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ANALYSIS AND DESIGN OF MULTIMODAL AND MULTIMEDIA USER INTERFACE FOR E-LEARNING BASED REMEDIAL EDUCATION

Master thesis

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Abstract

The purpose of this study was to identify the current approaches to integrating multimodal user interface design principles into existing E-learning platforms and how these patterns can be applied to the design of E-learning platforms tailored towards E-learning based Remedial Education. A literature review and document analysis have been done to understand the challenges faced by students in Remedial Education and how these can be addressed based on the Critical Success Factors(CSFs) identified from existing Computer-Supported Collaborative Learning(CSCL) literature. Through the study, three main personas have been identified for learners in Remedial education. Using the document analysis methodology, the User Interface (IU) of ten E-learning platforms were studied to understand the current application of multimodal theory and multimedia tools and principles in the User Interface Design of E-learning platforms.

On the bases of the personas determined, the CSFs and the current application of multimodal principles in the design of E-learning user interfaces, a design has been proposed and tested that incorporates multimodal and multimedia design principles such as video lectures, text to speech, and peer and tutor feedback which are critical components of Remedial education.

Whilst the need for quick and direct feedback in E-learning is well established, the existing platforms mainly employ text-based forums or question and answer like mechanisms as the main feedback mechanism in their user interfaces. This study proposes that, given the engineering capabilities available today, E-learning platforms for Remedial Education would benefit from integrating videos, voice and text-based feedback and other multimodal communication mechanisms to achieve the critical success factors.

Keywords: E-learning, multimedia, multimodal, redial education, user interfaces.

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List of Abbreviations

CSFs	Critical Success Factors
UI	User interface
MUI	Multimodal User Interface
GUI	Graphical User Interface
CSCL	Computer Supported Collaborative Learning
LMS	Learning Management System
MOOC	Massive Open Online Course
SUS	System Usability Scale
IDE	Integrated Development Environment
CC	Closed Caption
AMPs	Active Multimodal Presentations (AMPs)
AI	Artificial Intelligence
IDE	Integrated Development Environment

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1. Introduction

This work is aimed at understanding current approaches to integrating multimodal user interface design principles into existing E-learning platforms and how these approaches can be applied to designing user interfaces tailored to E-learners in Remedial education. A systematic literature review has been conducted identifying the personas, challenges, goals and the Critical Success Factors of E-learning and Remedial education. A detailed document analysis of ten E-learning platforms has been done identifying the approaches and patterns employed in integrating multimodal and multimedia functionality into their user interfaces. Lastly, a prototype has been developed and tested incorporating multimodal user interface design principles to support learners in post secondary Remedial education.

1.1 Definitions

We briefly define some key terminology that would be used in this work as defined by various authors.

1.1.1 Multimodal Theory

Multimodality is a theory that deals with how people communicate and interact with each other. It includes a variety of modes, including image, gaze, gesture, movement, music, speech and sound and other visual forms(Niels, 2008; Kress et al, 2001).

1.1.2 Remedial Education

Remedial education is used in different countries for different purposes, in more developed countries, it is used to bridge the gap and learning deficiencies between students entering universities from different backgrounds for instance students coming from other countries or from backgrounds with known education deficiencies. Remedial education is also referred to in the literature as developmental education and is meant for imparting developmental or basic skills. In this case it refers to courses taken on a college campus that are below college level and mainly aimed at bringing students who were initially underprepared for college level education

in writing and math up to the threshold for registration into credit-bearing courses (The Alliance for Excellent Education, 2011 as quoted by Lotte et al, 2009).

(Battistin et.al, 2002) provides an alternative view of remedial programmes describing them as "a course consisting in extra-class time offered to low-achieving students in order to improve their performance in one or more subjects" (Oduro-ofori et al., 2014). (Oduro-ofori et al., 2014) based on the various characteristics drawn from different authors succinctly defines Remedial education as "coursework that is offered at the postsecondary level to boost the academic performance of underprepared or low-achieving students in order to earn them a place in the higher institutions." In this work, the later definition provided by (Oduro-ofori et al., 2014) would be our working definition.

1.1.3 Computer Supported Collaborative Learning(CSCL)

Computer-Supported Collaborative Learning (CSCL) refers to the activity of peers interacting with each other for the purpose of learning and with the support of information and communication technologies (ICT). CSCL also refers to the learning that results from such activity, and to the research field that studies such activity (Suthers, 2012).

1.1.4 E-Learning

E-learning is a concept in which digital training contents are provided to participants via the internet, intranet or extranet connection and participants are provided with various options of communication. In plain words E-learning is the ability to access learning tools (learning resources) anytime and anywhere (Holmes & Gardner, 2006; Yılmaz, 2012 as quoted in Ülker et. al , 2016).

1.1.5 Learning Management Systems (LMS)

A learning management system (LMS) is an online platform that enables the delivery of materials, resources, tools, and activities to students both in and out of the classroom environment. It allows teachers to offer tailored instruction that can be accessed by students anytime, anywhere without geographic constraints (K-12 Blueprint, 2014).

For convenience, in this work, no distinction would be made between CSCL, E-learning and LMS platforms. The term “E-learning” would be used mostly in this work in their stead.

1.2 Research problem and significance

In developing countries Remedial education is an important part of the educational set up (Oduro-ofori et al., 2014; Schwartz & Analice, 2012). This is more so in countries where standardized placement testing is needed after post secondary education to enter tertiary institutions (Biao, 1992; Chitsa, 2018). The Figure 1 below illustrates the role of Remedial education in the Ghanaian Education System. In these cases a student's failure to pass standardized placement tests at the end of secondary school education can lead to the student dropping out of the school system(Alfonso et al., 2018; Shahidul & Karim , 2015). When students fail their secondary school examinations they might find alternative education such as Vocational Education or enter the Remedial education system(Biao, 1992). Traditional Remedial education comes at a high cost and this coupled with lack of infrastructure and support systems results in students essentially becoming school dropouts (Alfonso et al., 2018; Shahidul & Karim, 2015).

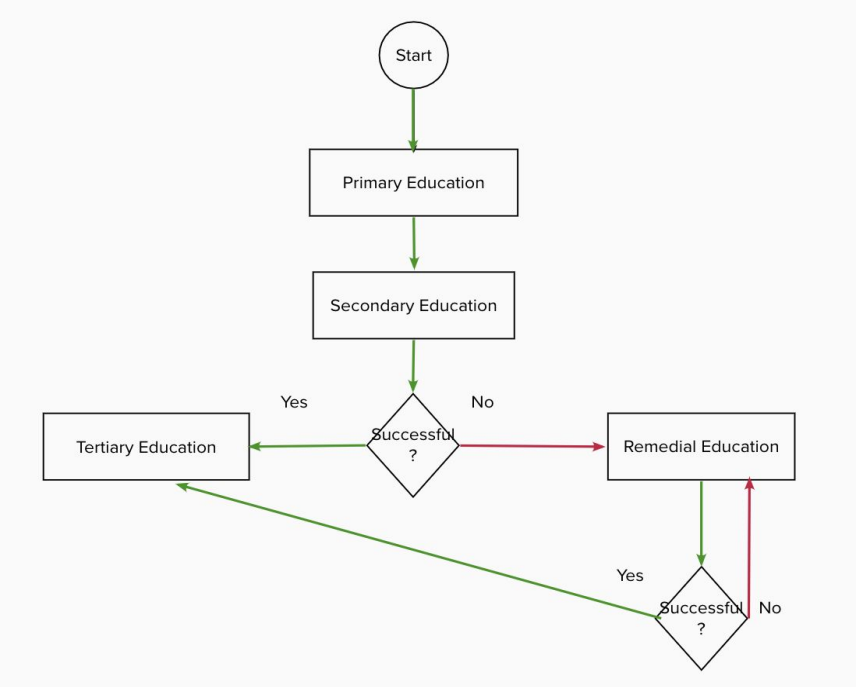


Figure 1: A simplified diagram of the education system Ghana illustrating the role Remedial education.

In addition to the aforementioned problems plaguing Remedial education, students in Remedial education might require different learning environments (Robert,1958; Beena, 2019), teaching techniques and learning activities to effectively overcome their learning difficulties (Mercer & Mercer, 1989).

The application of E-learning in Remedial education is growing. E-learning for Remedial education has found applications in English Language Remedial Education (Luo, 2009), and in remediating Reading deficiencies, (Ali & Zahari, 2005). Until recently, there was little work on E-learning user interfaces as noted by Faghih (Faghih et al, 2014). There has been increasing interest in the topic however and recent works on the topic have been done by (Podder et al, 2016) on developing a user interface framework for E-learning through mobile devices. Some recent studies have been focused on evaluating the usability of E-learning platforms (Junus et al, 2015). (Farhan et al, 2016) studied E-learning user interfaces for Visual and Hearing Impaired Students. However this study found no peer reviewed literature on understanding how to design effective user interfaces specifically for E-learning based Remedial education.

In this work, we focused on the use of Multimodality theory, E-learning and Remedial Education approaches to design effective user interfaces for E-learning for students in Remedial education. The approaches explored included techniques aimed at improving social interaction, increasing cohesion and collaboration amongst students and creating reflective study activities to enhance students' learning (Kreijns et al.,2013; Kreijns et al.,2002).

This study focused on understanding the needs, challenges and critical success factors of remedial students and how these can be addressed using the techniques and findings available in Remedial education literature in particular Multimodality Theory.

This study investigates how existing E-learning platforms incorporate multimodality into their user interfaces, examine how multimodality in E-learning can improve learning outcomes of remedial students and propose a conceptual prototype of a user interface to address the needs of post secondary Remedial education students. Such a platform when developed will provide support for students to remediate and achieve their educational goals at a reduced cost compared to traditional face to face remedial courses and thus help bridge

the gap for students in areas lacking infrastructure and the necessary support systems.

This thesis represents a comprehensive report documenting user interface patterns used in existing E-learning platforms, an analysis of user requirements derived from the development of personas and user needs analysis based on the critical success factors of E-learning and Remedial education and finally a prototype incorporating multimodal theory of user interactions and demonstrating best practises from from literature to enhance collaboration, improve motivation and enhance interaction for Remedial education.

1.3 Research goal and motivation

The goal is to analyse and design an innovative E-learning product based on the existing E-learning knowledge base and best practises that offers students the opportunity to remediate their school work at a reasonable cost and thus help reduce the negative consequences associated with this phenomena. The aim is to leverage the increasing internet and digital penetration in developing countries to deliver Remedial education.

This study seeks to prototype various user interaction techniques particularly multimodal user interaction techniques to help students and E-learning practitioners to address their specific needs in order to be able to organise authentic and meaningful activities, manage the complexities of E-learning and address problems peculiar to Remedial education.

1.4 Research Questions

Two main research questions are proposed for this study, first we want to understand the state of the art practises of how existing E-learning platforms incorporate multimodal and multimedia interface techniques for their users. We want to understand which patterns are common among them and why they are used. Specifically, our first research question is:

- **Q1: What multimodal user interface techniques are used in existing E-learning platforms?**

The second question we seek to answer is what multimodal and multimedia techniques can be incorporated into the design of an E-learning platform to support learners in post secondary

Remedial education. We approach this problem by proposing a prototype of a novel E-learning platform and evaluating the usability of a proposed design.

- **Q2: What multimodal user interface techniques can be used in E-learning to enhance remedial learning?**

1.5 Research Methodology and Procedure

Due to the nature of the research questions to be answered a document analysis approach would be adopted. Document analysis is a form of qualitative research in which documents are interpreted by the researcher to give voice and meaning around an assessment topic (Bowen, 2009). In this work a documentary analysis of existing E-learning platforms and CSCL literature would be done. The user interfaces patterns of ten existing E-learning and collaborative learning environments were reviewed and a prototype was proposed to meet the needs of learners in Remedial education. We then employed a semi-structured user interview together with the Think-aloud method[1](Nielsen, 2012) of usability evaluation to test our prototype. The think-aloud method is a usability testing method where test participants use the system while continuously thinking out loud, that is, simply verbalizing their thoughts as they navigate the user interface.

Lastly, we used the System Usability Scale (SUS)[2] (Brooke, 1996) to gather usability information of our proposed design due to its quick and easy administration. The SUS is a usability testing instrument that has been extensively adopted for usability questionnaires for the appraisal of perceived usability of commercial products.

1.5.1 Theoretical Background

The first phase of this study was a literature review based on the collected papers in Remedial education, multimodality theory and the CSCL domain to establish a good theoretical background for this study. This was done to expand the basis of the thesis, expound on the research problem and recommended solutions in the literature and help establish the goals, challenges and CSFs of remedial students.

