. The channels of communication to and from the web server were http requests and responses. The web server, was embedded in the Google Cloud Platform (Google, 2018). This platform has a number of features favourable to the artefact which was discussed in-depth in section 4.6 below.
Docker containers were used to containerize the application frontend and backend for maintenance purposes as well as scalability. The database used in the artefact was firebase due to its real-time NoSQL nature of data distribution and storage (Khedkar & Thube, 2017). Content Delivery Network, CDN, was required to save the course content in their material form.

When a http request came from the end user, it first went to the application image where it was routed to the database; this phenomenon in-turn gave a JSON response. The JSON data was required for text analysis by the NLP word counting tool before reporting back to the user (instructor) via Restful response. The Python text processor saved this information in a PostgreSQL through object relation mappers, ORMs, found in Python Django.

4.4 Testing

Ghuman (2014) defines software testing as a process of establishing the quality of software developed by identifying and eliminating errors. It is a crucial process in the software development life cycle whereby system requirements and system components are exercised and evaluated manually or automatically with the aim of satisfying them (Hooda & Chhillar, 2015).

The testing type adapted in this study include functional and performance testing.

4.4.1 Functional Testing

Functional testing is conducted to check whether the software developed meets the end user requirements (Mahajan & Pune, 2016). This is done in various stages of software development. This study developed a manual test case for unit testing, integration testing and system testing as guided by Hooda and Chhiller's (2015) research.
<table>
<thead>
<tr>
<th>Module Name</th>
<th>Test Description</th>
<th>Tester</th>
<th>Anticipated Results</th>
<th>Actual Results</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Login</td>
<td>Testing whether all users can login with provided credentials</td>
<td>Author</td>
<td>Admin, Instructor and Student users are able to login successfully.</td>
<td>All were able to login successfully.</td>
<td>✓ Complete</td>
</tr>
<tr>
<td>Admin User Management</td>
<td>Testing whether the admin can create users (Instructors and Students) respectively</td>
<td>Author</td>
<td>Successful creation of users.</td>
<td>User creation was successful for both types of users.</td>
<td>✓ Complete</td>
</tr>
<tr>
<td>Admin Course Management</td>
<td>Testing whether the admin can create courses.</td>
<td>Author</td>
<td>Admin is able to create course ID and course description.</td>
<td>Course creation was successful.</td>
<td>✓ Complete</td>
</tr>
<tr>
<td>Linking Users to Course through web interface</td>
<td>Testing whether users (Instructors and Students) are linked to their respective courses.</td>
<td>Author</td>
<td>User linkage to course is successful.</td>
<td>Linkage of users to course was successful.</td>
<td>✓ Complete</td>
</tr>
<tr>
<td>Instructor Content Management</td>
<td>Testing whether the instructor is able to create course weeks and upload content in three types namely: Audio, Text and Video</td>
<td>Author</td>
<td>Course week creation and uploading of audio, text (PDF) and video is successful.</td>
<td>Course creation and content upload was successful.</td>
<td>✓ Complete</td>
</tr>
<tr>
<td>Student course selection and</td>
<td>Testing whether student is able to select</td>
<td>Author</td>
<td>Student is able to navigate to course week</td>
<td>Successful course week selection</td>
<td>✓ Complete</td>
</tr>
</tbody>
</table>
Table 4 above, indicates the functional tests that were conducted during development of the artefact.

### 4.4.2 Performance Testing

According to Hooda and Chhillar's (2015), performance testing is done to ascertain different non-functional requirements. It consists of Load, Spike, Stress, Soak and configuration testing (Ghuman, 2014). This study adapted client platform configuration testing. The other types of performance testing were not done due to time constraints in the project.
Figure 14: Performance Testing done at https://app.loadimpact.com

The above results were adapted from Load Impact (LoadImpact, 2018), a website that gives free performance status of web applications. Based on these results, the artefact performed well in terms of request - response times. Using twenty-two virtual users, the artefact gave results at a rate of fifty requests per seconds.

That indicated that the configurations were done properly and could satisfy the sample size with ease, without the pages loading for more than one second.

4.5 Proof of Concept

4.5.1 Admin Concept

The admin concept was meant to manage system wide administration. The artefact in this study provided basic features for the admin. More features can be added in a later version.
Figure 15: Admin Course Management

The figure above (Figure 15) shows the admin course management view whereby, the administrator of the system could create courses using their course code and description. This facilitated a smooth creation of courses as viewed by both instructors and students.

Figure 16: Admin Add User

The administrator of the system could also create other users of the system based on their roles. This was seen on the illustration above (Figure 16) where a user role was either instructor or student.

Figure 17: Admin User Management
A basic table of created users could be viewed by the administrator. For this artefact, the administrator of the system did not have much capabilities because the focus of the study was on the instructor and student user respectively.

4.5.2 Instructor Concept

The instructor concept was meant to manage course content as well as view student content interaction reports.

![Figure 18: Instructor Course View](image)

The illustration above (Figure 18) showed the view where the instructor had been enrolled to a particular course. It also showed the number of students who were enrolled in that course.

![Figure 19: Instructor Week View](image)

Figure 19 above is an illustration of the course the instructor was enrolled to in depth. For example, there were four weeks in the above course.
Figure 20: Instructor Weekly Content Upload

Figure 20 shows weekly content that was required for upload. And in this case three content items were needed for upload. These are audio, text and video.

Figure 21: Instructor Audio Upload View

Figure 21 illustrates the first content upload. When the instructor clicked the audio upload button, it took them to this view where they were required to upload an audio file.

Figure 22: Instructor Text Upload View
Figure 22 illustrates text file upload. Here the instructor could upload text files that were viewed by the respective students, who had enrolled in that class.

Figure 23: Instructor Video Upload View

Figure 23 illustrates video upload. Video files were uploaded from this view.

Figure 24: Instructor Reports View

Lastly, the instructor was able to see interaction reports. This was very important because the artefact provided filtering of interaction based on weeks. Which allowed for analysis of interaction data as well as content dominance.
4.5.3 Student Concept

Student concept was illustrated to show how the student viewed information from their end of the artefact. The figures below show this phenomenon. It is important to note that student interaction data was collected per session.

The use of sessions was elaborated in section 2.6 of the literature where it showed how the data was collected per student.

![Student Login View](image1.png)

**Figure 25: Student Login View**

Figure 25 above shows the initial view that the student saw once they accessed the URL.

![Student Course List View](image2.png)

**Figure 26: Student Course List View**

Figure 26, shows the course that the student was enrolled on.
Figure 27: Student Course Weeks View

Figure 27 illustrates the view of the course in-depth by showing the number of weeks that were there in that course.

Figure 28: Student Course Weekly View

Figure 28 shows the view that the student saw when they further explored the course weeks. Each week had three content types where, the student was allowed only to choose one. Upon clicking any one of the three buttons, the other two were automatically disabled. This allowed collection of proper content types.

Figure 29: Student Audio Content View
Figure 29 illustrates the audio view, where the student could listen to the audio version of the course. In this particular view, they could not fast forward the lesson. However, they were allowed to pause or rewind where they did not understand. Upon rewinding, the audio player could resume up-to the initial listening time.

![Image of audio view]

**Figure 30: Student Text Content View**

Figure 30 shows the text content view. This was in the form of a slider that played content page per page. In this view, the student was allowed to play the slides back but could not fast forward them. Hence, the missing **next** button. The principle used in this phenomenon was illustrated in the activity UML diagram where the next button appeared after thirty seconds and disappeared on the **click** event. This facilitated some time for the student to have read that particular slide. It also allowed for validity of the algorithm proposed in section 2.5.1 of the literature review.

![Image of text content view]

**Figure 31: Student Video Content View**

Lastly, figure 31 above illustrates the video content view. This view had the same characteristics as the audio view.
4.6 System Architecture

A system architecture influences the extent to which a system achieves its functional and quality requirements (Tofan, Galster, Avgeriou, & Schuitema, 2014). It is mentioned that architectural decisions are derived from design decisions.

This study adapted a three-tier system architecture which according to Nasim (2014), is the physical separation of system components. These components were: system admin, instructor and student. The architecture was also made of web services that were accessed via request response modes.

The use of a three-tier architecture enabled the encapsulation of the various components in the artefact. The artefact used cloud-based web services to allow access to and from the application as well as the database. Figure 32 below shows this phenomenon.

![System Architecture](image)

Figure 32: System Architecture (Author's Illustration)

4.6.1 Implemented Technologies

4.6.1.1 ReactJS

Anurag Kumar and Singh (2016) defines React as an open-source UI library developed and maintained by Facebook to facilitate the creation of interactive, stateful & reusable UI components. These components form the view layer. One of the advantages of using ReactJS is that it utilizes virtual DOM-based mechanisms (Accomazzo, Lerner, Murray, Allsopp, & Mcginnis, 2018).
Through the listing of elements and their attributes as objects and properties, virtual DOM only allowed changes of the individual DOM elements instead of reloading complete DOM every time. This in-turn provided flexibility and speed of rendering the artefact’s views.

4.6.1.2 HTML5

HTML5 is a later version of the original Hyper Text Markup Language, which according to Baker (2014) is the basic building block of Web sites since the Web’s inception. The artefact developed in this study made use of HTML5’s support for multimedia content through APIs. HTML5 is a semantic language with new elements which offer more specificity (Walker-headon, 2016).

4.6.1.3 CSS3

CSS3 is used to control the layout of Web pages separately from page content (Walker-headon, 2016). It is a styling agent that when combined with HTML5 provides beautiful UI (Baker, 2014). CSS3 was used to style the rendered HTML in the artefact.

4.6.1.4 Node JS

According to Shah and Soomro (2017), Node JS is a server-side JavaScript-based language which is lightweight in nature and fulfils frontend demands through event-driven and non-blocking I/O models. It is also open source under the MIT License.

It uses single threaded event loop architecture that handles multiple concurrent clients (Posa, 2018). Node JS is good for asynchronous web communication. The artefact in this study, used Node JS as a backend server to handle rendering of web pages.

Node JS is designed for heavy applications with intensive logical calculations on the backend side. It can also be deployed with a number of databases i.e. SQL-based, NoSQL-based and JSON-based (Bangare, Gupta, Dalal, & Inamdar, 2016).

4.6.1.5 Python

Python is a multipurpose interpreter programming language developed as an open source project by Guido Van Rossum in 1989 (Mészároslová, 2015). It supports OOP, procedural as well as functional programming.
Its syntaxes are related to natural human language and are therefore, easy to use and understand. There are two versions of python namely python 2 and python 3 that are currently being supported (Kohn, 2017).

This study used python 3 due to its standard libraries that support Natural language processing in the form of text pre-processing. It is a portable high level language that supports machine learning (Srinath, 2017). The python API extracted contents from the slides using PYPDF libraries.

4.6.1.6 Firebase

According to Valokafor (2017), Firebase is a cloud-based real-time NoSQL database. It works with application listeners to find real-time data on the cloud. Generally, NoSQL databases emphasize on analytical processing of large-scale datasets in warehouses, offering enlarged measurability over product hardware and servers (Lahudkar, Sawale, Deshmane, & Bharambe, 2018).

The artefact developed in this study, utilized key-value store in Firebase database. This was made possible by the creation of simple standalone tables that were uniquely identified by the use of UUID. Through the providence of an API that allows developers to store and sync data across multiple clients (H. S. Singh & Singh, 2017), Firebase made it easier for storage and manipulation of retrieved textual content (interaction) in the artefact. This data is converted to JSON text processing.