[1] https://www.nngroup.com/articles/thinking-aloud-the-1-usability-tool/

[2] https://en.wikipedia.org/wiki/System_usability_scale

1.5.2 Analysing Existing E-learning and LMS platforms

In the next phase, a document analysis study of various learning management platforms was done and the multimodal and multimedia features and patterns were documented. The platforms chosen for this study are : Open edX, Coursera, LinkedIn, Amity Online, Busuu, Duolingo, Cognitive Class, Udemy, Future Learn, and Khan Academy that incorporate multimodal user interface techniques.

1.5.3 Prototyping of User Interaction Patterns

A prototype was then developed incorporating various multimodal and multimedia patterns from literature and the document analysis of the above mentioned E-learning platforms. The Figma design and prototyping tool was used for this exercise.

1.5.4 Usability Testing of Prototype

The study was completed by conducting usability testing of the proposed design to understand how our proposed design would be useful to our e-learners and recommend improvements based on the outcome of the usability testing.

1.6 Structure of the thesis

The structure of the thesis is illustrated in Figure 2 below, it is organised as follows: In the first chapter, we briefly define some relevant terminology for this work most important among them being the concepts of Multimodal Theory and Remedial Education. We then proceed to define the research problem and the significance of the problem, the goals this work seeks to achieve and the Research Methodology adopted to understand and address the problem.

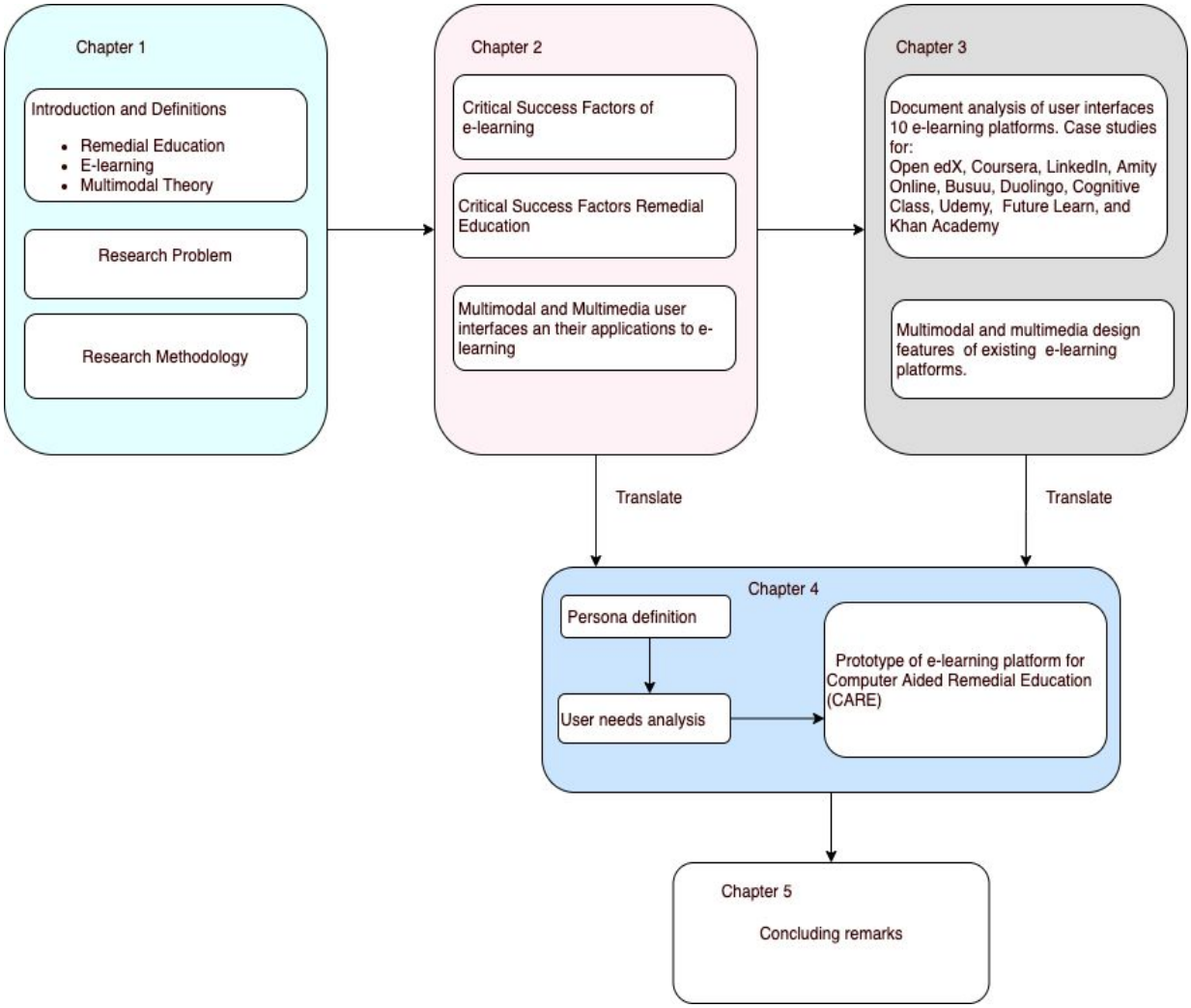


Figure 2: Structure of the thesis.

The next chapter is dedicated to a review of current literature. We focus on the Critical success factors (CSFs) of E-learning and Remedial education. In addition, we delve into the concepts of Multimodal and Multimedia User interfaces to understand their relationship and the guidelines from literature of how these concepts should be applied to the design of user interfaces to The third chapter of this work will focus on a document analysis of ten E-learning platforms namely: Open edX, Coursera, LinkedIn, Amity Online, Busuu, Duolingo, Cognitive Class, Udemy, Future Learn, and Khan Academy. The chapter concludes with the discussion of the features, multimodal and multimedia user interface design patterns employed by these platforms and how they can be applied in the context of E-learning for Remedial education given our knowledge of the CSFs.

In chapter 4, a design is proposed for an E-learning platform to support Remedial education. Using the work done by (Oduro-ofori et al., 2014), personas are defined for the type of students that are involved in Remedial education. An additional persona is defined for the teacher. A user needs analysis is carried out for these features and a feature list is built out of these needs. Using the knowledge of the CSFs and the multimodal design patterns from the previous chapter, a conceptual prototype is proposed called Computer Aided Remedial Education(CARE). We further present in this chapter the results of our usability testing of the proposed design.

Finally, in the last chapter, we share some concluding remarks on this work as well as some remarks on the limitations of this work and the next relevant steps.

2. Theoretical Background

A number of compounding factors have been identified for the phenomenon of school dropouts including the cost of education, social circumstances and conditions within schools that contributes to school dropouts. These factors include: the attitude of teachers and peers' to students who are handicaped physically or intellectually, grade or class repetition of underperforming students, the lack of attention from teachers and teenage pregnancy(Adam et al., 2016; Sarker et al., 2019; Ananga, 2010). These factors can further be classified into political factors, environmental factors, government initiatives to reduce dropout, geographical factors and social norms and values (Sarker et al., 2019).

School dropouts experience significant social and economic consequences throughout their lives such as fewer employment opportunities and negative impacts on individual psychological well-being(Alfonso, 2018; Owusu-Boateng, 2015; Shahidul & Karim, 2015). The general society on its part has the burden of having to provide social assistance or having to deal with drugs, crime and other delinquent behaviours due to the inability of dropouts to secure skilled employment (Owusu-Boateng, 2015; Sabates et al, 2010). A detailed study conducted in Ghana, highlight some of the reasons leading to high failure rates in post secondary placement examinations including: teachers' inability to complete between 50% and 75% of the curricula, insufficient-time to enact and complete the curriculum, lack of enough qualified teachers, and use of poor teaching approaches (Abreh, 2018). The multidimensional nature of the causes of poor performances and failure in secondary school education have been studied in (Ajayi & Osalusi, 2013). Due to the aforementioned issues and consequences of school dropouts, in many countries Remedial education is an essential part of the education system (Schwartz & Analice, 2012).

Traditional, classroom based Remedial education and the educators involved face many challenges. Some of the challenges facing teachers in Remedial education includes; lack of suitable room for remedial classes, lack of funds to purchase and develop learning materials and lack of support from other colleagues and school administrators (Kasran et al, 2012), lack of inservice training and ineffective methods and materials of teaching (Chitsa, 2018). In some

instances teachers may not be equipped or qualified to handle students in Remedial education, even in cases where teachers have the right qualifications they may lack the expertise to deal with remedial students in their classrooms (Townsend, 2007 as cited in Chitsa, 2018). This lack of expertise is compounded by the fact that students in Remedial education are more likely to suffer from severe academic deficiencies like short attention span, weak problem solving skills, poor memory, lack of self confidence and low self esteem.

The ubiquitous nature of the internet and the advances in E-learning and Learning Management Systems can help address some of the above mentioned problems related to funding, teaching materials and infrastructure (Manisah & Zawawi 2005). Providing the necessary online learning environment for remedial students is a challenge given that E-learners require a higher level of discipline, dedication and self starter initiative than traditional face to face education.

In addition to the above, the existing E-learning and learning management platforms have been built for a different student audience and do not address the specific needs of remedial students. E-learning is most effective and achieves best performance when the contents adapt for the learners. There is therefore the need to design E-learning platforms targeting specifically the needs of students in Remedial education.

Most existing E-learning interfaces are largely text-based with graphics and mostly disregard the use of other communication metaphors within the visual and auditory channels (Alseid & Rigas, 2009). The lack of multi modality, puts stress on the students visual channel. In order to increase usability of such interfaces, some studies suggest incorporating different communication metaphors into user interfaces for E-learning allowing an increased use of visual and auditory channels and hence increase the usability of the interfaces. The advantages to multi-modal user interfaces for E-learning interfaces such as shorter task completion, high tasks completion and general student satisfaction have been established (Alseid & Rigas, 2009; Sallam & Rigas, 2009; Rigas & Sallam, 2010). Other studies have also found that audio feedback from teachers and peers might have a more positive effect on students as it provides more avenues for reflection (Cann, 2014).

Finally, the current CSCL literature espouses learner centric approaches to learning (Ibrahim & Khalil 2017; Thropp et al, 2020). To this end, this study will also take a look at how to integrate the learner centric, collaborative practises into the user interfaces and reduce the amount of scaffolding / scripting by teachers that traditionally characterizes Learning Management Systems. This is because over-scripting has been found to have various counterproductive effects on learners including disturbing the natural interactions, problem solving processes and increasing cognitive load on the students (Dillenbourg, 2002).

In the next session of this study, we examine some of the success factors of E-learning as well as the success factors for Remedial education. This is done to broaden our understanding of what students in Remedial education need to succeed in their learning goals and enhance our understanding of what should go into the design of user interfaces to support them E-learning for Remedial education. This rational and thought process is illustrated in the Figure 3 below.

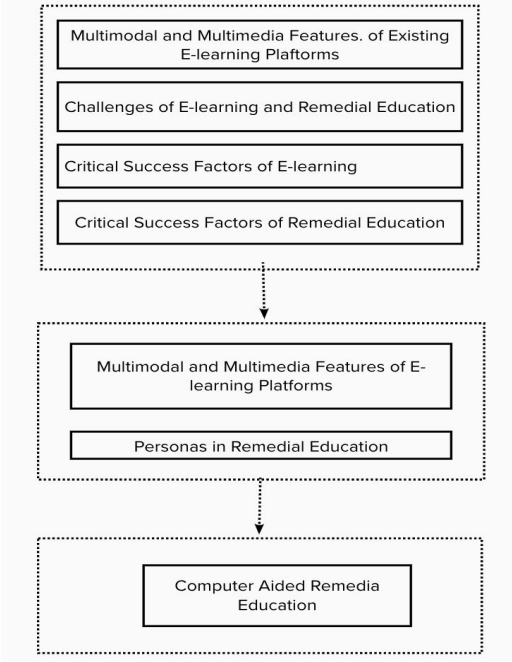


Figure 3: Main ideas and components motivating the thesis

Thus, by combining our knowledge of multimodal and multimedia features of existing E-learning platforms, the challenges of E-learning and the CSFs for E-learning and Remedial

Education, we identified the personas, goal, motivations and challenges of learners, and the multimodal features that can be used to address the challenges and enhance the CSFs and hence lead to the development of an effective and efficient Computer Aided Remedial Education (CARE).

2.1 Critical Success Factors (CSFs) for E-learning

E-learning has its own challenges. For instance the completion or retention rates amongst students in E-learning are still lower than the counterparts in face to face courses and blended learning environments (Bawa, 2016). However, due to the rapid development, ubiquity and interest of E-learning, there is a large body of research on success factors from different studies addressing different E-learning audiences.

Critical success factors are those areas that must be critically taken care of to ensure the success of E-learning implementation. CSFs in E-learning have been classified by various studies into categories such as instructor characteristics, student characteristics, ICT infrastructure, institutional support, ease of access, user interface design, level of interaction, system quality, service quality, and internet quality etc. **(**Parsazadeh et al, 2013, Musa et al, 2012)**. (**Musa et al, 2012) found that in a large Malaysian undergraduate audience, internet browsing speed and instructor participation in discussion groups are the most critical factors for E-learning. (Parsazadeh et al, 2013) found the following CSFs in an Australian university:

- Ease of access determined by correct information architectire, well designed navigation of the user interface and the level of usability of the E-learning platform and general look and feel(i.e Typography , Color Schemes).
- Technical competence, teaching style, and interaction capabilities of the instructor influence outcomes.
- Previous experience of students with the use of technology i.e computer and internet use literacy, anxiety and attitudes to use of technology also influence the outcomes of E-learning.

(Bhuasiri et.al, 2012) defined a framework for understanding the CSFs of E-learning illustrated in Figure 4 below, this work enumerated the following as CSFs for E-learning in developing countries :

- Motivation of learners.
- Awareness and knowledge of E-learning technologies.
- Institutional support.
- Quality of ICT infrastructure.
- Quality of instructors and content.

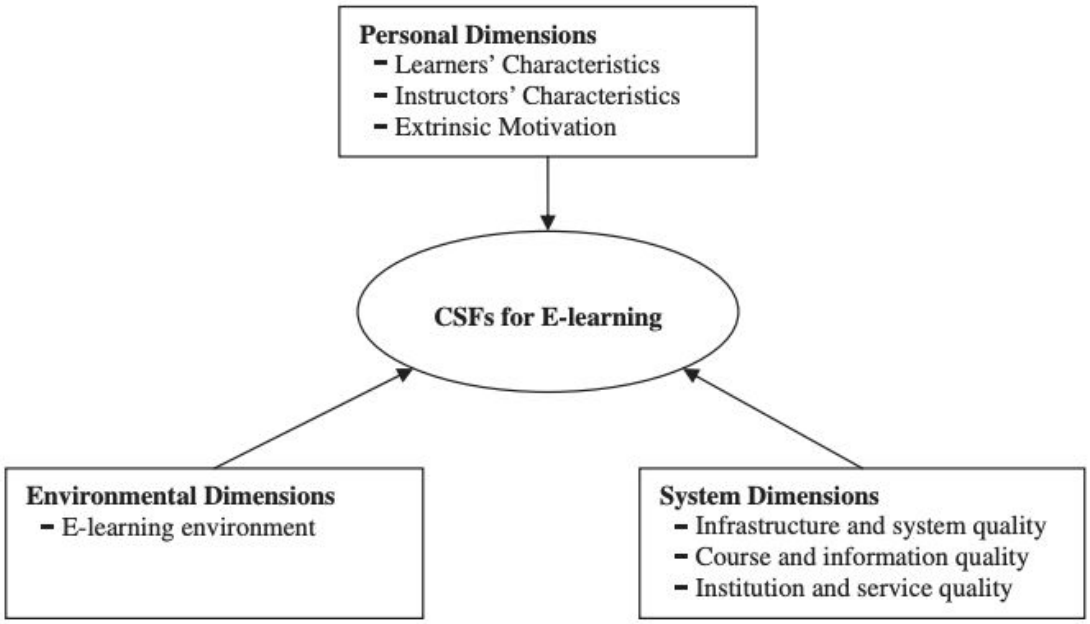


Figure 4: A research framework for understanding CSFs for E-learning. Reproduced from (Bhuasiri et.al , 2012)

2.2 Critical Success factors for Remedial education.

Many studies have been done on the CSFs of face-to-face Remedial education. In the case of online Remedial education, (Lotte et al, 2009) enumerated 24/7 online availability, adaptability to meet the needs of students who may have different learning styles, different prior competencies. Related to the concept of adaptability is the concept of flexibility in E-learning. E-learning for Remedial education should have flexible learning methods and assessments so that students would have maximum freedom to schedule their individual learning. Active stimulation of communication between students and teachers is another important success factor and hence quick and direct feedback and interaction mechanisms should be integrated in E-learning platforms. Another CSF of E-learning is the integration of activities to stimulate active learning. E-learning interfaces should thus be structured to support learners in this way. Researchers also found that experiences with online education are positive when quick and direct feedback and adequate technical support is given by teachers and students learn in a highly structured and well-designed course interface (El Mansour & Mupinga, 2007 ad quoted by Lotte et al 2009)

2. 3 Multimodal and Multimedia User Interfaces

Human interaction in the world is inherently multimodal, we employ multiple senses to passively and actively interact without our environment, to confirm expectations about our environs and to perceive new information. In contrast, HCI has historically been focused on unimodal forms of communication where information is primarily a single mode or channel such as text on a screen for output and a keyboard for input.

Multimodal interfaces describe interactive systems that seek to leverage natural human capabilities to communicate via speech, gesture, touch, facial expression, and other modalities, bringing more sophisticated pattern recognition and classification methods to human–computer interaction (Turk, 2014).

Multimodal interfaces are achieved through a process called fusion. Fusion is done to extract meaning from a set of input modalities and this meaning is then passed to a human-machine dialog manager which then decides the output modality.

Table 1 below presents the distinguishing differences between general Graphical User Interfaces(GUI) and Multimodal User Interfaces(MUI) as follows.

GUI	MUI
Single input stream	*Multiple input streams*
Atomic, deterministic	*Continuous, probabilistic*
Sequential processing	*Parallel processing*
Centralized architectures	*Distributed & time-sensitive architures*

Table 1: Differences between GUIs and MUIs. Reproduced from (Dumas et. al, 2009)

Multimodal user interfaces are growing in importance due to advances in both hardware and software and the benefits these interfaces offer to users and the natural fit into solving certain usability problems in increasingly ubiquitous computing applications.
(Turk, 2014) enumerated a number of benefits of multimodal interfaces namely: Flexible use of inputs, potential improvement of efficiency, support for shorter or simpler speech utterances for voice only user interfaces, greater precision of spatial information, affordances of alternative interaction techniques, enhanced error avoidance and ease of error resolution, wider range of users; tasks and environmental conditions, accommodation for user handicaps and prevents overuse of unimodal interaction for extended computer usage.

(Anastopoulou et. al, 2001) defined the commonality and difference between multimedia and multimodal systems. Medium is defined as a means of conveying information to people and could take the form of diagrams , text, sound etc. Multimedia can be defined as computer information represented through audio, video, and animation in addition to traditional information conveying methods through text, graphics drawings, images)

In E-learning parlance, modality refers to the sensory or perceptual experience such as auditory, visual, tactile etc and is closely related to the individual. Multimodality thus refers to the use of at least two sensory modalities by humans to receive information. The use of multimedia and multimodal systems share a common motivation in delivering effective user interaction systems

and support users In performing the tasks in the case of E-learning helping the learner to achieve their learning goals.

One of the distinguishing differences between Multimedia Interfaces and and Multimodal User Interfaces is that Multimodal user interfaces support multiple input and outputs while Multimedia user interface supports multiple output. Secondly, multimedia research is carried out generally as a subset of multimodal research (Turk, 2000 as quoted by Anastopoulou et al 2001) . Additionally, we can distinguish between these systems by looking at it from the learners perspective, in multimedia systems the user has to adapt to the systems capabilities whilst in multimodal user interface can adapt to the learning needs of the user. Multimedia systems are therefore considered subsets of multimodal systems.

(Moreno et. al, 2007) enumerated some multimodal interaction techniques for interactive multimodal environments including Dialoguing where learners receive questions and answers of feedback as input, Controlling where user is given the chance to determine the pace of audio visual inputs, Manipulation where users are allowed to move objects and artefacts around and zoom in or out on these artefacts, Searching and Navigation techniques where the learner is able to query for new information and is able to navigate around the interface. These interaction techniques can further be broken down into interface design principles which we enumerate below as adapted from (Moreno et. al, 2007)

Principle	*Theoretical rationale*
Guided Activity	*Guided activities encourage essential and generative processing by prompting students to engage in the selection, organisation and the integration of new information.*
Reflection	*Reflection promotes essential and generative processing by encouraging more active organisation and integration of new information.*
Feedback	*Explanatory feedback reduces extraneous processing by providing students with proper schemas to repair their misconceptions.*
Pacing	*Pace control reduces representational holding by allowing students to process smaller chunks of information in working memory.*

Pretraining	*Pre-training helps guide the learners generative processing and showing which aspects of prior knowledge to integrate with incoming information.*

Table 2: Five Design Principles of Multimodal learning environments and their Corresponding Theoretical Rationale (adapted from Moreno et al, 2007)

2.4 Challenges to Multimedia and Multimodal user interfaces in E-learning.

(Karpov, 2018) enumerated a number of challenges facing the development and introduction of multimodal interfaces including the need to synchronise information from various inputs, the computing complexity of parallel processing of heterogeneous information and information fusion and other organisation problems associated getting specialists to process heterogeneous information such as audio, video, textual etc. Other studies have shown that multimodal interfaces do not always lead to positive learning outcomes students using low interactive interfaces can outperform students using highly interactive and multimodal user interfaces (Savoji et al, 2011). Building adequate prototypes that can simulate real multimodal environments for testing and feedback gathering is a major challenge of multimodal interface design (Anoop et. al , 2002). The application of multimedia has gained increasing importance in creating effective learning environments. Multimedia systems however, still lack support for active interaction and engagement of learners. For this reason, multimodal information interfaces which are driven by active user engagement has been proposed (Khamayseh, 2007).

2.5 Guidelines principles for multimodal user interfaces

(Reeves et al. 2004), outlined some guidelines for the design of multimodal user interfaces. Firstly, multimodal interface designers should avoid unnecessary presentation of information in different modalities. The redundancy of information tends to increase the cognitive load at the cost of learning the material. Furthermore, designers should maximize the advantages of each modality to reduce the user's memory load in certain tasks and situations.

Additionally, modalities must be integrated in a manner compatible with user preferences, context, and system functionality. Thus, additional modalities should be added to the interface only if they improve user satisfaction, increase efficiency, or add some measurable improvement

to the usability of the product for the user. (Joseph et al, 2014) enumerated a number of design considerations when designing usable multimodal systems.

- Building multimodal systems does not imply that users would use it as designed, multimodal systems should therefore be flexible.
- It is not easy to determine the right multimodal input combinations to support natural interaction metaphors for any given task.
- Individuals have different ways of combining multimodal inputs and these inputs could be simultaneous, sequential or complementary making the interface of such systems difficult to build.
- Even though speech is the dominant input channel for human communications, for privacy and technological reasons like difficulty in speech acquisition it should not be required as a primary input mode when designing such multimodal interaction scenarios.
- Input recognition for speech, 2D and 3D gesture inputs can be error prone and producing error prone, and unreliable systems.
- The fusion system for the inputs should be flexible and adaptable for different users' needs.

2.6 Multimedia tools for E-learning

2.6.1 Use of Discussion Forums in E-learning

CSCL literature often suggests that online discussion forums is a useful collaborative method for more engaged constructivist learning (Clark, 2003). Discussion forums are often the favored method of collaboration due to its several advantages and conveniences. It has a low bandwidth consumption, relatively cheap and technically accessible to students and teachers . Online discussion forums can extend the best elements of face to face learning (McLoughlan, 1999 quoted in Clark, 2003), is more democratic giving a chance to everyone to articulate their ideas thus leading to regular and wider participation, flexible independent learning, ease of access, asynchronous learning reduces drop out rate of courses by means of positive peer collaboration and socializing. Despite these advantages and ubiquity of discussions integration in E-learning platforms (Clark, 2003) and (Seethamraju, 2014) enumerates a number of disadvantages such as the fact that, discussion forums can become time consuming and eating from other study

activities, students abandon reading long messages, informative answers with external links may not be read, superficial discussions since short postings are more likely to get a response, excessive focus on new posts and overlapping discussions, some students may not participate as discussions may not be intellectually stimulating enough. One other problem is that usually a core group of users congregate and thus nullifying the democratic and open access ideal of online forums.

2.6.2 Use of Online Wikis in E-learning

The use of Wikis have been advocated for by various learning paradigms, particularly cooperative and constructivist paradigms(Parker et al, 2007) . Wikis are characterized by a variety of unique and powerful information sharing and collaboration features (Parker et al, 2007) . Wikis have been used in a lot of collaborative CSCL environments to enhance peer interaction and group work, and facilitates sharing and distributing knowledge and expertise among a community of learners (Lipponen, 2002 quoted by Parker et al, 2007). It is also used as an asynchronous communication tool (De Pedro et al., 2006 quoted by Parker et al, 2007) . Wikis are a flexible medium dnca cbe be adapted for various purposes and for a large range of educational contexts. It is a useful means of creating engagement, dialogue and information sharing and hence useful when creating student centered learning environments. One disadvantage of wikis in E-learning is that, when students are assessed on the basis of their participation in wikis, it is difficult to objectively evaluate their contributions. Other disadvantages include the accuracy of information, quality of writing skills of wiki participants may be limited and lastly it puts pressure on students to create the correct content and use the correct language since it is potentially seen by a large number of students (Bakardjieva et al, 2012).