4.6.1.7 Docker Containers

In an article published on Digital Ocean, Ellingwood (2015) argues that, docker containerization is used to solve issues of program dependencies, scalability as well as program component updates. Different programs respond differently in their respective deployment environments. In order to harmonize this issue and scale the program horizontally, containerization is used (G. Chen, 2018).

4.6.1.8 Content CDN

Cloudflare (2018), defines content delivery network as group of servers that are geographically distributed with an effort to provide fast internet content. CDNs improve load times on websites,
they provide content at all times through their redundancy and lastly, they reduce bandwidth costs through caching.

This study used content CDN to store and deliver course content at all times. Connection of these contents to the artefact was through RESTful API.

4.7 Chapter Summary

This chapter presented the various requirements for the artefact in order for it to work. Both functional and non-functional requirements were articulated. System design and modelling was done by use of UML diagrams following the 4+1 view model.

Implementation of the artefact was done using JavaScript based frontend and backend. Both React and Node JS were discussed. The tool used for natural language processing was produced by use of python 3 programming language due to its robustness and ease of use as well as vast text processing libraries. Firebase real-time database was discussed and the connection it has to the artefact.

Two test cases were designed to conduct unit, system and client performance testing during and after development to ensure quality of the artefact in its minimal viable state. Finally, the proof of concept showed that the artefact developed worked as intended.
CHAPTER 5: RESULTS AND FINDINGS

5.1 Introduction

This chapter provides the results and analysis obtained from the lab experiment as elaborated in chapter 3. A sample size of 50 random students (undergraduate) participated in four lessons and provided a dataset of 200. All the respondents were genuine to their study habits as they undertook the experiment.

Interpretation of the data was done based on specific objective three which evaluated the level of learner-content interaction as well as dominance of content items. Tables, charts and graphs were used to analyse the data.

However, in order to understand and analyse the results, descriptive statistics was undertaken, clearly elaborating the measure of their central tendencies.

5.2 General Information

The lab experiment was conducted unbiasedly across all the 50 students. With the help of the lab technician students were allocated their login credentials and explained thereafter on what was expected of them.

The general studying behaviours of the students (population under study) was emphasized so as to facilitate efficient collection of data. Short micro economics courses were prepared from the MIT open courseware. This is because the course is a general core course that is done by nearly all the students in the population (USIU – Africa).

All the students participated in the exercise from beginning to end after which, they signed out. Data integrity was maintained by collecting it in real time firebase database that required Google login credentials with 2FA.

5.2.1 Level of Learner-Content Interaction

5.2.1.1 Video Content Interaction

i. Week 1 results

Table 5, shows the levels of learner-video interaction as it was recorded in week 1 of the course. The table shows the course UID which was unique, it also shows the student UID, the week, time spent on the video out of the total time. This calculated the interaction percentage using the
percentage formulae illustrated in the literature section 2.6. \[ \text{Interaction} = \left( \frac{C_{\text{during}}}{C_{\text{total}}} \right) \times 100. \]

Week 1 video had 34 minutes of play.

Table 5: Video Content Interaction Report - Week 1

<table>
<thead>
<tr>
<th>courseUid</th>
<th>format</th>
<th>studentUid</th>
<th>week</th>
<th>Time Spent</th>
<th>Out Of</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST101</td>
<td>video</td>
<td>5BcEYKuxn3aokuQ2njNm5L5Mrunl2</td>
<td>week1</td>
<td>7.14</td>
<td>34</td>
<td>21</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>FDoz0uyoJTIkJG09TI7XJiWYfb0IL3</td>
<td>week1</td>
<td>10.88</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>0SDAUeqjy713WtxOZ1UZTMn HF3</td>
<td>week1</td>
<td>0.34</td>
<td>34</td>
<td>1</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>rajgRoE78fgyWW2zMDFOV20jdl1</td>
<td>week1</td>
<td>2.72</td>
<td>34</td>
<td>8</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>60lbMimVXhmQYBBTzUFxyzH43D2</td>
<td>week1</td>
<td>8.16</td>
<td>34</td>
<td>24</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>HsbzL7938Xgo0XPCyHPaVW440e2</td>
<td>week1</td>
<td>10.2</td>
<td>34</td>
<td>30</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>vocWS0989Y9QOsIp4je1MF3Bc5z1</td>
<td>week1</td>
<td>4.08</td>
<td>34</td>
<td>12</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>5wtC3J7xqSGkPTzXk3m3DoxDzdJ3</td>
<td>week1</td>
<td>7.48</td>
<td>34</td>
<td>22</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>qZuOfc8m9wRTXL3uUUOKfupkSA2</td>
<td>week1</td>
<td>8.16</td>
<td>34</td>
<td>24</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>BuZvmPDjTrRHkXMSPeuMrGPVSc2</td>
<td>week1</td>
<td>4.08</td>
<td>34</td>
<td>12</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>TvfZrXfHNMZ454CvleCo5EwQyN2</td>
<td>week1</td>
<td>8.84</td>
<td>34</td>
<td>26</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>LPiH7QFbhrSBhrmZzAk3ab9Frd72</td>
<td>week1</td>
<td>9.52</td>
<td>34</td>
<td>28</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>vFTW8pa0pec60GSfspyP8P5wpC2</td>
<td>week1</td>
<td>6.46</td>
<td>34</td>
<td>19</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>od128RTlwLNRzJraq7qud10DFm1</td>
<td>week1</td>
<td>34</td>
<td>34</td>
<td>100</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>1M6C899pVyeYfmFkUpxzxthJ9OF1</td>
<td>week1</td>
<td>0.68</td>
<td>34</td>
<td>2</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>fdpriXxH5HtaV1y27FbkhMF63</td>
<td>week1</td>
<td>2.04</td>
<td>34</td>
<td>6</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>2dU9RHJtnzXzepqn7e5z72YF2P</td>
<td>week1</td>
<td>2.72</td>
<td>34</td>
<td>8</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>C7s3kIYXS0KvKHP6pKDO8wzOr01</td>
<td>week1</td>
<td>0.68</td>
<td>34</td>
<td>2</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>q02tb1Vlb8YC4HjFgbb46WvmmCvq2</td>
<td>week1</td>
<td>9.52</td>
<td>34</td>
<td>28</td>
</tr>
</tbody>
</table>

Figure 33: Week 1 Video Interaction Analysis

Table 6, indicates the analysis in a 2D graph for table 5 above. This graph shows that majority of the students who chose the video content type on week one watched only for a few minutes. The analysis provided showed that students with interaction lower than 1% did not appear on the graph.
To elaborate this phenomenon, the average of the course item was taken and results were as follows:

Table 6: Average Count of Video Interaction - Week 1

<table>
<thead>
<tr>
<th>Week 1 Video Analysis</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Student Count</td>
<td>19</td>
</tr>
<tr>
<td>Total Percentage interaction</td>
<td>405</td>
</tr>
<tr>
<td>Average</td>
<td>((\frac{405}{19}) = 21.32%)</td>
</tr>
</tbody>
</table>

The total number of students who used video content in week 1 were 19 and the average of their percentage of interaction was 21.32%. This indicated a low interaction with the course item.

ii. Week 2 results

Table 7: Video Content Interaction Report - Week 2

<table>
<thead>
<tr>
<th>courseUid</th>
<th>format</th>
<th>studentUid</th>
<th>week</th>
<th>Time Spent</th>
<th>Out of</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST101</td>
<td>video</td>
<td>5wtC3i7xc5gkPTzXk3m3rtDNzdI3</td>
<td>week2</td>
<td>16.2</td>
<td>20</td>
<td>81</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>vFTW8pa0pec60G5fsylPBtPSbWpC2</td>
<td>week2</td>
<td>3.2</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>FG3S5WLOHMvS1hxTezbBY4eMp672</td>
<td>week2</td>
<td>0.2</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>od128RTiwLNR2jrg7qwd110dFm1</td>
<td>week2</td>
<td>11.6</td>
<td>20</td>
<td>58</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>fdqxlXh5HTaaiY2q7fBkflhM63</td>
<td>week2</td>
<td>3.4</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>60lbMimvXHhmCYBTzUFxyzH43D2</td>
<td>week2</td>
<td>9.4</td>
<td>20</td>
<td>47</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>q02tbIvbY4C4HjFggb46WvmOvq2</td>
<td>week2</td>
<td>3.6</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>raijRoEZ8fCgWVzMDFOV20jdlt1</td>
<td>week2</td>
<td>2.6</td>
<td>20</td>
<td>13</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>FDCz0uyoIb3kGO9TI7XIjWYfboLI3</td>
<td>week2</td>
<td>6.2</td>
<td>20</td>
<td>31</td>
</tr>
</tbody>
</table>

The table above shows distribution of students’ video levels of interaction in week 2. The video had 20 minutes of play. The total number of students who attempted to use video content interaction were 9.
Figure 34: Week 2 Video Interaction Analysis

Figure 34 above shows a 2D graph plotted against the interaction percentages.

Table 8: Average Count of Video Interaction - Week 2

<table>
<thead>
<tr>
<th>Week 2 Video Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Student Count</td>
</tr>
<tr>
<td>Total Percentage interaction</td>
</tr>
<tr>
<td>Average</td>
</tr>
</tbody>
</table>

Table 8 above shows a summary of week 2’s video content interaction, whereby the average was 31.33%. This implies that students who interacted with video content in week 2 had an improvement over week 1.

iii. Week 3 results
Table 9: Video Content Interaction Report - Week 3

<table>
<thead>
<tr>
<th>courseUid</th>
<th>format</th>
<th>studentUid</th>
<th>week</th>
<th>Time Spent</th>
<th>out of</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST101</td>
<td>video</td>
<td>pie2QGwx4QaoavRVcWETWuQKqrA3</td>
<td>week3</td>
<td>15.2</td>
<td>20</td>
<td>76</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>od128RITwLN2Jrpg7qwd110dFm1</td>
<td>week3</td>
<td>14.0</td>
<td>20</td>
<td>70</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>Hsb2L7938Xggq0XPCyHPaKW44OJ</td>
<td>week3</td>
<td>5.2</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>rajgRoEZ8fCGWzMDFOV20j1j1</td>
<td>week3</td>
<td>9.2</td>
<td>20</td>
<td>46</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>vFTW8pa0pec60G5fsyPbtPsbWpc2</td>
<td>week3</td>
<td>3.6</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>5wct3l7xq5gPtztXk3m3rDnJzJ3</td>
<td>week3</td>
<td>10.0</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>FD0z0uyojTbkGO9T7X2f0ULJ3</td>
<td>week3</td>
<td>9.2</td>
<td>20</td>
<td>46</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>q02tb1Vib8YCHHfgb46WvmCqv2</td>
<td>week3</td>
<td>2.6</td>
<td>20</td>
<td>13</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>EKGTSWkiYCaZkLx9Wv23cd5e7d33</td>
<td>week3</td>
<td>3.8</td>
<td>20</td>
<td>19</td>
</tr>
</tbody>
</table>

Week 3 video results indicated major improvements over week 1 and 2. Majority of the students who watched video content recorded 40% and above.

Figure 35: Week 3 Video Interaction Analysis

Figure 35 above shows a 2D graph summarizing the results captured on table 9. These results indicated that majority of the students watched video content fairly well.