2.6.3 Use of Videos in E-learning applications

Videos offer an alternative visual learning medium to text and breaks the monotony of reading and hence convenient for visual learners, videos are more engaging as an alternative to reading from books. Videos are convent for demonstrations and reduce the time needed for training.

The disadvantages or challenges of using videos include the fact that videos need to be created, scripted, edited and hence are expensive. It consumes a lot of bandwidth and hence not

convenient for low bandwidth areas. Low quality videos can be distracting for students and finally videos have historically had a higher technical barrier to entry for users.

2.6.4 Use of Text-based in E-learning applications

The use of texts is considered boring and creates a lack of focus. Readers read in the F-shaped scanning pattern (Pernice, 2017) when reading text over the content as they scroll through the page, reading is therefore not deep and immersed but shallow reading techniques leading to less retention. In addition reading text is considered flat and non interactive, high cognitive load leads to exhaustion and lower retention(Burns , 2019).

However text has the advantage of ubiquity and its long history makes it predominant form of knowledge transfer removing text from E-learning will remove the mental conversation that readers have with the author (Burns, 2019). Text can be used to augment other media, for instance while videos are used for demonstration and text can be used for sharing descriptive information and for delivering conceptual knowledge. The text itself should be well organized and structured, use engaging language imagery and storytelling techniques and should be accessible to readers by being clear, concise and without the use of idioms. Other elements to consider include the typography and the use of colors. Use multimedia principles as discussed in (Mayer, 2001). Include quizzes after text based readings, this increases the needs for engagement and hence accountability on the part of the learner. Allow easily printable or offline versions of the text as research points to the fact that reading on paper has better results than reading on a screen.

2.6.5 Use of Active Multimodal Information Presentation

Active Multimodal Presentations (AMPs) are short stand alone and free running multimodal presentations that form up a computer based multimodal learning environment using appropriate integration of speech, imagery and gesture (Faisal et al, 2007). Advantages of AMPs include increased accessibility of users as it combines user inputs such as speech, pen, gaze, manual gestures and movement of head and hands. These input modalities also improve performance of recognition based systems. Some AMPs systems come with multiple output modalities such as visual and auditory modes and these help to encourage active learning environments to

encourage active and effective learner engagement and participation. One shortcoming identified by Faisal et al for this E-learning medium is the fact that the choice of modality is left in the hands of the learner whose knowledge of the modalities might be limited.

2.6.6 Use of 2D and 3D Animations

2D and 3D animation are respectively digital two-dimensional or three-dimensional use of imagery, which together with movement, creates a vivid, realistic and engaging tool which can be used in E-learning. It can be incorporated to increase engagement, enhance visual experience for learners. It can be adopted to explain difficult concepts which are difficult to explain with other mediums. 3D animations have found use already in medical learning(Pandey et al, 2019) and can be used training in unsafe environments such as driver safety training[3].

2.6.7 Feedback as an engagement and supporting mechanism.

(Hattie & Timperley 2007) state that feedback is "information provided by an agent regarding some aspects of one's task performance". (Hattie & Timperley, 2007. p.81). (Narciss, 2008) also defines feedback as "all post-response information that is provided to a learner to inform the learner on his or her actual state of learning or performance". (Hattie and Timperely, 2007 p.127). What is clear from these definitions is that feedback is designed to provide an understanding of performance through offering guidance on the knowledge that they possess.
Feedback supports learning in the following ways: It serves as an incentive to increase response rate and accuracy, reinforcing and connecting to prior stimuli (focuses on correct answers), validates or changes previous responses and finally allows the learner to reconstruct the learning processes. There are two types of feedback identified by (Nelson & Schunn 2009) namely cognitive and affective.

Peer feedback is an important tool for instance in language learning. While teachers' feedback is important, peer level feedback is important because of the cognitive, and social benefits of peer feedback. Peer feedback and instructor feedback can play a vital role in students' learning experience (Rajapakse, 2011) . Rajapakse further asserts that early, frequent, and incremental feedback provided in a non-threatening environment can play an effective formative role in

[3] https://www.vectorsolutions.com/news-media/blog/benefits-3d-animation-in-elearning/

students' personal development. Such feedback can help students to recognize and rectify gaps between peer/instructor expectations and their own performance.

Generally, good feedback is regarded as the heart of good pedagogy. (Nicol & Macfarlane-Dick 2006) synthesised from literatute that good feedback practices in learning environments helps to:

1. Clarify what good performance is (goal, criteria, expected standards).
2. Facilitates the development of self-assessment (reflection)in learning.
3. Delivers high-quality information to students about their learning.
4. Encourages teacher and peer dialogue around learning.
5. Encourages positive motivational beliefs and self-esteem.
6. Provides opportunities to close the gap between current and desired performance.
7. Provides information to students that can be used to help shape teaching.

In the design phase of this thesis, we will use these good feedback guidelines to provision the interface with these guidelines Specifically, for the seven principles above we will make the following provisions respectively.

1. Principle 1: We can incorporate simple designs like showing the student how much they are achieving their goals compared to other students in their class, whether the goals they set for themselves are challenging enough and whether they are meeting their goals.
2. Principle 2: Incorporating self assessment questions in various sections of the course and at the end of the module / course etc.
3. Principle 3: Quick and easy integrations of textual, video and audio modes of feedback to provide quality and in depth feedback to students on their performance and pitfalls etc.
4. Principle 4: Integrated feedback and dialogue mechanisms integrated in various parts of the platform to encourage peer and teacher dialogue around learning through ease of use and using social media interaction mechanisms.
5. Principle 5: Boot self esteem by giving badges as feedback when students meet their goals or finish sections of the course.
6. Principle 6: Again ease of communication on the platforma and the provision of different avenues such chat, phone calls, and textual feedback.
7. Incorporate polling mechanisms to get understand what topics need to be addressed.

3. Analysis of Multimodal E-learning Applications

3.1 Research Problem and Strategy

With a plethora of E-learning platforms available which generally fall into two groups namely platforms for corporate audiences and platforms designed for direct academic audiences. The selection criteria of the platforms concentrate on the later. The most important criteria in the selection was whether the platform was "open access", that is whether the platform can be used without paying for it. We selected half of the platforms using a simple web search query of "top E-learning platforms" and selecting the five platforms that fall into the category we are interested in. The other half of the platforms analysed were chosen for their importance in domains such as Languages, Business or Computing and Data Science. The UI of these platforms were analysed and when necessary, additional information about the platforms were found using web search techniques.

Platform	*Open Access*	*Top E-learning platforms*	*General purpose or domain specific*
Amity Learning	✓**	✗	General purpose
Busuu	✓**	✗	Languages
Cognitive Class	✓	✗	Computing and Data Science
Coursera	✓	✓	General purpose
Duolingo	✓**	✗	Languages
Edx	✓	✓	General purpose
FutureLearn	✓	✓	General purpose
Linkedin Learning	✓*	✓	Business, Creative and Software
Udemy	✓	✓	General purpose

✓* - Offers free trial period to access courses.

✓** - Access limited to some courses or levels.

Table 3: E-learning selection checklist

For the purposes of this analysis we use the guidelines and sensory modalities presented in (Turk, 2013) as shown in Table 4 below, for our analysis to produce a guide of what multimodal features to look for on the various chosen platforms.

Modality	Example
Visual	*Face location, Gaze , Facial expression Lipreading, Face-based identity (and other user characteristics such as age, sex, race, etc.) Gesture (head/face, hands, body) Sign language*
Auditory	*Speech input, Non-speech audio*
Touch	*Pressure, Location and selection, Gesture*
Other sensors	*Sensor-based motion capture*

Table 4: Human sensory modalities relevant to multimodal human–computer interaction, (Blattner and Glinert (1996) as produced from Turk, 2013)

3.2 Results of User Interface Analysis for Amity Online

URL: https://amityonline.com/

Amity Open Learning is the platform powering Amity University's online learning platform. Amity offers courses from Certificates, Post Graduate Certificates, Bachelors and Masters degrees. Some of the courses are powered from a third party Open Learning platform and delivered in an iframe when a student accesses the course. The platform is mostly text-based and complimented by images (pictures, diagrams and illustrations) . The platform also makes use of integrated interactive slides also known as Active Multimodal Presentations (AMPs) embedded in the lessons as well as video lessons. The Figure 5 below shows some screenshots of the platform illustrating the use of embedded images in text, progress and feedback indicators, embedded AMPs and embedded videos.

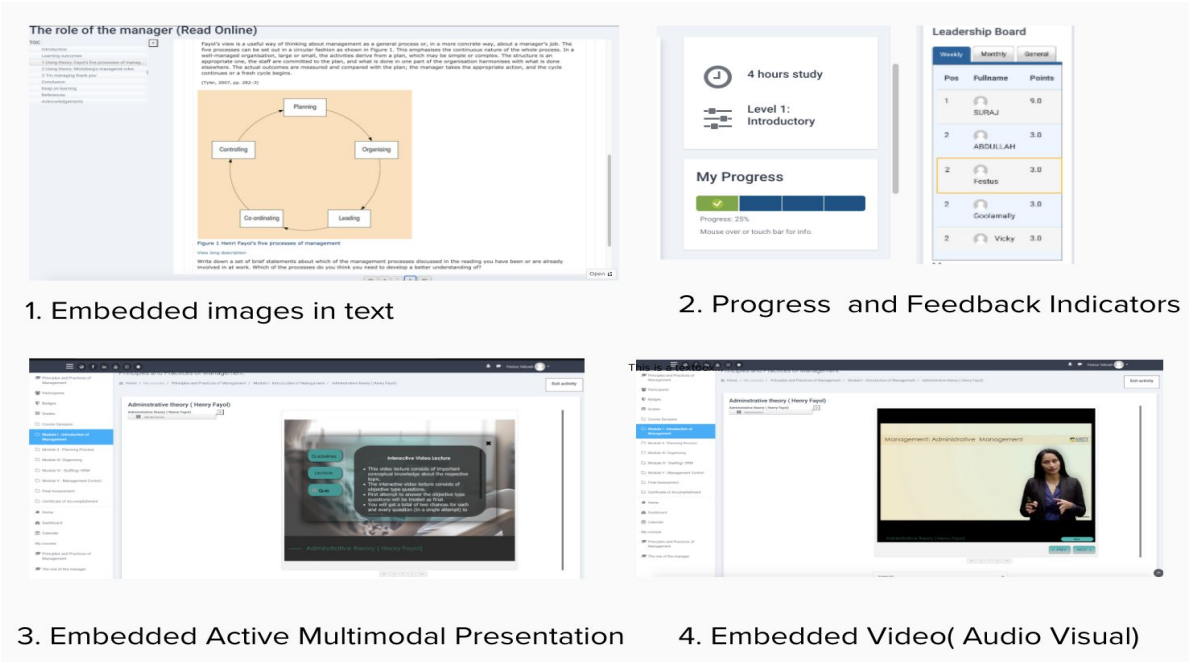


Figure 5: Screenshots of some features of the Amity Online platform accessed in November, 2020

The features of this platform includes progress reports to highlight to the learner the sections of the course completed in percentages and time spent on the platform completing the course. It offers a social presence session and an integrated leaderboard functionality where students are able to compare their performance against other learners enrolled in the same course on a weekly, monthly and general terms. Learners can also interact with their peers by joining specific learning groups which could be private or open to all.

The multimodal features of this platform includes integrated AMPs with sonification, images, videos, integrated quizzes and a text based discussion forum. Table 5 below summarizes the different modalities and features of the platform.

Modality	Uses cases
Visual	*Embedded images in text, Videos, Active Multimodal Presentations (AMPs)*
Auditory	*Audio, sonification features on embedded slides*
Touch	*Keyboard inputs, and touch screen for quizzes, discussion forums etc.*
Other sensors & features	Social presence indicators, Private groups for communication and collaboration,Notifications Scorecards, Social sharing on LinkedIn, Facebook, etc, Calendar, Leaderboard

Table 5: Modality use cases in amity online platform

3.3 Results of User Interface Analysis for Busuu

URL: https://www.busuu.com/

Busuu is an online platform for language learners , it has text, speech / audio (aural) , images and sound bites for the text shown. Users can regulate the speed of the audio snippets as well as video lessons. The platform has engaging visual feedback when a user answers questions. These visual responses are accompanied by sonication for both positive and negative feedback. These visuals are employed as well in sentence completion exercises. The Figure 6 below shows various screenshots of the features of Busuu such as the use of colors and imagery, audio feedback, social interaction and presence and progress report and score cards.

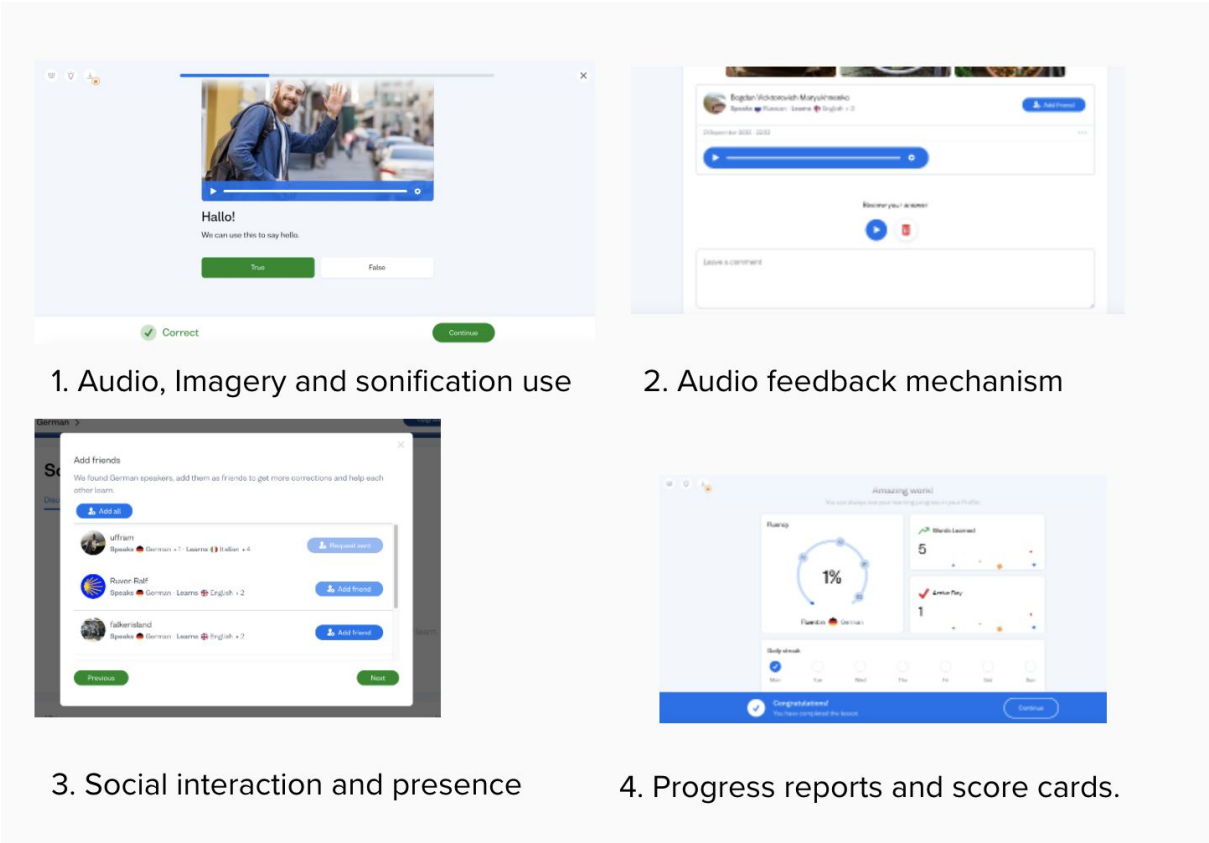


Figure 6: Screenshots of some features of the Busuu platform accessed in November, 2020

It makes use of regular colors for success and failure namely red and and green. Busuu also has a dashboard for progress of the students in terms of fluency, vocabulary learnt per day etc. It also tracks their streak time that is, how consistent the students use the platform on a daily basis. Since Busuu is a language learning platform, it also uses flashcards for engaging the students. One unique feature of Busuu is that students can request peer feedback on their pronunciation and enunciation of words from other students. Table 6 below summarizes the different modalities and features of the Busuu platform.

Modality	Uses cases
Visual	*Heavy use of images and colors , user can record videos*
Auditory	*Sonification employed feedback for positive and negative answers, recorded audio texts read to the user,*
Touch	*Keyboard and mouse inputs for feedback*
Other sensors & features	Audio feedback from peers, Add friends

Table 6: Modalities and use cases in Busuu platform

Busuu also allows students to add other language learners as friends to increase social connectivity and interaction as shown in Figure 7 below.

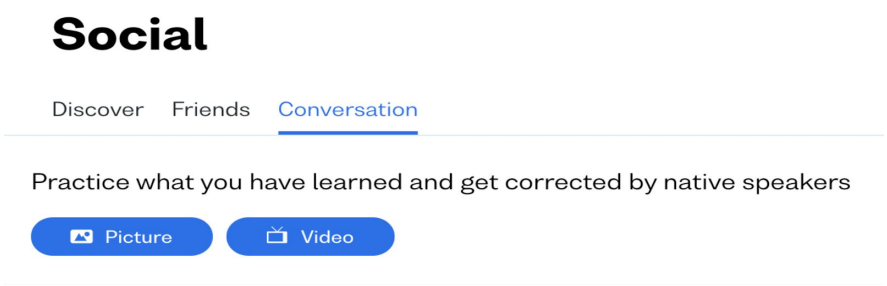


Figure 7: Social connectivity functions on Busuu

3.4 Results of User Interface Analysis for CognitiveClass.ai

URL: https://cognitiveclass.ai/

Cognitiiveclass.ai is an online platform set up to "address the skills shortage in emerging technologies, including data science, Artificial Intelligence (AI), big data, cloud computing and blockchain." Their online video courses are backed by a virtual lab environment that enables users to practice what they learn. The platform uses video and textual transcript like where the relevant transcript text is highlighted as the user speaks. The videos and textual transcripts can be downloaded. The platform also uses images, learners progress reports, and integrates a commenting section on courses. Like most E-learning platforms serving video, the speed of

videos can be set by the learner. Supplementary files can be downloaded for practise and reading such as code snippets for various lessons. The platform also has embedded questions per session where students can answer questions that would be graded in the end. Figure 8 below shows some screenshots of some of the multimodal features such as embedded quizzes, embedded wikis, downloadable video and text transcripts and an integrated code editor.

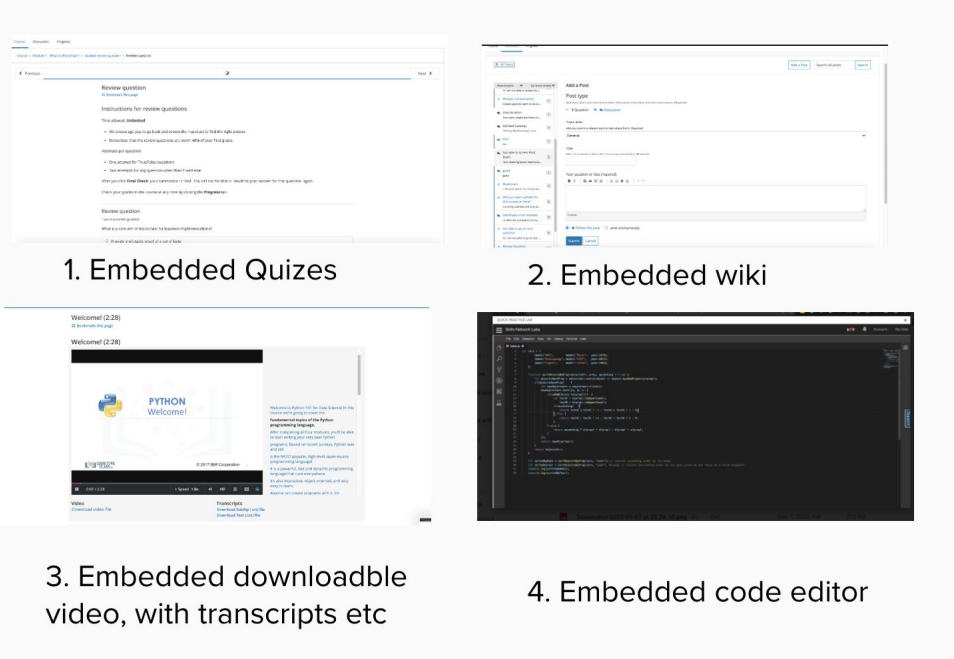


Figure 8: Screenshots of some features of the Cognitive Class platform accessed in November, 2020

This platform is tailored for software developers and data scientists and has an embedded laboratory where students can execute code jupyter notebook and an embedded web based Integrated Development Environment (IDE). Each module has a well defined overview for the students. This principle of overviews can be built into our application as it allows the teacher to to see the actual progress made by the students. The platform incorporates a discussion forum for students enrolled in the course, it also incorporates a wiki section. Students can also bookmark sessions and have it appear in their course overview for easy access. Table 7 below summarizes the different modalities and features of the CognitiveClass.ai platform.

Modality	Uses cases
Visual	*Embedded videos with associated generated texts*
Auditory	*Audio-visual through video*
Touch	*Keyboard and mouse input for Integrated code editor, quizzes, discussion forums and wikis.*
Other sensors & features	

Table 7: Modality use cases in Cognitive learning platform

3.5 Results of User Interface Analysis for Coursera

URL: https://www.coursera.org/

Coursera is an American massive open online course provider founded in 2012 by Stanford University's computer science professors Andrew Ng and Daphne Koller that offers massive open online courses, specializations, degrees, professional and master track courses[4]. The Figure 9 below shows some screenshots of the Coursera platform.

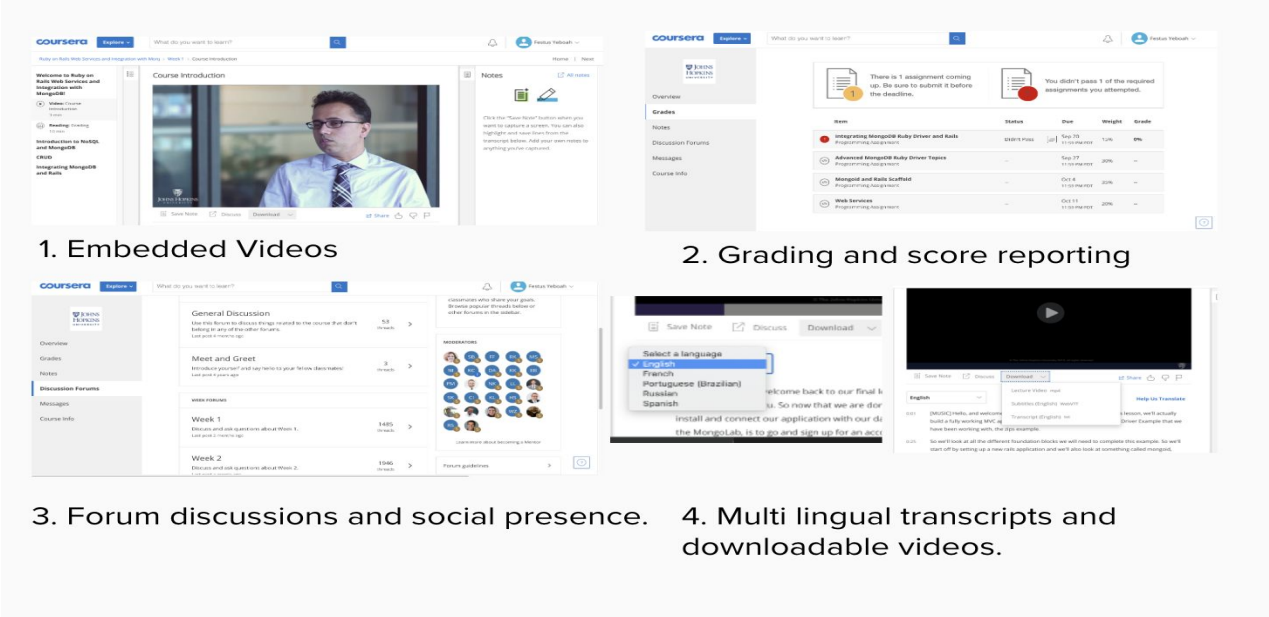


Figure 9: Screenshots of some features of the Coursera platform accessed in November, 2020

[4] **https://www.coursera.org/**

Again the concept of showing a progress overview of the student is prominent on this platform and a timeline of a learners progress can be visualized. Students are able to add notes to a section or topic, social interaction elements such as a thumb down and thumbs up, sharing and flagging session allows for (kinematic activictives as well as increase the engagement on the platform) . Table 8 below shows the various modalities of the Coursera platform.