Table 10: Average Count of Video Interaction - Week 3

<table>
<thead>
<tr>
<th>Week 3 Video Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Student Count</td>
</tr>
<tr>
<td>Total Percentage interaction</td>
</tr>
<tr>
<td>Average</td>
</tr>
</tbody>
</table>
Video content interaction of week 3 has been summarized on table 13. It shows that at least 40.44% of the total video content was watched by the 9 students who got involved.

iv. Week 4 results

Table 11 below shows the students who participated in week 4 video content and their interaction levels. The video had a 20-minute duration; hence, the interaction times were recorded in minutes.

Table 11: Video Content Interaction Report - Week 4

<table>
<thead>
<tr>
<th>courseUid</th>
<th>format</th>
<th>studentUid</th>
<th>week</th>
<th>Time Spent</th>
<th>out of</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST101</td>
<td>video</td>
<td>vFTW8pa0pec60GfsyPBlPSbWpC2</td>
<td>week4</td>
<td>2.4</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>LPH7Q5hbrSBhMrMcZaK3ab9FrD72</td>
<td>week4</td>
<td>4</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>fdqixXhSHTaaiY2qT7fPbkflhM63</td>
<td>week4</td>
<td>0.6</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>od128RITwLNR2rJqg7qwd11odFm1</td>
<td>week4</td>
<td>5.2</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>Hsb2l7938xqoXPCyHpaW44Oe2</td>
<td>week4</td>
<td>3.8</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>FDO20uyqJ7bKG9T7XWyFb0L3</td>
<td>week4</td>
<td>11.4</td>
<td>20</td>
<td>57</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>q02lb1Vlb8YC4JhFgb46WvmCv2q</td>
<td>week4</td>
<td>3.4</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>FG355WLOQuIm51hjTezbBY4e4M672</td>
<td>week4</td>
<td>0.2</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>rajgRoE8fScgWWzMDFOV20ldt1</td>
<td>week4</td>
<td>3.6</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>Swt3C7xqgkPTzK3m3dDnDz3j</td>
<td>week4</td>
<td>13.4</td>
<td>20</td>
<td>67</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>OSDAUnegljY73WIXOZU2TmzHF3</td>
<td>week4</td>
<td>0</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>TEST101</td>
<td>video</td>
<td>j8KrYGNrFbSbMqYiY0M7F6C253</td>
<td>week4</td>
<td>2.8</td>
<td>20</td>
<td>14</td>
</tr>
</tbody>
</table>

Figure 36 below indicates the analysis of week 4. On this table only 2 students reached the half percentage mark.

Figure 36: Week 4 Video Interaction Analysis
Table 12: Average Count of Video Interaction - Week 4

<table>
<thead>
<tr>
<th>Week 4 Video Analysis</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Student Count</td>
<td>12</td>
</tr>
<tr>
<td>Total Percentage interaction</td>
<td>254</td>
</tr>
<tr>
<td>Average</td>
<td>(254/12) = 21.17%</td>
</tr>
</tbody>
</table>

Table 12 above shows that students who watched the video content in week 4 did not watch them for a longer time. Thus, a low interaction percentage.

5.2.1.2 Audio Content Interaction

i. Week 1 results

The table below indicates the level of interaction for students who picked audio content in week 1. There were 9 students who picked the audio content item in week 1. The interaction was recorded in minutes.

Table 13: Audio Content Interaction Report - Week 1

<table>
<thead>
<tr>
<th>courseUid</th>
<th>format</th>
<th>studentUid</th>
<th>week</th>
<th>Time Spent</th>
<th>out of</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>wT2D9rnjobQmik05S2NphqgjxR092</td>
<td>week1</td>
<td>4.4</td>
<td>34</td>
<td>22</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>Jt5Qw5wRwNUmG0CIAFbITyHHPJ3</td>
<td>week1</td>
<td>4.6</td>
<td>34</td>
<td>23</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>u3EK7pVdWWQwk7FWGF2yT5A1EA22</td>
<td>week1</td>
<td>11</td>
<td>34</td>
<td>55</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>FYPlFybFVobhv72B3tWrp1dSpcV2</td>
<td>week1</td>
<td>0.8</td>
<td>34</td>
<td>4</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>FG355WLQHm6S1hTezbB4e4Mr672</td>
<td>week1</td>
<td>0.2</td>
<td>34</td>
<td>1</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>60lMmWmXtmqY8BTzluH43D02</td>
<td>week1</td>
<td>0</td>
<td>34</td>
<td>0</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>dwrbxTegkTMr8SkSeHuO6S5Ldr1</td>
<td>week1</td>
<td>0</td>
<td>34</td>
<td>0</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>HzXmawwxsSM0UdTIkeGFrQsY32</td>
<td>week1</td>
<td>2.8</td>
<td>34</td>
<td>14</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>X9ajiOQtqvXhVFRjOv7LeR4glu1</td>
<td>week1</td>
<td>5.8</td>
<td>34</td>
<td>29</td>
</tr>
</tbody>
</table>

Figure 37: Week 1 Audio Interaction Analysis
The analysis figure 37 above shows that 2 students did not listen to the audio content provided. It also shows that the highest audio interaction was 55%.

**Table 14: Average Count of Audio Interaction - Week 1**

<table>
<thead>
<tr>
<th>Total Student Count</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Percentage interaction</td>
<td>148</td>
</tr>
<tr>
<td>Average</td>
<td>$(148/9) = 16.44%$</td>
</tr>
</tbody>
</table>

Table 14 above shows the average interaction of audio in week 1. It is noted that 16.44% of the total audio content was listened to. This low interaction might have been affected by curiosity levels of the students.

**ii. Week 2 results**

**Table 15: Audio Content Interaction Report - Week 2**

<table>
<thead>
<tr>
<th>courseUid</th>
<th>format</th>
<th>studentUid</th>
<th>week</th>
<th>Time Spent</th>
<th>out of</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>Jz5Qw5wvRzYNumGClAFbiTyHPJ3</td>
<td>week2</td>
<td>7</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>LPI7QFBhSzBiZaK3ab9FrD72</td>
<td>week2</td>
<td>4.8</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>05DAUeqJbY713xOZlUZTMnHf3</td>
<td>week2</td>
<td>0.2</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>LPI7QFBhSzBiZaK3ab9FrD72</td>
<td>week2</td>
<td>0</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>dwrBoXepKmJr85KseHuxOx65Ldr1</td>
<td>week2</td>
<td>8.2</td>
<td>20</td>
<td>41</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>05DAUeqJbY713xOZlUZTMnHf3</td>
<td>week2</td>
<td>0.4</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>1zXxawww5MOJUdtLIskGfQMSy5Q2</td>
<td>week2</td>
<td>17.4</td>
<td>20</td>
<td>87</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>u3EK7vWvWwwk7FwGf2yT3A1EA22</td>
<td>week2</td>
<td>20</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>w7Z59njobQrokK5S2NphsgjxRD92</td>
<td>week2</td>
<td>4.6</td>
<td>20</td>
<td>23</td>
</tr>
</tbody>
</table>

Table 15 above indicates the levels of interaction for students who listened to audio content. The interaction times were recorded in minutes. The total time for the audio content was 20 minutes.

The analysis graph below shows the distribution of interaction in week 2. It shows that there was a student who listened to the entire audio up-to the end hence recording 100% interaction for that student.

Figure 38 indicates that 34.78% of the total audio content was listened to. This implies that majority of the students did not go through the halfway mark of the content item time.
Figure 38: Week 2 Audio Interaction Analysis

Table 16: Average Count of Audio Interaction - Week 2

<table>
<thead>
<tr>
<th>Week 2 Audio Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Student Count</td>
</tr>
<tr>
<td>Total Percentage Interaction</td>
</tr>
<tr>
<td>Average</td>
</tr>
</tbody>
</table>

iii. Week 3 results

Table 17: Audio Content Interaction Report - Week 3

<table>
<thead>
<tr>
<th>courseUid</th>
<th>format</th>
<th>studentUid</th>
<th>week</th>
<th>Time Spent</th>
<th>out of</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>Jz5QwSvwRxNUmG0ClIAFbiTyHHpJ3</td>
<td>week3</td>
<td>3.8</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>IzMxawwx5MOJUdTikeGFdFQs5y32</td>
<td>week3</td>
<td>8.2</td>
<td>20</td>
<td>41</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>5RCEYKux3aokuQ2nNJmL5MUll2</td>
<td>week3</td>
<td>3.4</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>wT2D9rmjobQmk05S2NphqgjxRD92</td>
<td>week3</td>
<td>5</td>
<td>20</td>
<td>25</td>
</tr>
</tbody>
</table>

Week 3 results are shown on table 17 above. They indicated that only 4 students participated in the audio content item for week 3. The video was out of 20 minutes. Each interaction time was recorded in minutes.
Figure 39: Week 3 Audio Interaction Analysis

The analysis on figure 39 above shows that majority of the students interacted with the content below 25%.

Table 18: Average Count of Audio Interaction - Week 3

<table>
<thead>
<tr>
<th>STUDENT ID</th>
<th>PERCENTAGE INTERACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>wT2D9rnjobQmk0552NphqgxjR092</td>
<td>25</td>
</tr>
<tr>
<td>5BCeYKuxn3aokuQ2njNml5Munl2</td>
<td>17</td>
</tr>
<tr>
<td>IzMxawwxSMOJUdtikeGFQs5y32</td>
<td>41</td>
</tr>
<tr>
<td>Jz5QwSwvRxUMg0C1AFbTyHPJ3</td>
<td>19</td>
</tr>
</tbody>
</table>

Table 18 is a summary of the interaction levels in terms of the average percentage of interaction.

iv. Week 4 results

Table 19: Audio Content Interaction Report - Week 4

<table>
<thead>
<tr>
<th>courseUid</th>
<th>format</th>
<th>studentUid</th>
<th>week</th>
<th>Time Spent</th>
<th>ou of</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>dwrbxTepKtMjr8skSeHu0x6lDr1</td>
<td>week4</td>
<td>3.6</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>LPH7QFhhr5BlMrZaK3ab9Fr072</td>
<td>week4</td>
<td>0</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>u3K7pWdWQwK7FwGF2yT3A1E2</td>
<td>week4</td>
<td>14.2</td>
<td>20</td>
<td>71</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>Jz5QwS5vwRXUMg0C1AFbTyHPJ3</td>
<td>week4</td>
<td>14.4</td>
<td>20</td>
<td>72</td>
</tr>
<tr>
<td>TEST101</td>
<td>audio</td>
<td>IzMxawwxSMOJUdtikeGFQs5y32</td>
<td>week4</td>
<td>3</td>
<td>20</td>
<td>15</td>
</tr>
</tbody>
</table>

Week 4 interaction levels are indicated in table 19 above. They show the interaction time recorded in minutes.
The analysis graph in figure 40 indicates that students who listened to the audio content above 70% were two. There was a student who never listened to any content during the experiment.

**Table 20: Average Count of Audio Interaction - Week 4**

<table>
<thead>
<tr>
<th>Week 4 Audio Analysis</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Student Count</td>
<td>5</td>
</tr>
<tr>
<td>Total Percentage interaction</td>
<td>176</td>
</tr>
<tr>
<td>Average</td>
<td>(176/5) = 35.2%</td>
</tr>
</tbody>
</table>

Table 20, indicates the total number of students who participated in the audio content in week as 5. It also shows that there was an average of 35.2% of the total interaction.

**5.2.1.3 Text Content Interaction**

**i. Week 1 results**

Table 21 shows text content interaction of students in week 1. This table, captured the word count (Total number of words the student read). Using the percentage formulae, the interaction percentage was obtained.

The graph shows the distribution of interaction levels across the students who picked the text content.
Table 21: Text Content Interaction Report - Week 1

<table>
<thead>
<tr>
<th>CourseUid</th>
<th>format</th>
<th>Week</th>
<th>student_id</th>
<th>word_count</th>
<th>Out of</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>aA5USw4fCZ4RQjG3nU3kjjyG5m1</td>
<td>6</td>
<td>615</td>
<td>0.98</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>FYPlybfZVobh7Z3tWrp1d3pcV2</td>
<td>6</td>
<td>615</td>
<td>0.98</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>EKGT5WkCyZkX9Vv23dc5o7d33</td>
<td>239</td>
<td>615</td>
<td>38.86</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>SwtC3i7xqSgkPTxK3m3DrNdjz3</td>
<td>100</td>
<td>615</td>
<td>16.26</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>bKapwI6XyfChOhM5hS81RGuX652</td>
<td>100</td>
<td>615</td>
<td>16.26</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>Em5VRtfMWgT7Qqwaes4s7B1GKOna2</td>
<td>239</td>
<td>615</td>
<td>38.86</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>j8KrYGFrbbS7MqRIY0M7fck6CP253</td>
<td>514</td>
<td>615</td>
<td>83.58</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>0SDAUeqJbY7i3WLOZIuZTMnHF3</td>
<td>6</td>
<td>615</td>
<td>0.98</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>OyDRKzbv9iezrsk4YPOFQZv53</td>
<td>430</td>
<td>615</td>
<td>69.92</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>Xq13pTeAYK0bexCKxobYyzrR52</td>
<td>188</td>
<td>615</td>
<td>30.57</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>pie2QGwx4QaoVRCWETvuQKpxA3</td>
<td>239</td>
<td>615</td>
<td>38.86</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>bFu0kdcynnpj9RFDAKcrvK1</td>
<td>6</td>
<td>615</td>
<td>0.98</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>xqiwcDObcz8KrdBb8CmxQC3i1</td>
<td>430</td>
<td>615</td>
<td>69.92</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>ErgJddvgiPEnRMc098luyBvg1</td>
<td>128</td>
<td>615</td>
<td>20.81</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>nkS3TTmm3edKhh3N11dAeX1uk1</td>
<td>615</td>
<td>615</td>
<td>100.00</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>vocWS09B9YOSkP4je1MF3C5z1</td>
<td>615</td>
<td>615</td>
<td>100.00</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>NWfDjbjGqQ2U335FUC6pLSQY2</td>
<td>615</td>
<td>615</td>
<td>100.00</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>BHjuOcXADrV8wpNmfLQ2zhkNkm2</td>
<td>514</td>
<td>615</td>
<td>83.58</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>wYm0jg3paAeHdQX66mzS5P4C2</td>
<td>6</td>
<td>615</td>
<td>0.98</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>C7xSkRKSVOVKhP6gKQCB8wzQr1</td>
<td>615</td>
<td>615</td>
<td>100.00</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>IzMxawwx5MOJUDTikeGFdFQs5y32</td>
<td>615</td>
<td>615</td>
<td>100.00</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 1</td>
<td>oWvySkFVDYSWHAEbICfDIUHARr13</td>
<td>615</td>
<td>615</td>
<td>100.00</td>
</tr>
</tbody>
</table>
Figure 41: Week 1 Text Content Analysis

Table 22: Average Count of Text Interaction - Week 1

<table>
<thead>
<tr>
<th>STUDENT ID</th>
<th>Percentage Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>wYm0ig3paAeHdfrQXX6mszF5P4C2</td>
<td>0.98</td>
</tr>
<tr>
<td>Qx13pTeAYKV9bxckXzobYzrM5R52</td>
<td>0.98</td>
</tr>
<tr>
<td>0SDA1neqj5bY713wX9Z21U7HmHF3</td>
<td>0.98</td>
</tr>
<tr>
<td>EKGT5WikIYCaZkJx9Wv23dc073d3</td>
<td>0.98</td>
</tr>
<tr>
<td>FYPlybFZobhv72B3tWgpld3czvV2</td>
<td>0.98</td>
</tr>
<tr>
<td>aASUSxw4FCZ4RQJG3nI3kJyGSM1</td>
<td>0.98</td>
</tr>
<tr>
<td>oWyySkFVSYYhAEbeICdIuHAr13</td>
<td>0.98</td>
</tr>
<tr>
<td>IZMxaxw5SMOUDtIKeFdfQo5y32</td>
<td>0.98</td>
</tr>
<tr>
<td>C73xskiRVSOKvHPspKCE68wzQr1</td>
<td>0.98</td>
</tr>
<tr>
<td>wYm0ig3paAeHdfrQXX6mszF5P4C2</td>
<td>0.98</td>
</tr>
<tr>
<td>BjhuQcXArV8rpmNmlFZ2hknKjm2</td>
<td>0.98</td>
</tr>
<tr>
<td>NWjfDjfbGQVZUK33sFUC6pmLSQy2</td>
<td>0.98</td>
</tr>
<tr>
<td>vocWS09BYOsklP4je1MF3Bc5c1</td>
<td>0.98</td>
</tr>
<tr>
<td>nKs3Tnnmm3edKkh3N11dAcX1uki1</td>
<td>0.98</td>
</tr>
<tr>
<td>ErgUddvgpntEnRMr098ljBvyj1</td>
<td>0.98</td>
</tr>
<tr>
<td>aXqiwrLDCObcz8KrDb6CmxQc3i1</td>
<td>0.98</td>
</tr>
<tr>
<td>b3FJu0dC5sysenp9j9FDAkGcrjK1</td>
<td>0.98</td>
</tr>
<tr>
<td>pieGxwv4QaoqvRvCWEVTuvKqrxAs3</td>
<td>0.98</td>
</tr>
<tr>
<td>Qx13pTeAYKV9bxckXzobYzrM5R52</td>
<td>0.98</td>
</tr>
<tr>
<td>OyDRKZkv9iznmrk4iYOpQzS3</td>
<td>0.98</td>
</tr>
<tr>
<td>0SDA1neqj5bY713wX9Z21U7HmHF3</td>
<td>0.98</td>
</tr>
<tr>
<td>j8KrYGrfbbSmqRy0YMnHCP253</td>
<td>0.98</td>
</tr>
<tr>
<td>Em5VrfM1WgTq7qwaee4s781Gk0na2</td>
<td>0.98</td>
</tr>
<tr>
<td>bKapvJ6XyfChOhMh851RGuXa52</td>
<td>0.98</td>
</tr>
<tr>
<td>5wtC3i7qsgkP7xK3m3rDnTzdJ3</td>
<td>0.98</td>
</tr>
<tr>
<td>EKGT5WikIYCaZkJx9Wv23dc073d3</td>
<td>0.98</td>
</tr>
<tr>
<td>FYPlybFZobhv72B3tWgpld3czvV2</td>
<td>0.98</td>
</tr>
<tr>
<td>aASUSxw4FCZ4RQJG3nI3kJyGSM1</td>
<td>0.98</td>
</tr>
</tbody>
</table>

The summary table implies that an average of 50.56% of the content was read by the students. This meant that most of them read beyond 50% in their respective interaction levels.
ii. Week 2 results

Table 23: Text Content Interaction Report - Week 2

<table>
<thead>
<tr>
<th>CourseUid</th>
<th>follow</th>
<th>Week 2</th>
<th>student_id</th>
<th>word_count</th>
<th>out of</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>pie2QGwx4QaoVrVrtYuqKqnxA3</td>
<td>215</td>
<td>480</td>
<td>44.79</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>qZu0fcb8m6wRTXl3uUUQUkpuSA2</td>
<td>215</td>
<td>480</td>
<td>44.79</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>X9a1OQ5q5VrVrFv07l4R4glu1</td>
<td>215</td>
<td>480</td>
<td>44.79</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>aXqw1cDOBcz8K0DbBcmxQC31</td>
<td>132</td>
<td>480</td>
<td>27.50</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>SCExYkxzn3auq03QzNnJnM5Mumll2</td>
<td>24</td>
<td>480</td>
<td>5.00</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>b3Fu0kdcxypnp9RFDAKGrv0k1</td>
<td>4</td>
<td>480</td>
<td>0.83</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>bKapv6XxfCHOhMn581RGuAX652</td>
<td>4</td>
<td>480</td>
<td>0.83</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>ErG0ddv0FtEnRm0C98lu8Bvq1</td>
<td>132</td>
<td>480</td>
<td>27.50</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>a5USxv4fCZ4RqI3Jn3kijyGSm1</td>
<td>132</td>
<td>480</td>
<td>27.50</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>IzMxaww5SMOUItd0ge0FQs5y32</td>
<td>88</td>
<td>480</td>
<td>18.33</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>Em5VrFwTQv7Qwae4s781G0on2</td>
<td>215</td>
<td>480</td>
<td>44.79</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>Xq13pTeAYX8bexCkzobYzMsR5</td>
<td>283</td>
<td>480</td>
<td>58.96</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>wYm0g3paAedhrQX6mz5z5FPC2</td>
<td>88</td>
<td>480</td>
<td>18.33</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>TFeZrFHNMZ454CvEO5e0EwQYyN2</td>
<td>480</td>
<td>480</td>
<td>100.00</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>2dUJ9FhJn0wXzexp0n7eszlt2FyZP2</td>
<td>4</td>
<td>480</td>
<td>0.83</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>j8K1yG8nrbbS8rMq0YOM7f6CP253</td>
<td>132</td>
<td>480</td>
<td>27.50</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>OSDAUneq1Y713Wt0XO2UIZTMnHF3</td>
<td>4</td>
<td>480</td>
<td>0.83</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>nKs3Tnm3edkh3N11dAcX1uk1</td>
<td>480</td>
<td>480</td>
<td>100.00</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>Bhju0CXdrv8wpnMfLQZ2hknKjm2</td>
<td>480</td>
<td>480</td>
<td>100.00</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>OyDRKzvb91eznrsk1l4YrQOQzv53</td>
<td>283</td>
<td>480</td>
<td>58.96</td>
</tr>
<tr>
<td>TEST01</td>
<td>text</td>
<td>Week 2</td>
<td>NWfDJbFgQVZUK355FC6pMlsqy2</td>
<td>283</td>
<td>480</td>
<td>58.96</td>
</tr>
</tbody>
</table>

Table 23 above shows the interaction levels of textual content read in week 2.

Figure 42: Week 2 Text Content Analysis

The analysis in figure 42 above shows that 6 students out of 21 read beyond the 50% mark.
Table 24: Average Count of Text Interaction - Week 2

<table>
<thead>
<tr>
<th>Week 2 Text Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Student Count</td>
</tr>
<tr>
<td>Total Percentage interaction</td>
</tr>
<tr>
<td>Average</td>
</tr>
</tbody>
</table>

A summary of the week’s interaction is indicated above. It implies that there was a drop in the levels of interaction as compared to week 1.

iii. Week 3 results

Week 3 textual content interaction was recorded in table 25 below.