Modality	Uses cases
Visual	*Integrated videos, images*
Auditory	*Audio-visual through video*
Touch	*Keyboard and mouse input for quizzes, discussion forums,Creating notes, Download of videos and textual transcripts. ,*
Other sensors & features	Social sharing, liking, disliking and flagging of video content

Table 8: Modality use cases in Coursera platform

Students can further use the discussion forum integrated on the course sessions for interaction and social learning activities . One very advanced feature is the possibility to have the textual transcript of various videos in multiple languages as shown in Figure 10.

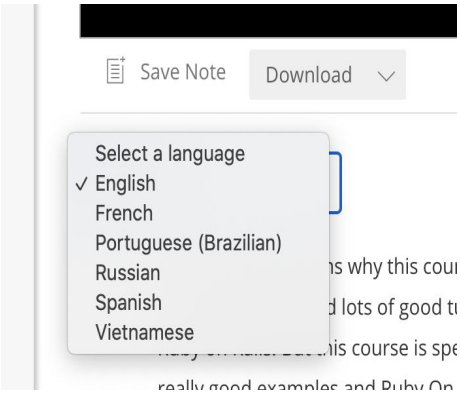


Figure 10: Multilingual transcript for a video lecture.

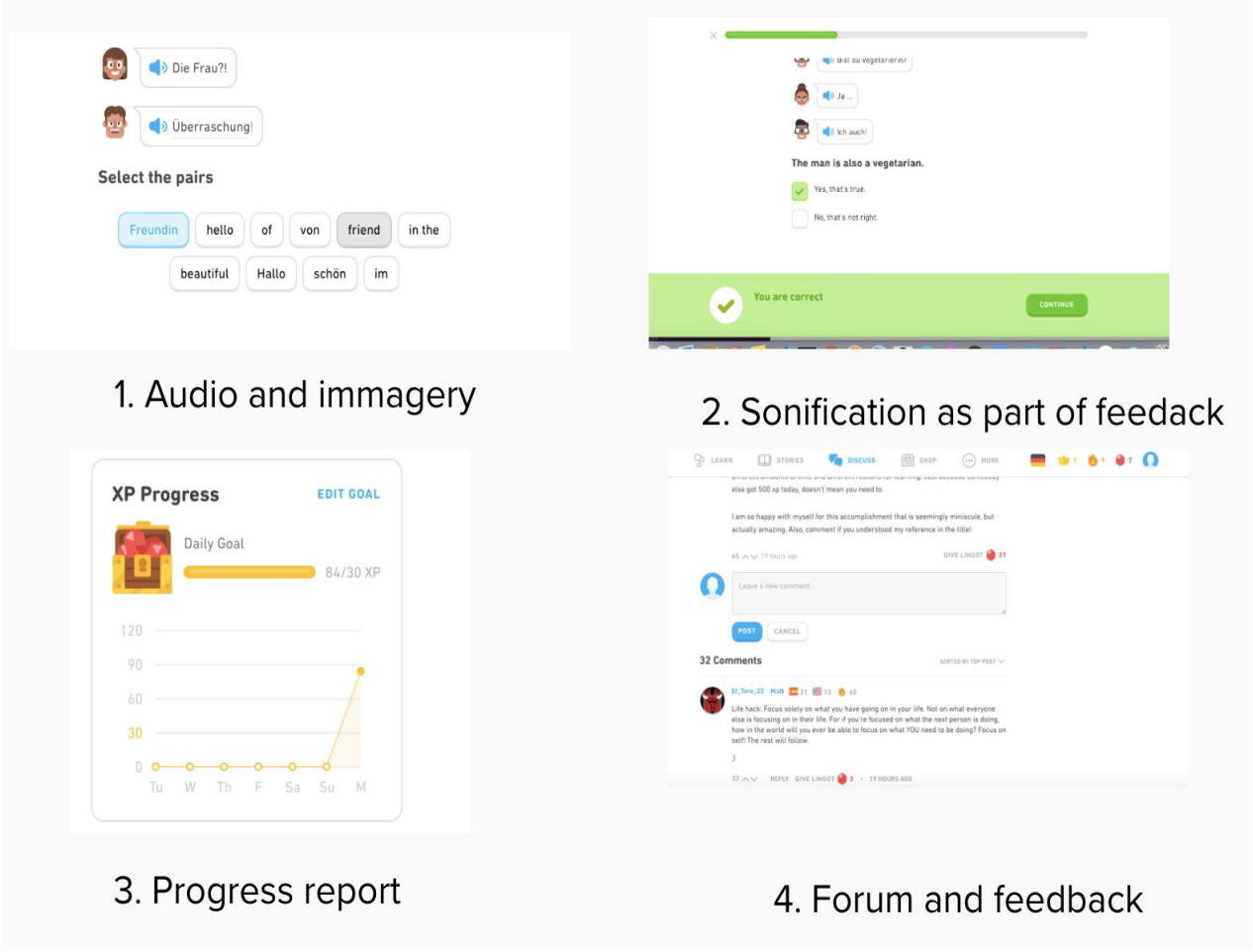
Coursera also has social presence indicators and roles like moderators of forum discussions are also assigned to students. There is the possibility to download the video, the transcript. In addition the transcript can be downloaded in different languages as indicated in the figure above.

Images and code snippets are used embedded quizzes and readings mixed in the videos plus surveys.

3.6 Results of User Interface Analysis for Duolingo

URL: https://www.duolingo.com

Duolingo is an American language learning platform that includes a web based E-learning platform and mobile app, as well as a digital language-proficiency assessment exam. The company uses the freemium model; the app and the website are accessible without charge, although Duolingo also offers a premium service for a fee[5]. Figure 11 below shows some screenshots of the Duolingo platform.



[5] https://en.wikipedia.org/wiki/Duolingo

Figure 11: Screenshots of some features of the Duolingo platform accessed in November, 2020.

Duolingo utilizes text and audio closely together. It also employs imagery such as avatars to establish emotional connections with the learners. Feedback responses are color coded in green and red. Red is used for wrong answers and green for correct answers. It has an integrated discussion forum for students to engage and social learn. Badges earned for progress as a form of gamification. Integrated dictionary for students since it is a language site. Progress tracking for learners is also one prominent feature of this platform. The platform also has application level feedback mechanisms for users to give feedback and report issues found on the plaftorm. Table 9 below shows the various modalities of the Duolingo platform.

Modality	Uses cases
Visual	*Stories, Visual avatar imagery, visual indicators of selected words, progress bars, y illustrated flash cards*
Auditory	*Podcasts, stories, Audio read out of texts, Sonification employed feedback for positive and negative answers, Voice recognition to aid pronunciation.*
Touch	*Keyboard and mouse input for discussion forums, fill-in-the-blank exercises, Write what you hear, translator.*
Other sensors & features	

Table 9: Modality use cases in Duolingo platform

3.7 Results of User Interface Analysis for edX

URL: https://www.edx.org/

edX is an American massive open online course provider created by Harvard and MIT. It hosts online university-level courses in a wide range of disciplines to a worldwide student body, including some courses at no charge. It also conducts research into learning based on how people use its platform[6]. Figure 12 below shows some screenshots of the edX platform.

[6] https://en.wikipedia.org/wiki/EdX

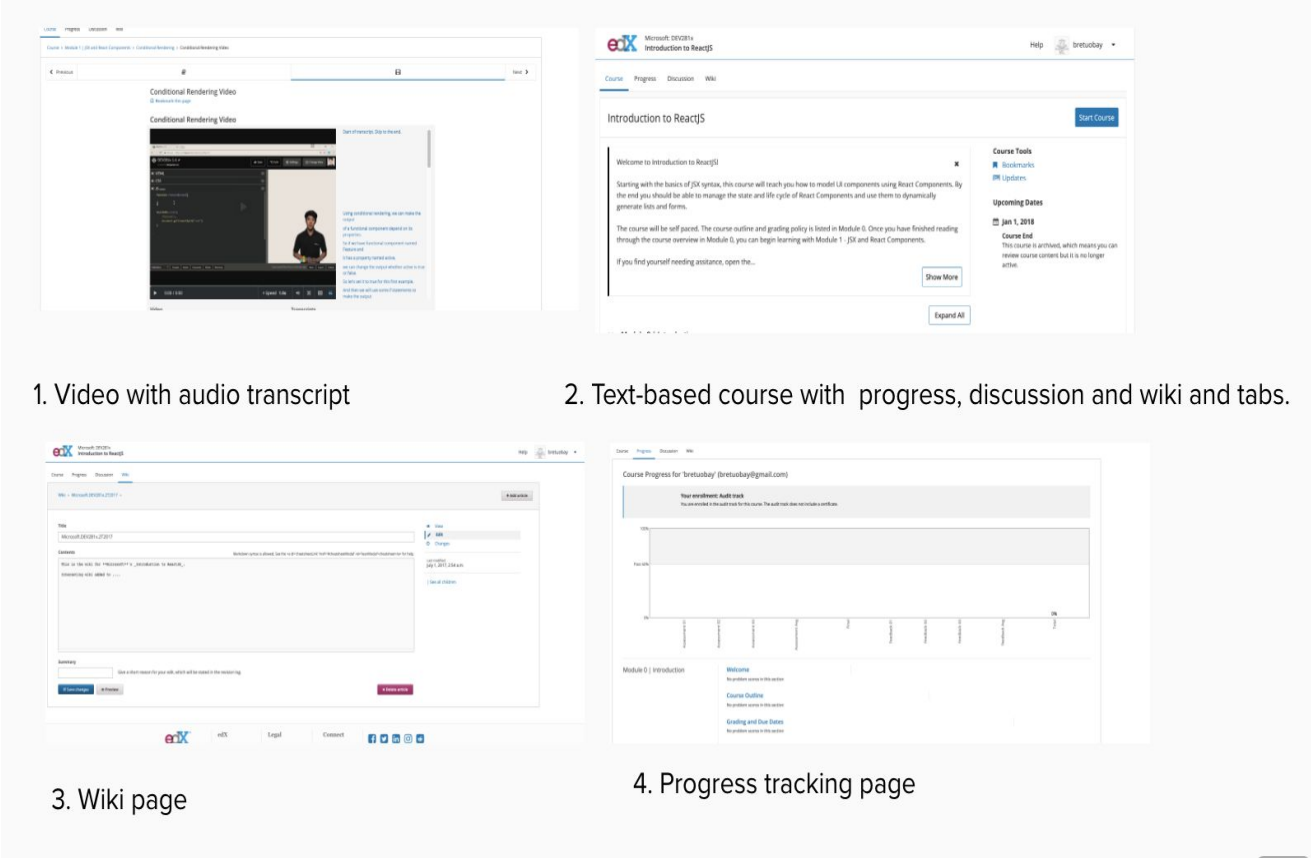


Figure 12: Screenshots of some features of the edx platform accessed in November, 2020

The platform has an integrated wiki, discussion forum, allows students to create articles and engagement on the platform. Downloadable videos, transcripts . Text transcript is highlighted , closed caption . Learners have the option to control the speed of the video sessions. Web based Integrated Development Environment (IDE) from a third party. Embedded images and diagrams. Video speed can be regulated to fit user needs. Textual transcripts of videos. Integrated third-party code sandboxes. Like other platforms progress tracking on the courses is a prevailing feature. Table 10 below shows the various modalities of the edX platform.

Modality	Uses cases
Visual	*Embedded videos, images, textual transcripts, embedded third party tools.*
Auditory	*Audio-visual through video*
Touch	*Keyboard and mouse input for discussion forum, wiki, download textual transcript or videos , integrated third party code sandboxes., share content to social platforms.*
Other sensors & features	

Table 10: Modality use cases in edX platform

3.8 Results of User Interface Analysis for Future Learn

URL: https://www.futurelearn.com/

FutureLearn is a digital education platform founded in December 2012. The company is jointly owned by The Open University and SEEK Ltd. It is a Massive Open Online Course learning platform, and as of June 2020 included 175 UK and international partners, including non-university partners[7]. Figure 13 below shows some screenshots of the FutureLearn platform.

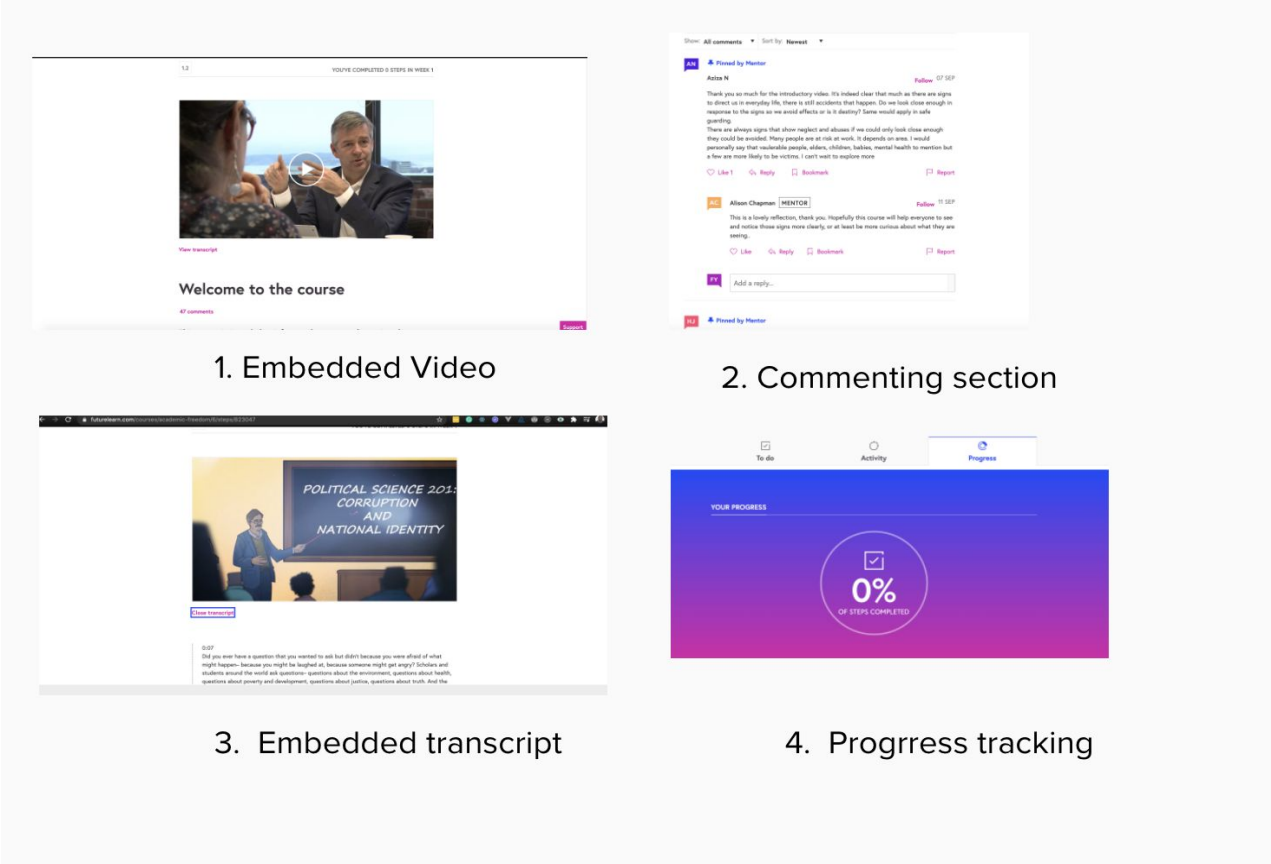


Figure 13: Screenshots of some features of the FutureLearn platform accessed in November, 2020

Features on FutureLearn include progress tracking, video and associated textual transcript, and interactive commenting sections . The platform clearly focuses on textual information and the sizes of the font reflects this as they are fairly large to enhance readability. There is also a good

[7] https://en.wikipedia.org/wiki/FutureLearn

use of colors and good contrast on this platform. The embedded videos have downloadable textual transcripts which are time annotated so that learners can easily trace back what was said and what time. Users can like, share and comment on context, additionally users can report contents and follow other students participating in the commenting session. Transcripts are annotated with time of the video where the relevant statement is made. This platform can certainly be improved with text-to-speech functionality as well. Table 11 below shows the various modalities of the FutureLearn platform.

Modality	Uses cases
Visual	*Embedded videos, use of images*
Auditory	*Audio-visual*
Touch	*Keyboard and mouse input for discussion forum / commenting section, quizzes, Students can keep a todo log,*
Other sensors & features	

Table 11: Modality use cases in FutureLearn platform

3.9 Results of User Interface Analysis for LinkedIn Learning.

URL: https://www.linkedin.com/learning/

LinkedIn Learning is an E-learning platform offering video courses taught by industry experts in software, creative, and business skills. The courses are categorized into Business, Creative, Technology, Subjects, Software, Learning paths. It is a subsidiary of LinkedIn and was was founded in 1995 by Lynda Weinman as Lynda.com before being its acquisition by LinkedIn in 2015[8]. Figure 14 below shows some screenshots of the LinkedIn Learning platform.

[8] https://en.wikipedia.org/wiki/LinkedIn_Learning

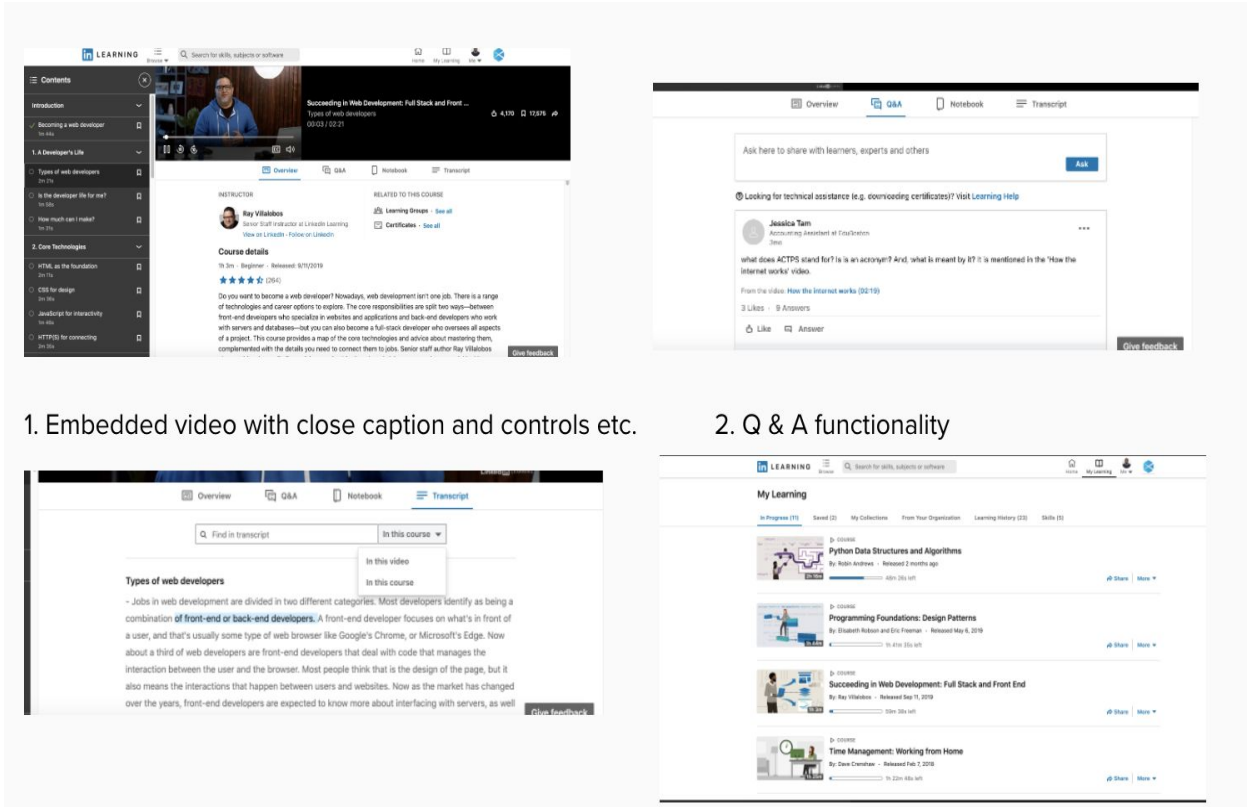


Figure 14: Screenshots of some features of the LinkedIn Learning platform accessed in November, 2020

The platform uses video presentations as the main form of instructional mode. The videos are supplemented by an associated textual transcript. When the presenter speaks, the relevant part of the speech is highlighted as text. The transcripts are also searchable for the video of interest or across the entire course. In addition, video courses have closed caption (CC). Furthermore, learners have control over the speed of videos to suit learning style, speed and language comprehension. Users can save relevant sessions of videos allowing for easier access. Table 12 below shows the various modalities of the LinkedIn Learning platform.

Modality	Uses cases
Visual	*Video, text, images, diagrams.*
Auditory	*Human voice.*
Touch	*Keyboard and mouse inputs to search and filter, share, like, comment, bookmark, notes.*
Other sensors & features	

Table 12: Modality use cases in LinkedIn Learning platform

There is an integrated commenting / Q & A functionality to encourage social learning, interaction and engagement. Learners can join learning groups, like content, bookmark and share content. There is an integrated Notebook for each section of the course allowing learners to keep notes on the platform.

Learners have access to their transcripts to track their scores and progress of students. Lessons can be shared or forwarded to friends , colleagues. Searchable transcripts. Social interaction through the concept of using learning groups, reward of certificates for encouraging participation and completion of courses.

3.10 Results of User Interface Analysis for Udemy

URL: www.udemy.com

Udemy, Inc. is an American Massive Open Online Course(MOOC) provider aimed at professional adults and students. Founded in May 2010 by Eren Bali, Gagan Biyani, and Oktay Caglar . The platform has more than 35 million students and 57,000 instructors teaching courses in over 65 languages[9]. Udemy is delivered as web and by mobile site as well as Android and iOS apps[10]. Figure 15 below shows some screenshots of the Udemy platform.

[9] https://en.wikipedia.org/wiki/Udemy

[10] https://support.udemy.com/hc/en-us/articles/229233847-Udemy-Platforms-and-Features

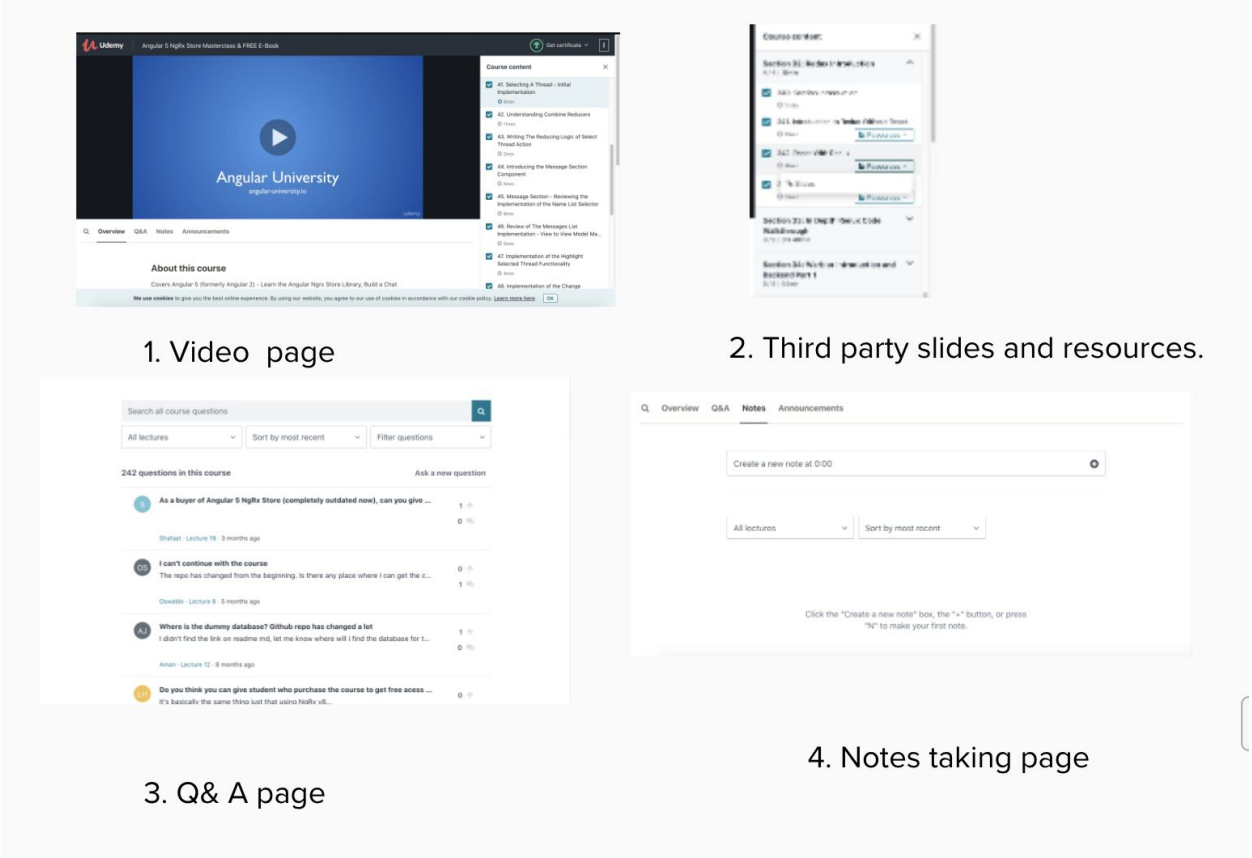


Figure 15: Screenshots of some features of the Udemy platform accessed in November, 2020

Udemy makes heavy use of videos as an instructional delivery mechanism. The video player allows the learner to change playback speed to suit the preferences. It also allows learners to skip ahead or back five seconds ,turn on closed captioning and see transcripts.