Table 25: Text Content Interaction Report - Week 3

<table>
<thead>
<tr>
<th>CourseUid</th>
<th>format</th>
<th>Week</th>
<th>student_id</th>
<th>word_count</th>
<th>out of</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>b3Fu0kdc9enpp9RFDAKGrJv1k1</td>
<td>293</td>
<td>293</td>
<td>100.00</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>dwrboTepKtMj8SksEUuOx6Ldr1</td>
<td>264</td>
<td>293</td>
<td>90.10</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>qZuOft8m6wRTXL3uUUQUKfpuKSA2</td>
<td>264</td>
<td>293</td>
<td>90.10</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>ErgUdvgijPfEnM00986ijBvgj1</td>
<td>164</td>
<td>293</td>
<td>55.97</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>X9ali0QtrXhVfERjOv7LeR4glu1</td>
<td>164</td>
<td>293</td>
<td>55.97</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>TvFzKrhNNZ454C3eCo5EwQlyN2</td>
<td>187</td>
<td>293</td>
<td>63.82</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>LPH7Qfbhr5BhrMzZaK3ab9F0D72</td>
<td>187</td>
<td>293</td>
<td>63.82</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>2dU9RjtNwZxepq7neszit2FyZP2</td>
<td>293</td>
<td>293</td>
<td>100.00</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>OyDRKzbv9Jer7rjk1yP0Qzv53</td>
<td>187</td>
<td>293</td>
<td>63.82</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>nks3TTtmm3edKh3N11dAcX1u1</td>
<td>293</td>
<td>293</td>
<td>100.00</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>BhjuOcXADTv8wpNmLQ2zhKjmm2</td>
<td>293</td>
<td>293</td>
<td>100.00</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>fdqdxIhSTaaiYq7TfBc6hm63</td>
<td>164</td>
<td>293</td>
<td>55.97</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>aXqiwqC0DCObcz8Krd8CmXQ3i1</td>
<td>7</td>
<td>293</td>
<td>2.39</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>wYm0q3paAeHdQ0X06mmszFSP4C2</td>
<td>187</td>
<td>293</td>
<td>63.82</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>NWfDjbfvQVZUK335FUC6PlmLSQy2</td>
<td>121</td>
<td>293</td>
<td>41.30</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 3</td>
<td>Em5VRtfMWgTJ7Qwa4s7B1GkoNa2</td>
<td>187</td>
<td>293</td>
<td>63.82</td>
</tr>
</tbody>
</table>
Figure 43: Week 3 Text Content Analysis

The analysis indicates that 14 students out of the total 16 students read the content beyond the 50% mark. This was an improvement compared to the previous week.

Table 26: Average Count of Text Interaction - Week 3

<table>
<thead>
<tr>
<th>Student ID</th>
<th>Percentage Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Em5VRtf MWgTx7Qwaes4s7B1GkOna2</td>
<td>63.82</td>
</tr>
<tr>
<td>NWjfdBfGqVZUK33FUC6PmLSQY2</td>
<td>41.30</td>
</tr>
<tr>
<td>wYm0i3paAeHdeRQXX6mszF5P4C2</td>
<td>63.82</td>
</tr>
<tr>
<td>aXqiwcDC0bcz8KrKDb8CmzXc3i1</td>
<td>2.39</td>
</tr>
<tr>
<td>fdqtxXh5HTaaI7q7TfBkIfiM63</td>
<td>55.97</td>
</tr>
<tr>
<td>BhuwCXdV8wpNmfLQZzhkNjkm2</td>
<td>100.00</td>
</tr>
<tr>
<td>nKs3TTnmn3edKh3N11dAcX1uki1</td>
<td>100.00</td>
</tr>
<tr>
<td>OyDRTkb9ileznrlk4YOFQZv5s3</td>
<td>63.82</td>
</tr>
<tr>
<td>2dU9bHjtNwZxepqn7esibt2FyZP2</td>
<td>100.00</td>
</tr>
<tr>
<td>LPi7QblhrSBhrMcZak3ab9FrD72</td>
<td>63.82</td>
</tr>
<tr>
<td>TvfzXFhNMF2454C5Teo5EwQlyN2</td>
<td>63.82</td>
</tr>
<tr>
<td>X9ajiQoqVxhVfERJov7LeR4glu1</td>
<td>55.97</td>
</tr>
<tr>
<td>ErgUddvgfPteRmc0981ujBgvi1</td>
<td>55.97</td>
</tr>
<tr>
<td>qZuOc8m6wRXL3uUUQkpfukSA2</td>
<td>90.10</td>
</tr>
<tr>
<td>dwrbxTepKtMjrR5sk5eHuOx6Sldr1</td>
<td>90.10</td>
</tr>
<tr>
<td>b3Fu0kdcyeppp9RFDAKGcrjvk1</td>
<td>100.00</td>
</tr>
</tbody>
</table>

The summary on table 26 above indicates that there was an average of 69.43% of the total interaction. This implies that majority of the students read most of the content.
iv. Week 4 results

Table 27: Text Content Interaction Report - Week 4

<table>
<thead>
<tr>
<th>CourseUid</th>
<th>format</th>
<th>Week</th>
<th>student_id</th>
<th>word_count</th>
<th>out of</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 4</td>
<td>TvfZrXFhNMZ454CleCo5EwQlN2</td>
<td>258</td>
<td>500</td>
<td>51.6</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 4</td>
<td>Xq13pTeAYXbBbxXkxobYzrs2</td>
<td>34</td>
<td>50</td>
<td>6.8</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 4</td>
<td>9x9aJ0QttqXVfFwRIoV/LeR4gku</td>
<td>34</td>
<td>50</td>
<td>6.8</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 4</td>
<td>wYm0ig3paAehdrcQxX66mszF5P4C2</td>
<td>226</td>
<td>500</td>
<td>45.2</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 4</td>
<td>ErgUddvgtpentoRmc098lujBvg1</td>
<td>226</td>
<td>500</td>
<td>45.2</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 4</td>
<td>nKs3TTnmm3edkh311dAcx1uk1</td>
<td>500</td>
<td>500</td>
<td>100</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 4</td>
<td>qZuOfc8m6wRTxL3uUQjdpukSA2</td>
<td>258</td>
<td>500</td>
<td>51.6</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 4</td>
<td>aA5USxv4fCz4RqIG3n3kjyG3m1</td>
<td>169</td>
<td>500</td>
<td>33.8</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 4</td>
<td>2dU9RHytnw2xeqpn7eszt2Fyp2</td>
<td>342</td>
<td>500</td>
<td>68.4</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 4</td>
<td>SBCeyKuxn3aokuQ2njNmL5MunIl2</td>
<td>500</td>
<td>500</td>
<td>100</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 4</td>
<td>FYPlybFZObhv72B3tWrpl3pcv2</td>
<td>9</td>
<td>50</td>
<td>1.8</td>
</tr>
<tr>
<td>TEST101</td>
<td>text</td>
<td>Week 4</td>
<td>pie2QGwxx4QaqoRVcWETgyuQkRxa3</td>
<td>258</td>
<td>500</td>
<td>51.6</td>
</tr>
</tbody>
</table>

The summary table 28 above, shows a drop in textual content interaction levels in week 4.

Figure 44: Week 4 Text Content Analysis

Figure 44 indicates that 6 out of 13 students read the content beyond 50% mark.

Table 28: Average Count of Text Interaction - Week 4

<table>
<thead>
<tr>
<th>Week 4 Text Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Student Count</td>
</tr>
<tr>
<td>Total Percentage interaction</td>
</tr>
<tr>
<td>Average</td>
</tr>
</tbody>
</table>

The summary table 28 above, shows a drop in textual content interaction levels in week 4.
5.2.2 Dominance of Content Items

i. Week 1

Table 29: Week 1 Content Item average and standard deviation

<table>
<thead>
<tr>
<th>Week</th>
<th>Content Item</th>
<th>n&lt;sup&gt;th&lt;/sup&gt; Value</th>
<th>Average</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Audio</td>
<td>9</td>
<td>13.93</td>
<td>16.21</td>
</tr>
<tr>
<td>1</td>
<td>Text</td>
<td>22</td>
<td>42.35</td>
<td>39.64</td>
</tr>
<tr>
<td>1</td>
<td>Video</td>
<td>19</td>
<td>21.32</td>
<td>21.65</td>
</tr>
</tbody>
</table>

Table 30: Content Items Anova Single Factor - week 1

<table>
<thead>
<tr>
<th>Groups</th>
<th>Count</th>
<th>Sum</th>
<th>Average</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video</td>
<td>19</td>
<td>405</td>
<td>21.32</td>
<td>468.56</td>
</tr>
<tr>
<td>Text</td>
<td>22</td>
<td>1112.38</td>
<td>50.56</td>
<td>1615.97</td>
</tr>
<tr>
<td>Audio</td>
<td>9</td>
<td>148</td>
<td>16.44</td>
<td>332.28</td>
</tr>
</tbody>
</table>

Table 29 above shows the comparison of week 1 items. Table 30, indicates the single factor Anova measuring significant difference between the three content items in week 1. According to the test, F value was greater than F critical, meaning that there was a significant difference between the three means. Therefore, text content was dominant in week 1 due to its highest mean.
ii. Week 2

Table 31: Week 2 Content Item average and standard deviation

<table>
<thead>
<tr>
<th>Week</th>
<th>Content Item</th>
<th>( n )</th>
<th>( n^{th} ) Value</th>
<th>Average</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Audio</td>
<td>9</td>
<td>34.78</td>
<td>36.57</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Text</td>
<td>21</td>
<td>38.62</td>
<td>32.29</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Video</td>
<td>9</td>
<td>31.33</td>
<td>25.73</td>
<td></td>
</tr>
</tbody>
</table>

Table 32: Content Items Anova Single Factor - Week 2

<table>
<thead>
<tr>
<th></th>
<th>Count</th>
<th>Sum</th>
<th>Average</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video</td>
<td>9</td>
<td>282</td>
<td>31.3333</td>
<td>662.25</td>
</tr>
<tr>
<td>Text</td>
<td>21</td>
<td>811.02</td>
<td>38.62</td>
<td>1042.82</td>
</tr>
<tr>
<td>Audio</td>
<td>9</td>
<td>313</td>
<td>34.7777</td>
<td>1337.44</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>( F )</th>
<th>( P)-value</th>
<th>( F_{crit} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>353.492219</td>
<td>2</td>
<td>176.746109</td>
<td>0.17264991</td>
<td>0.84212471</td>
<td>3.25944631</td>
</tr>
<tr>
<td>Within Groups</td>
<td>36854.1178</td>
<td>36</td>
<td>1023.72549</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>37207.61</td>
<td>38</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 31 above shows the standard deviation of the three content items used in week 2. From the single factor Anova shown in table 32, \( F \) value was less than the \( F \) critical value. Therefore, the mean difference was not significant. From, week 2 results, there was no statistical proof that any of the items was dominant.

Table 33: Week 3 Content Item average and standard deviation

<table>
<thead>
<tr>
<th>Week</th>
<th>Content Item</th>
<th>( n^{th} ) Value</th>
<th>Average</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Audio</td>
<td>4</td>
<td>25.50</td>
<td>10.88</td>
</tr>
<tr>
<td>3</td>
<td>Text</td>
<td>16</td>
<td>69.43</td>
<td>25.56</td>
</tr>
<tr>
<td>3</td>
<td>Video</td>
<td>9</td>
<td>40.44</td>
<td>22.96</td>
</tr>
</tbody>
</table>

Table 33 above shows the standard deviations for the three content items in week 3.
From the Anova table 34 above, the F-Statistic value was greater than the F critical value. Therefore, there was a significant difference between the three mean of the content items. Week three showed that textual content was dominant.

Table 35: Week 4 Content Item average and standard deviation

<table>
<thead>
<tr>
<th>Week</th>
<th>Content Item</th>
<th>n&lt;sup&gt;th&lt;/sup&gt; Value</th>
<th>Average</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Audio</td>
<td>5</td>
<td>35.20</td>
<td>33.83</td>
</tr>
<tr>
<td>4</td>
<td>Text</td>
<td>13</td>
<td>45.49</td>
<td>35.91</td>
</tr>
<tr>
<td>4</td>
<td>Video</td>
<td>12</td>
<td>21.17</td>
<td>20.81</td>
</tr>
</tbody>
</table>
Table 36: Content Items Anova Single Factor - Week 4

<table>
<thead>
<tr>
<th>SUMMARY</th>
<th>Count</th>
<th>Sum</th>
<th>Average</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video</td>
<td>12</td>
<td>254</td>
<td>21.17</td>
<td>432.88</td>
</tr>
<tr>
<td>Text</td>
<td>13</td>
<td>630</td>
<td>48.46</td>
<td>1262.55</td>
</tr>
<tr>
<td>Audio</td>
<td>5</td>
<td>176</td>
<td>35.20</td>
<td>1144.70</td>
</tr>
</tbody>
</table>

ANOVA

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>4648.96923</td>
<td>2</td>
<td>2324.48462</td>
<td>2.56261228</td>
<td>0.09571665</td>
<td>3.35413083</td>
</tr>
<tr>
<td>Within Groups</td>
<td>24491.0574</td>
<td>27</td>
<td>907.076201</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>29140.0267</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 36 above shows that the F critical value was greater than the F value. Hence, the difference in the means recorded in the week’s content items was not statistically significant.

Table 37: Linear Regression Statistics Showing Content Item Relationship

<table>
<thead>
<tr>
<th>SUMMARY OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression Statistics</td>
</tr>
<tr>
<td>Multiple R</td>
</tr>
<tr>
<td>R Square</td>
</tr>
<tr>
<td>Adjusted R Square</td>
</tr>
<tr>
<td>Standard Error</td>
</tr>
<tr>
<td>Observations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>df</td>
</tr>
<tr>
<td>---------------------------</td>
</tr>
<tr>
<td>Regression</td>
</tr>
<tr>
<td>Residual</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Standard Error</th>
<th>t Stat</th>
<th>P-value</th>
<th>Lower 95%</th>
<th>Upper 95%</th>
<th>Lower 95.0%</th>
<th>Upper 95.0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>32.78659904</td>
<td>5.14583372</td>
<td>6.371484355</td>
<td>1.8861E-08</td>
<td>22.51824773</td>
<td>43.05495036</td>
<td>22.51824773</td>
</tr>
<tr>
<td>Audio</td>
<td>-0.017320561</td>
<td>0.119969203</td>
<td>-0.144375058</td>
<td>-0.885631354</td>
<td>-0.256715378</td>
<td>0.222074257</td>
<td>-0.256715378</td>
</tr>
<tr>
<td>Text</td>
<td>0.095487427</td>
<td>0.072042054</td>
<td>1.325440101</td>
<td>0.189461228</td>
<td>-0.048270253</td>
<td>0.239245106</td>
<td>-0.048270253</td>
</tr>
<tr>
<td>Video</td>
<td>-0.053432808</td>
<td>0.111103621</td>
<td>-0.480927691</td>
<td>0.632111735</td>
<td>-0.275136632</td>
<td>0.168271016</td>
<td>-0.275136632</td>
</tr>
</tbody>
</table>

From table 37 above, the P-value of the three content items was greater than the alpha (α) value which was 0.05. It meant that there was no significant correlation between the three content
items in-terms of their dominance over each other. The linear regression graph in figure 45 below indicates the absence of audio content item due to its low interaction.

This means that the three content items did not compete. Although the P-value of text content seemed lower and closer to 0.05, it still did not qualify to be the dominant content item.

Arguably, it can be said that audio and video content had close P-values because audio was also applied in the video content.

![Linear Regression of Content Items](image)

Figure 45: Linear Regression Scatter Graph

These results prove the cognitive theory of multimedia learning. Which states that instructional design is affected by how the human mind works. Therefore, the three content items can be used in one content instruction to elaborate different phenomena instead of using them interchangeably to teach different content instructions. The low interaction percentages in the different content items implies that cognitive processing of content information was different based on content items.
5.3 Chapter Summary

This chapter provided the general information of the experiment and the population sample. Micro economics short course from MIT open courseware was used to administer the course content.

The lab experiment was conducted with the help of the lab technician who helped issue access credentials to the students. The chapter also revealed the level of interaction in the content items that were used by the students. This could be seen in the data tables presented in section 5.2.1.1 to 5.2.1.3.

Content item dominance was also evaluated by calculating the analysis of variance and significant difference in their means. Findings showed that different content items dominated over the weeks.

Finally, linear regression was done to check overall content item dominance. The results proved that the content items were not dominant over each other instead they could be used together to elaborate different phenomena in the same content instruction.
CHAPTER 6: DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

In this chapter, a summary of the objectives and scope of study are discussed and compared against the artefact developed. It also examines the results obtained by the artefact, challenges encountered during development and assumptions made during data collection.

Lastly, conclusions are drawn from the results obtained and future recommendations are given based on the challenges.

6.2 Summary

The main objective of this study was to investigate content items in asynchronous e-learning environment as well as using a monitoring tool to evaluate the level of interaction and their dominance over one another. According to the study’s specific objectives, an investigation was done to determine the influence of content items in learner-content interaction. This was evident in the literature section, where three content items were identified as audio, text and video. Secondly, a tool was developed in order to monitor learner-content interaction using natural language processing. A conceptual framework of the same was modelled illustrating the connectivity of the objectives. Lastly, an evaluation of content item dominance as well as their interaction levels were determined using the results obtained by the tool.

The scope of the study was to develop a web-based asynchronous virtual learning environment. The artefact developed in chapter 4 of the study shows that the scope was met. Simulation of the artefact was done to prove this phenomenon. The artefact had two major users namely, instructors and students whose roles were clearly defined.

6.2.1 Research Process

In order to fulfil the objectives of the study, the research process was undertaken in three phases. The first phase was conducted through thorough literature review where three content items were identified as audio, text and video. It was noted that they were common in e-learning artefacts and were being used interchangeably. The literature obtained argued that, in asynchronous e-learning; lessons were being recorded and saved in all multimedia forms. Evidently, in audio as podcasts, video as tutorials and in text as notes. The literature also provided two key algorithms
that would be used by the artefact to provide interaction level for textual content as well percentage of interaction per session respectively.

The second phase of the project was to create a web-based e-learning tool. This was done by use of modern object-oriented programming methodology and tools. The artefact’s requirements were documented and Kruchten’s 4+1 view model was used to explain the analysis.

React JS was used to render interactive user interfaces. This minimized the development time and created room for a minimum viable artefact (MVA). Firebase was deployed as the database of choice due to its NoSQL nature as well as real-time data update to the Google cloud. Cloudinary CDN was used to store content items. Finally, python was used to create an NLP text processing API that provided word tokenization as well as word counting. This was made possible through feeding the API with JSON data obtained from uploaded textual content arrays.

The third phase was to obtain the level of interaction as well as dominance. To do this, an experiment was setup and 50 students were put in a lab. The lab simulated student’s normal reading environments. Participation duration of thirty minutes per student was allowed.

In order to fulfil the asynchrony of the artefact, four different lessons were picked and modified from MIT open-source courseware, principles of microeconomics. They were then uploaded in one course that had three different formats. This course was manned by one instructor who collected data through system generated reports. Participation of 50 students in the lessons yielded 50 datasets of each. Therefore, deriving a collection of 200 datasets where observation and analysis were drawn from.

6.3 Discussions
6.3.1 Influence of Content Items in Learner-Content Interaction

The examination of content items in the literature section results to the understanding of audio, textual and video content. These three items are then used to determine their dominance in learner-content interaction.

Audio content has been considered beneficial to the learner when used as narratively to relay content information. According to Drew (2017), the integration of audio podcasts in various e-learning platforms brings about its influence.
Textual content is better used with a combination of graphics says Mayer (2017). The integration of textual content in this study, resulted to a number of students opting for it as compared to the other two. According to weekly statistics in the results, textual content came out dominantly in two of them.

Video content can be used cognitively, as a reminder of what the students read. Carmichael, Reid, and Karpicke's (2017) study indicated that video content could be very useful where the student required motivation.

6.3.2 Validity of Text Extraction Algorithm

According to the literature section 2.5.1, the text extraction algorithm was developed to match the number of slides read by the students against the JSON data obtained upon text content upload.

![Text Interaction Array](image)

**Figure 46: Text Interaction Array**

The figure above shows student ID aASUS…., and the textual course UID they interacted with in week 4. From the console logs, it is evident that the student interacted with 4 slides as indicated by the length of the array. This array was posted to the text extraction API.
Figure 47: Text API Response without Calculations

The text extractor then matched the array length with its own. These logs show the raw output before calculation. Therefore, for all items in the POST array and all items in the GET array, the API was able to produce the results below.

Figure 48: API GET Response

GET API response returned the exact total number of words read (169 out of total 500) by this student as well as percentage of interaction (33.8%).
6.3.3 Content Interaction Levels

The data collected through the artefact indicated that it was possible to determine the level of learner-content interaction. Section 5.2.1 revealed that the artefact collected data in real time as the students interacted with the content.

The results also indicated that normal student studying habits were observed considering that the lab experiment was based on participants’ own will.

6.3.4 Content Item Dominance

In order to conclude on content item dominance, weekly standard deviation on individual items was calculated and the averages displayed as well. Section 5.2.2 showed a consistent trend with the content items per week.

Although audio content item dominated in the second week, textual item came in second. Additionally, the trend observed in the results was consistent, some students still had their preferences for individual content items. i.e. if a student chose audio content item in week one, they maintained with it all through the lab experiment.

The results obtained from the linear regression indicated that text content item was lower than the other two content items. Audio and video P-values were close to each other (i.e. 0.89 and 0.63 respectively) and might be used to explain the correlation between the two items. This might mean that they were close to each other because audio is used in the video content to express speech.

6.4 Conclusions

The study’s objectives were examined and reported in various sections. First and foremost, objective one was to investigate the influence of content items in learner-content interaction. This was thoroughly discussed in the literature, section 2.4. The section talked about audio, text and video content and how they were used interchangeably in e-learning platforms.

The literature indicated that audio content could be used narratively to benefit an e-learner. It was argued that audio narratives could be used in three types: descriptively, verbatim or paraphrasing. For example, the study of Drew (2017) informed that the use of audio in the form of podcasts had been integrated across the world by a number of higher education institutions.
Mayer's (2017) study showed that textual content could be appealing to the e-learner either by using it as a stand-alone or with graphics. This indeed proved that effective e-learning could go on with regards to subject matter. In the study of Kifor (2017), conclusions were made that e-learners would remember more of the subject’s context if the textual content was accompanied with other multimedia tools.

The report produced by Carmichael, Reid, and Karpicke (2017) indicated that, the use of video content affected learners motivations, confidence and attitudes positively. This was evident through the use of video content to provide course practical as well as simulations.

The second objective in this study was to develop a framework and a tool for monitoring learner-content interaction using NLP. In order to understand how this would be done, section 2.5 of the literature provided various methods that were used for content monitoring. Studies done by Estacio and Raga Jr (2017) indicated how session data analytics were used to collect a learner’s studying behaviour online. In another study, Agnihotri, Aghababyan, Mojarad, Riedesel, and Essa (2015), used machine learning to evaluate the learner’s login attempts with an effort to understand the sessions.

A conceptual framework was developed emphasizing the three content items that were observed in the study. This was key in providing leeway for the development of the tool. The requirements of developing the study were derived from the conceptual framework. Analysis and design were done with the help of Kruchten’s 4+1 view model.

The literature also provided an algorithm that was used for capturing and analysing content interaction levels in all the three content items. Capturing of user sessions was used to store the level of interaction at that particular time. That led to calculating the percentage of interaction as well as dominance of content items.

Lastly, the third objective was to evaluate the level of interaction and dominance of content items. The experiment conducted proved that learner content interaction could be monitored in real time in all the content items. The algorithm discussed in 6.3.1 is a proof that textual content item could be monitored in real time. Both video and audio content items were monitored through capturing current time and seeking time.

There was no dominant content item over the other. The cognitive theory of multimedia learning was evident in the linear regression results. It showed that the three content items were close to each other and could be used in the same content instruction to elaborate various phenomena.
6.5 Recommendations

The artefact developed in this study, indicated that there is more to e-learning that just posting course content for downloading. Self-paced students can be monitoring through their interactions with the content items. It also provided knowledge that instructors could tailor-make content based on their student’s preferences.

For the future, automatic question generation could be applied based the learner’s level of interaction. Using the item dominance evaluation, adaptive learning could be added to the artefact. The study also recommends use of machine learning in the NLP tool to generate abstractive course summaries based on the learner’s studying pace.
REFERENCE


Alhawiti, K. M. (2014). Natural Language Processing and its Use in Education. *IJACSA*  


Made Rajendra, I., & Made Sudana, I. (2018). The Influence of Interactive Multimedia


Appendices

Appendix I: Sample Project Dependencies

```javascript
{
  "name": "elimu_app",
  "version": "0.1.0",
  "private": true,
  "dependencies": {
    "@google-cloud/storage": "^2.3.0",
    "@material-ui/core": "^3.3.2",
    "axios": "^0.18.0",
    "cloudinary-react": "^1.0.0",
    "convertapi": "^1.1.0",
    "final-form": "^4.10.0",
    "firebase": "^5.5.6",
    "fs": "^0.8.1-security",
    "history": "^4.7.2",
    "mui-css": "^0.9.41",
    "patch-package": "^5.1.1",
    "postinstall-prepare": "^1.0.1",
    "pure-react-carousel": "^1.16.0",
    "react": "^16.6.0",
    "react-advanced-form": "^1.5.5",
    "react-advanced-form-addons": "^1.3.3",
    "react-dom": "^16.6.0",
    "react-drozone": "^7.0.1",
    "react-final-form": "^3.6.7",
    "react-flexbox-grid": "^2.1.2",
    "react-router-dom": "^4.3.1",
    "react-scripts": "^2.0.5",
    "react-slideshow-ui": "^1.1.8",
    "request": "^2.88.8",
    "simple-flexbox": "^1.2.0",
    "superagent": "^4.0.0",
    "validator": "^10.8.0",
    "video-react": "^0.13.1",
    "video.js": "^7.3.8"
  },
  "scripts": {
    "start": "react-scripts start",
    "prepare": "patch-package",
    "build": "react-scripts build"
  }
}
```

Figure 49: Artefact Dependencies

The figure above shows the dependencies that were used to enable the project run. Line 6 shows the cloud storage that was used to run the database together with firebase as seen on line 12. Line 10 shows the API that was used to convert pdf files to PNG arrays. These arrays were used to run the textual slider.

Line 28, indicates the slideshow JavaScript library used to enable the textual content usability. Lines 33 and 34 show the video JavaScript libraries.
Appendix II: Sample Project Routes

```javascript
1 import React, { Component } from "react";
2 import { BrowserRouter as Router, Route } from "react-router-dom";
3 import Navigation from ".//Navigation";
4 import HomePage from ".//Home";
5 import Courses from ".//Courses";
6 import ReportsPage from ".//Reports";
7 import createUsers from ".//createUsers";
8 import MyProfilePage from ".//MyProfile";
9 import LogOutPage from ".//LogOut";
10 import SignInPage from ".//SignIn";
11 import SignUPPage from ".//SignUP";
12 import courseContent from ".//courseContent";
13 import courseContentType from ".//courseContentType";
14 import uploadAudio from ".//uploadAudio";
15 import uploadText from ".//uploadText";
16 import uploadvideo from ".//uploadVideo";

17 import * as routes from "../constants/routes";

18 export default class App extends Component {
19     render() {
20         return {
21             <Router>
22                 <div>
23                     <Navigation />
24                     <hr />
25                     <Route exact path={routes.HOME} component={HomePage} />
26                     <Route exact path={routes.COURSES} component={Courses} />
27                     <Route exact path={routes.COURSE_CONTENT} component={courseContent} />
28                     <Route exact
29                         path={routes.COURSE_CONTENT_TYPE}
30                         component={courseContentType}
31                     />
32                     <Route exact path={routes.UPLOAD_AUDIO} component={uploadAudio} />
33                     <Route exact path={routes.UPLOAD_TEXT} component={uploadText} />
34                     <Route exact path={routes.UPLOADVIDEO} component={uploadvideo} />
35                     <Route exact path={routes.REPORTS} component={ReportsPage} />
36                 </div>
37             </Router>
38         }
39     }
40
41 Figure 50: Export and Import of Routes
```

Figure 50: Export and Import of Routes
Appendix III: Sample Project Database Configuration

```javascript
import { db } from "./firebase";

// Create User
export const doCreateUser = (role, email, firstName, lastName, password) =>
  db
  .collection(role)
  .doc()
  .set({
    email,
    firstName,
    lastName,
    password
  });

// Get Students
export const onceGetStudent = uid =>
  db
    .collection("Student")
    .doc(uid)
    .get();

// Get Instructor
export const onceGetInstructor = uid =>
  db
    .collection("Instructor")
    .doc(uid)
    .get();

// Get Slides
export const onceGetSlides = id =>
  db
    .collection("Slides")
    .doc(id)
    .get();

// Create Course
export const doCreateCourse = (courseCode, CourseDescription) =>
  db
    .collection("Courses")
    .doc(courseCode)
    .set({
```

Figure 51: Firebase Database Configuration

In the Firebase database **uid** is created automatically and is unique for every entity in their respective datastores.
Appendix IV: Sample Firebase Authentication Configuration

```javascript
import firebase from "firebase/app";
import "firebase/auth";
import "firebase/firestore";
import "firebase/storage";

const config = {
  apiKey: "",
  authDomain: "elimu-app-f2cb5.firebaseapp.com",
  databaseURL: "https://elimu-app-f2cb5.firebaseio.com",
  projectId: "",
  storageBucket: "elimu-app-f2cb5.appspot.com",
  messagingSenderId: ""
};

if (!firebase.apps.length) {
  firebase.initializeApp(config);
}

const auth = firebase.auth();
const db = firebase.firestore();
const store = firebase.storage();

export { db, auth, store };```

**Figure 52: Firebase Configuration**

The above figure indicates the authentication and authorization keys used to connect to Firebase.
Appendix V: Sample Sign In

```javascript
import React from "react";
import { Form } from "react-advanced-form";
import { Input, Button } from "react-advanced-form-addons";
import { auth } from "../../firebase";
import { withRouter } from "react-router";
import "../../styles/App.css";

class SyncValidation extends React.Component {
  constructor() {
    super();
    this.state = {
      userEmail: "",
      userPassword: "",
      error: "",
      signin: false
    }
  }

  signInUser = event => {
    console.log(this.state);

    const { userEmail, userPassword } = this.state;

    auth
      .doSignInWithEmailAndPassword(userEmail.nextValue, userPassword.nextValue)
      .then(authUser => {
        console.log(authUser);
        this.props.history.push("/courses");
      })
      .catch(error => {
        console.log(error);
        //this.setState(byPropKey('error', error));
      });

    /* Perform async request with the serialized data */
    return new Promise(resolve => resolve());
  }

Figure 53: User Login JS Code
Appendix VI: Sample Audio Content Upload

```javascript
import React, { Component } from "react";
import Dropzone from "react-dropzone";
import "../styles/Upload.css";

export default class uploadAudio extends Component {
  _onDrop = files => {
    console.log(files);
  }
  render() {
    return (
      <div className="Page-Container">
        <Dropzone onDrop={(this._onDrop.bind(this))} accept="audio/*">{
          (isDragAccept, isDragReject, acceptedFiles, rejectedFiles) => {
            if (acceptedFiles.length || rejectedFiles.length) {
              return `Accepted ${acceptedFiles.length}, rejected ${rejectedFiles.length}
            } files`;
          } }
          if (isDragAccept) {
            return "This file is authorized";
          }
          if (isDragReject) {
            return "This file is not authorized";
          }
          return <h3>Click or drag audio files here to upload.</h3>;
        }
      </Dropzone>
      </div>
    );
  }
}
```

Figure 54: Audio Upload JS Code
Appendix VII: Sample Text Content Upload

```javascript
import React, { Component } from "react";
import Dropzone from "react-dropzone";
import "../styles/Upload.css";
import { firebase } from "../firebase";
export default class uploadText extends Component {
  _onDrop = file => {
    console.log(file);
  };
  render() {
    return ( 
      <div className="Page-Container">
        <Dropzone onDrop={this._onDrop.bind(this)} accept="" >
          {isDragAccept, isDragReject, acceptedFiles, rejectedFiles }) => {
            if (acceptedFiles.length || rejectedFiles.length) {
              return `Accepted ${acceptedFiles.length}, rejected ${rejectedFiles.length}
              files`;
            }
            if (isDragAccept) {
              return "This file is authorized";
            }
            if (isDragReject) {
              return "This file is not authorized";
            }
            return <h3>Click or drag text files here to upload.</h3>;
          }
        </Dropzone>
      </div>
    );
  }
}
```

Figure 55: Text Upload JS Code
Appendix VIII: Sample Video Content Upload

```javascript
import React, { Component } from "react";
import Dropzone from "react-dropzone";
import "../styles/Upload.css";

export default class uploadVideo extends Component {
  _onDrop = files => {
    console.log(files);
  }
  render() {
    return {
      <div className="Page-Container">
        <Dropzone onDrop={(this._onDrop.bind(this))} accept="video/*">
          {({ isDragAccept, isDragReject, acceptedFiles, rejectedFiles }) => {
            if (acceptedFiles.length || rejectedFiles.length) {
              return `Accepted ${acceptedFiles.length}, rejected ${rejectedFiles.length} files`;
            }
            if (isDragAccept) {
              return "This file is authorized";
            }
            if (isDragReject) {
              return "This file is not authorized";
            }
            return <h3>Click or drag video files here to upload.</h3>;
        }}
      </Dropzone>
    </div>
  }
};
```

Figure 56: Video Upload JS Code
import "react-bootstrap-table2-paginator/dist/react-bootstrap-table2-paginator.min.css";
export default class ReportsPage extends Component {
  constructor(props) {
    super(props);
    this.state = {
      audioVideoData: [],
      week1: [],
      week2: [],
      week3: [],
      week4: []
    }
  }
  componentDidMount() {
    let SessionRef = firebase.db.collection("Session");
    let { audioVideoData } = this.state;
    SessionRef.get()
      .then(snap => {
        snap.forEach(doc => {
          let sesh = doc.data().session;
          if (sesh.courseId) {
            //console.log(sesh);
            if (sesh.format === "text") {
              //console.log("TEXT");
            } else {
              audioVideoData.push(sesh);
              console.log(audioVideoData);
              let myArr = audioVideoData;
              let week1s = _.map(myArr, function(o) {
                if (o.week === "week1") return o;
              });
              week1s = _.without(week1s, undefined);
              console.log(week1s);
              //console.log(sesh.format);
            }
          }
        })
      });
}

Figure 57: Reports JS Code
Appendix X: Sample Python Text Processor

```python
def word_count(content_id, student_id, contents):
    total_words = 0
    words = []
    word_count = 0
    all_content = JsonContent.objects.filter(content_id=content_id).get()
    all_content = all_content.content
    for content in all_content:
        content = content['content']
        tokenized_words = content.split()
        total_words = total_words + len(tokenized_words)
        for i in contents:
            tokenized_words = i.split()
            words = words + len(tokenized_words)
            word_count = str(words) + '/' + str(total_words) + ' ' + str(words/total_words * 100) + '%
            try:
                student_word_count = StudentWordCount.objects.filter(content_id=content_id, user_id=student_id).get()
                student_word_count.word_count = word_count
                student_word_count.save()
            except StudentWordCount.DoesNotExist:
                StudentWordCount.objects.create(content_id=content_id, user_id=student_id, word_count=word_count)

class StudentContentView(APIView):
    def get(self, request, content_id=None, student_id=None):
        student_content = StudentContent.objects.filter(content_id=content_id, student_id=student_id).get()
        return Response(
            "content_id": student_content.content_id,
            "student_id": student_content.student_id,
            "content": student_content.content
        )

class StudentContentPostView(APIView):
    def post(self, request):
        data = request.data
        try:
            student_content = StudentContent.objects.filter(content_id=data['content_id'], student_id=data['student_id']).get()
            json_content = JsonContent.objects.filter(content_id=data['content_id']).values('content')
            content = []
            json_content = json_content.get()
Appendix XI: Sample Database

Figure 59: Firebase Database
Appendix XII: Sample CDN Content Storage

Figure 60: Cloudinary CDN Content Storage
Appendix XIII: Course Content

Below is an excerpt of the course: - principles of microeconomics by Gruber (2011), adapted from the MIT open courseware for undergraduates. This course contains both videos and lecture notes.

Figure 61: Principles of Microeconomics MIT Open Courseware

The course is about fundamentals of microeconomics. That includes, supply and demand as well as the basic forces that control balance in a market economy.
Appendix XIV: System Access Matrices

The tables below show different user access matrices to the system. Each table contains the name allocated to every user, a unique username and a password for accessing the system.

Table 38: Students’ Access Matrix

<table>
<thead>
<tr>
<th>User</th>
<th>Username</th>
<th>Password</th>
<th>User</th>
<th>Username</th>
<th>Password</th>
</tr>
</thead>
<tbody>
<tr>
<td>User1</td>
<td><a href="mailto:user1@elimu.com">user1@elimu.com</a></td>
<td>1@Elimu</td>
<td>User26</td>
<td><a href="mailto:user26@elimu.com">user26@elimu.com</a></td>
<td>26@Elimu</td>
</tr>
<tr>
<td>User2</td>
<td><a href="mailto:user2@elimu.com">user2@elimu.com</a></td>
<td>2@Elimu</td>
<td>User27</td>
<td><a href="mailto:user27@elimu.com">user27@elimu.com</a></td>
<td>27@Elimu</td>
</tr>
<tr>
<td>User3</td>
<td><a href="mailto:user3@elimu.com">user3@elimu.com</a></td>
<td>3@Elimu</td>
<td>User28</td>
<td><a href="mailto:user28@elimu.com">user28@elimu.com</a></td>
<td>28@Elimu</td>
</tr>
<tr>
<td>User4</td>
<td><a href="mailto:user4@elimu.com">user4@elimu.com</a></td>
<td>4@Elimu</td>
<td>User29</td>
<td><a href="mailto:user29@elimu.com">user29@elimu.com</a></td>
<td>29@Elimu</td>
</tr>
<tr>
<td>User5</td>
<td><a href="mailto:user5@elimu.com">user5@elimu.com</a></td>
<td>5@Elimu</td>
<td>User30</td>
<td><a href="mailto:user30@elimu.com">user30@elimu.com</a></td>
<td>30@Elimu</td>
</tr>
<tr>
<td>User6</td>
<td><a href="mailto:user6@elimu.com">user6@elimu.com</a></td>
<td>6@Elimu</td>
<td>User31</td>
<td><a href="mailto:user31@elimu.com">user31@elimu.com</a></td>
<td>31@Elimu</td>
</tr>
<tr>
<td>User7</td>
<td><a href="mailto:user7@elimu.com">user7@elimu.com</a></td>
<td>7@Elimu</td>
<td>User32</td>
<td><a href="mailto:user32@elimu.com">user32@elimu.com</a></td>
<td>32@Elimu</td>
</tr>
<tr>
<td>User8</td>
<td><a href="mailto:user8@elimu.com">user8@elimu.com</a></td>
<td>8@Elimu</td>
<td>User33</td>
<td><a href="mailto:user33@elimu.com">user33@elimu.com</a></td>
<td>33@Elimu</td>
</tr>
<tr>
<td>User9</td>
<td><a href="mailto:user9@elimu.com">user9@elimu.com</a></td>
<td>9@Elimu</td>
<td>User34</td>
<td><a href="mailto:user34@elimu.com">user34@elimu.com</a></td>
<td>34@Elimu</td>
</tr>
<tr>
<td>User10</td>
<td><a href="mailto:user10@elimu.com">user10@elimu.com</a></td>
<td>10@Elimu</td>
<td>User35</td>
<td><a href="mailto:user35@elimu.com">user35@elimu.com</a></td>
<td>35@Elimu</td>
</tr>
<tr>
<td>User11</td>
<td><a href="mailto:user11@elimu.com">user11@elimu.com</a></td>
<td>11@Elimu</td>
<td>User36</td>
<td><a href="mailto:user36@elimu.com">user36@elimu.com</a></td>
<td>36@Elimu</td>
</tr>
<tr>
<td>User12</td>
<td><a href="mailto:user12@elimu.com">user12@elimu.com</a></td>
<td>12@Elimu</td>
<td>User37</td>
<td><a href="mailto:user37@elimu.com">user37@elimu.com</a></td>
<td>37@Elimu</td>
</tr>
<tr>
<td>User13</td>
<td><a href="mailto:user13@elimu.com">user13@elimu.com</a></td>
<td>13@Elimu</td>
<td>User38</td>
<td><a href="mailto:user38@elimu.com">user38@elimu.com</a></td>
<td>38@Elimu</td>
</tr>
<tr>
<td>User14</td>
<td><a href="mailto:user14@elimu.com">user14@elimu.com</a></td>
<td>14@Elimu</td>
<td>User39</td>
<td><a href="mailto:user39@elimu.com">user39@elimu.com</a></td>
<td>39@Elimu</td>
</tr>
<tr>
<td>User15</td>
<td><a href="mailto:user15@elimu.com">user15@elimu.com</a></td>
<td>15@Elimu</td>
<td>User40</td>
<td><a href="mailto:user40@elimu.com">user40@elimu.com</a></td>
<td>40@Elimu</td>
</tr>
<tr>
<td>User16</td>
<td><a href="mailto:user16@elimu.com">user16@elimu.com</a></td>
<td>16@Elimu</td>
<td>User41</td>
<td><a href="mailto:user41@elimu.com">user41@elimu.com</a></td>
<td>41@Elimu</td>
</tr>
<tr>
<td>User17</td>
<td><a href="mailto:user17@elimu.com">user17@elimu.com</a></td>
<td>17@Elimu</td>
<td>User42</td>
<td><a href="mailto:user42@elimu.com">user42@elimu.com</a></td>
<td>42@Elimu</td>
</tr>
<tr>
<td>User18</td>
<td><a href="mailto:user18@elimu.com">user18@elimu.com</a></td>
<td>18@Elimu</td>
<td>User43</td>
<td><a href="mailto:user43@elimu.com">user43@elimu.com</a></td>
<td>43@Elimu</td>
</tr>
<tr>
<td>User19</td>
<td><a href="mailto:user19@elimu.com">user19@elimu.com</a></td>
<td>19@Elimu</td>
<td>User44</td>
<td><a href="mailto:user44@elimu.com">user44@elimu.com</a></td>
<td>44@Elimu</td>
</tr>
<tr>
<td>User20</td>
<td><a href="mailto:user20@elimu.com">user20@elimu.com</a></td>
<td>20@Elimu</td>
<td>User45</td>
<td><a href="mailto:user45@elimu.com">user45@elimu.com</a></td>
<td>45@Elimu</td>
</tr>
<tr>
<td>User21</td>
<td><a href="mailto:user21@elimu.com">user21@elimu.com</a></td>
<td>21@Elimu</td>
<td>User46</td>
<td><a href="mailto:user46@elimu.com">user46@elimu.com</a></td>
<td>46@Elimu</td>
</tr>
<tr>
<td>User22</td>
<td><a href="mailto:user22@elimu.com">user22@elimu.com</a></td>
<td>22@Elimu</td>
<td>User47</td>
<td><a href="mailto:user47@elimu.com">user47@elimu.com</a></td>
<td>47@Elimu</td>
</tr>
<tr>
<td>User23</td>
<td><a href="mailto:user23@elimu.com">user23@elimu.com</a></td>
<td>23@Elimu</td>
<td>User48</td>
<td><a href="mailto:user48@elimu.com">user48@elimu.com</a></td>
<td>48@Elimu</td>
</tr>
<tr>
<td>User24</td>
<td><a href="mailto:user24@elimu.com">user24@elimu.com</a></td>
<td>24@Elimu</td>
<td>User49</td>
<td><a href="mailto:user49@elimu.com">user49@elimu.com</a></td>
<td>49@Elimu</td>
</tr>
<tr>
<td>User25</td>
<td><a href="mailto:user25@elimu.com">user25@elimu.com</a></td>
<td>25@Elimu</td>
<td>User50</td>
<td><a href="mailto:user50@elimu.com">user50@elimu.com</a></td>
<td>50@Elimu</td>
</tr>
</tbody>
</table>

Table 39: Instructor's Access Matrix
### Instructor User Access Matrix

<table>
<thead>
<tr>
<th>User</th>
<th>Username</th>
<th>Password</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor1</td>
<td><a href="mailto:instructor1@elimu.com">instructor1@elimu.com</a></td>
<td>Inst1@elimu</td>
</tr>
</tbody>
</table>

### Table 40: Admin Access Matrix

<table>
<thead>
<tr>
<th>User</th>
<th>Username</th>
<th>Password</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admin</td>
<td><a href="mailto:admin@elimu.com">admin@elimu.com</a></td>
<td>aDm!n@elimu</td>
</tr>
</tbody>
</table>