Udemy employs a text based Q & A type section for each video in a course for interaction and engagement. Learners can take notes as well on Udemy which can be annotated by the timestamp of the video they are taking notes on. Table 13 below shows the various modalities of the Udemy platform.

Modality	Uses cases
Visual	*Video lectures*
Auditory	*Audio lectures*
Touch	*Keyboard and mouse input to share content, Third Party repositories, Question and Answer of forum like , Add notes to sessions of videos and Coding exercises*
Other sensors & features	*Personalised learning Dashboard , Subtitles, downloadable lectures, certificates of completion, reviews, View instructor announcements, search marketplace and enrol in courses.*

Table 13: Modality use cases in Udemy platform

Sharing buttons via social media and email or copied link to clipboard, video player with call back, Notes and Q&A section to encourage engagement and dialogue on the course section. Take notes, capture the timestamp of the video so that students can point back to the video section where the note was taken. Integrated quizzes in some sections . Sharing of content via third party social media sites like Facebook, Twitter and via email.

3.11 Results of User Interface Analysis for Khanacademy

https://www.khanacademy.org/

Khan Academy is an American non-profit educational organization created in 2008 by Sal Khan, with the goal of creating a set of online tools that help educate students. The organization produces short lessons in the form of videos. Its website also includes supplementary practice exercises and materials for educators[11]. The platform is offered as a website and has an Android and iOS version as well.

The platform makes heavy use of short video explanations, quizzes which use sonification to alert students of right and wrong answers. The platform offers learners self paced learning using practice exercises, lesson aligned practice, topic reviews and homework assignments[12].

[11] https://en.wikipedia.org/wiki/Khan_Academy

[12] https://www.khanacademy.org/khan-for-educators/resources/teacher-essentials/implementation/a/introduction-to-using-khan-academy-in-the-classroom

Some video lessons come with a transcript which is highlighted and time annotated for the learner as shown in the Figure 16 below. Videos also come with CC.

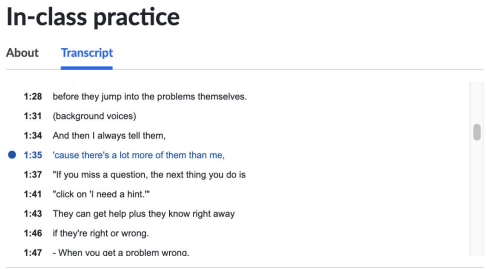


Figure 16: Time annotated textual transcript from Khanacademy

Social learning, learner and tutor interaction is handled by a Question and answer functionality.

Table 14 below shows the various modalities of the Khanacademy platform.

Modality	**Uses cases**
Visual	*Video lectures, Images and diagrams, Avatars*
Auditory	*Audio lectures, sonification on quiz responses.*
Touch	*Quizzes, Course search functionality, Social sharing*
Other sensors & features	*Personalized dashboard, Articles, Topic review, Self-passed practise.*

Table 14 : Modalities and features of Khanacademy

Figure 15 below shows some screenshots of the Khanacademy platform.

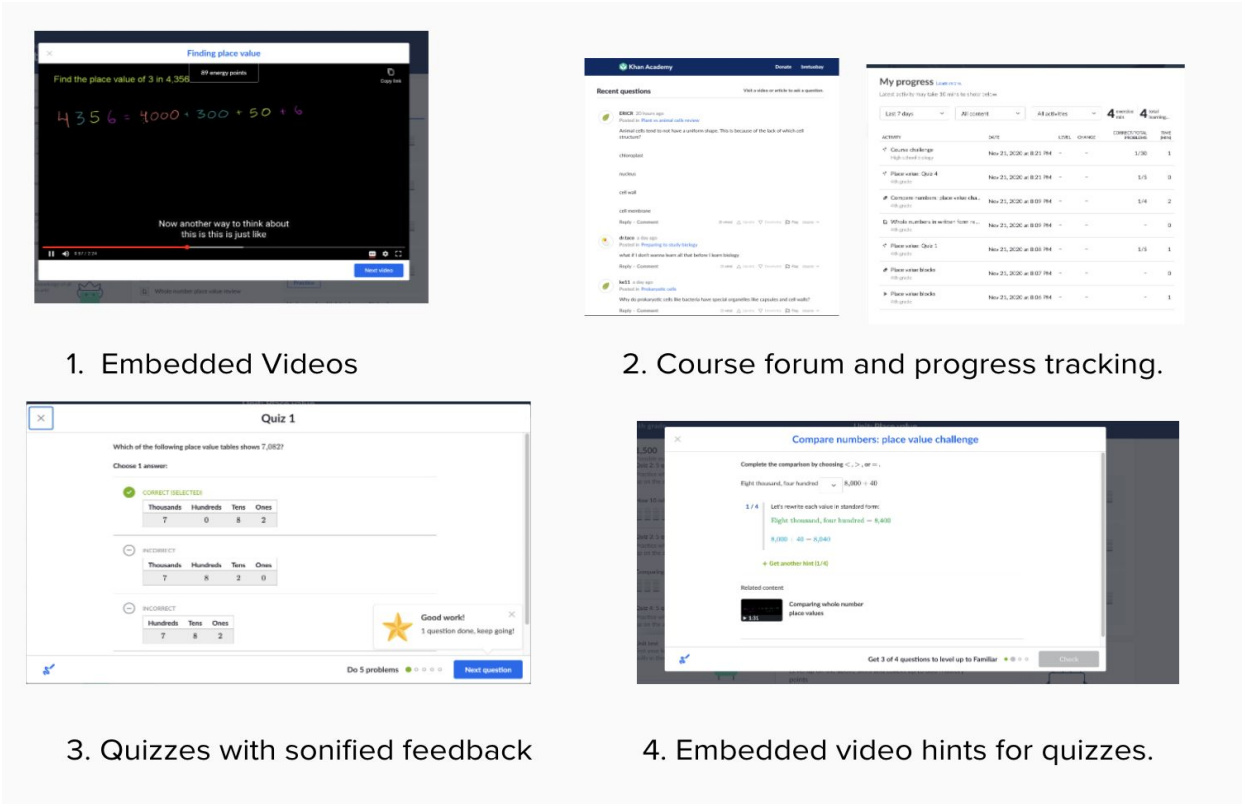


Figure 17: Screenshots of some features of the Khanacademy platform accessed in November, 2020

3.12 Discussion of results

The use of video lessons is the most predominant medium of instruction used in the ten platforms studied. Some form of video instruction has been integrated in all platforms under study. Some platforms for example Coursera allow learners to download videos at different quality levels whilst others like edX do not allow for downloads. The use of video is accompanied by the use of text transcripts often highlighted visually when the speaker is on that particular part of the video. This is a common pattern employed by Udemy, Khan Academy, edX, Coursera and Cognitive Class platforms.

The language learning platforms of Duolingo and Busuu make use of audio visual techniques incorporating patterns such as the use of avatars to represent people, embedded audio players and sonification as a feedback mechanism when answering embedded quizzes. Non-human audio or sonification is not a predominant feature of the platforms studied, sonification has however been

used on Khanacademy, Duolingo and Busuu platforms as a feedback mechanism for positive and negative responses on quizzes.

The predominant feedback and interaction mechanism between peers and and between tutors and students is through text based discussion forums or commenting sections in the course. Only the language learning platform Busuu allows learners to send and receive audio and video to peers and tutors for feedback on the language skills. Some form of social interaction and social presence was found on all platforms.

None of the non language teaching platforms integrated text-to-speech functionality. Although the literature suggests that text-heavy content will benefit from this functionality. Platforms such as FutureLearn, Amity and Cognitive Learning will benefit from such functionality if available since their interfaces are text-heavy.

Most of the platforms make use of third party integrations to allow them to be effective for learners, for instance platforms that teach computer programming skills usually integrate some form of online coding editor hosted by third party platforms to make them effective in teaching coding skills to students. This suggests that for most platforms it is not feasible to integrate all the complex tools to enable successful delivery of E-learning and hence tutors and instruction designers resort to the use of third party tools to enable them to effectively deliver courses to learners.

In the next section, we will develop some personas for E-learning based Remedial education based on the work done by (Oduro-ofori et al., 2014) and do a feature mapping for our personas based on the CSFs of E-learning and Remedial education as well as the predominant user interface patterns discussed in this section.

4. Prototype Development and Testing

4.1 Design Process and Methodology

With the knowledge of multimodal and multimedia user interface features of existing E-learning applications, this thesis proposes a design for E-learning based Remedial education or more formally Computer Aided Remedial Education(CARE). Literature provides good examples of personas that CARE should cater for. We develop three student personas and one teacher persona from the work done in (Oduro-ofori et al., 2014) and internet penetration and usage data from (GSMA, 2020) as shown in Figures 18 and 19 below.

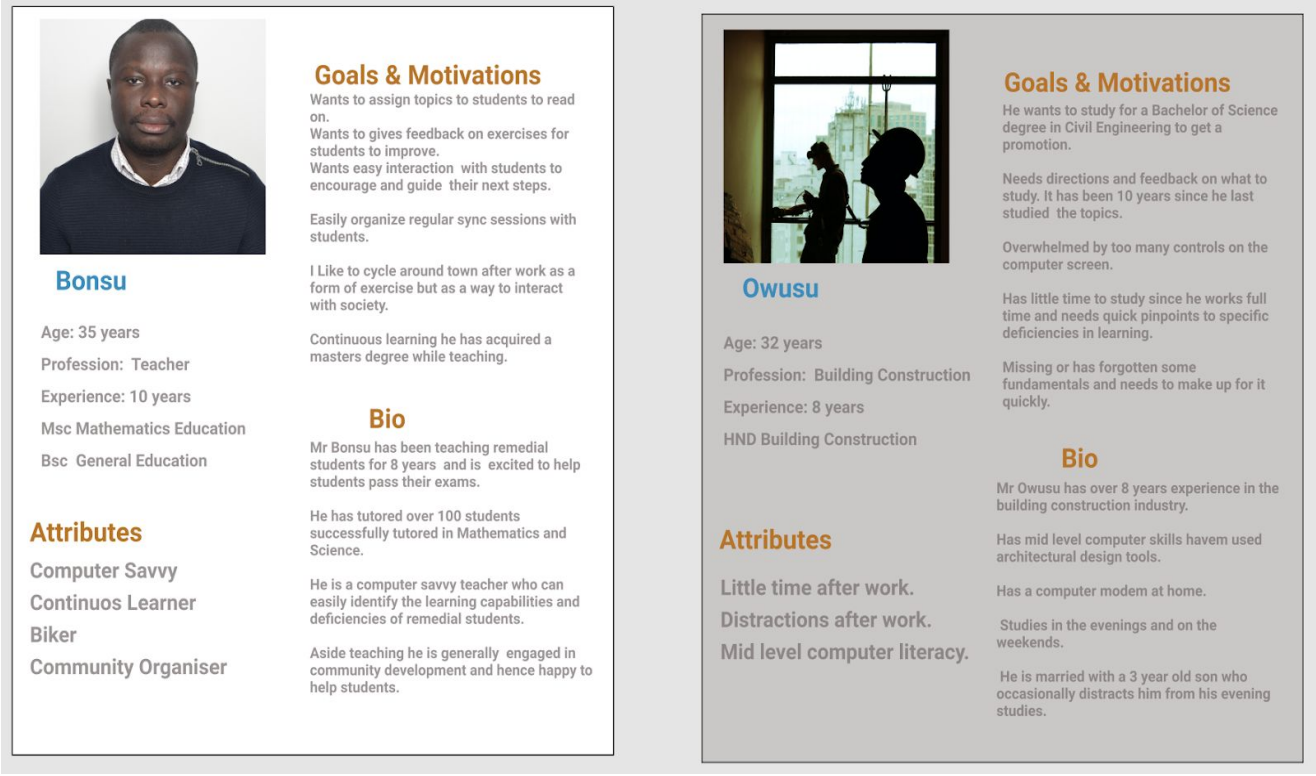


Figure 18: Personas for tutor, Mr Bonsu and student Mr Owusu.

Figure 19: Personas for students Personas Mariama and Oteng

The persona definition was then followed by a feature mapping session where the goals of our personas were mapped to features that allow them to achieve their learning goals in CARE.

We focused on enhancing feedback and communications as the main CSF that is most relevant for our use case. We propose design features in CARE that integrate feedback and social interaction mechanisms for both peer feedback and tutor feedback mechanisms built into the interface. This will encourage active participation, sustain engagement , develop critical thinking and social interaction.

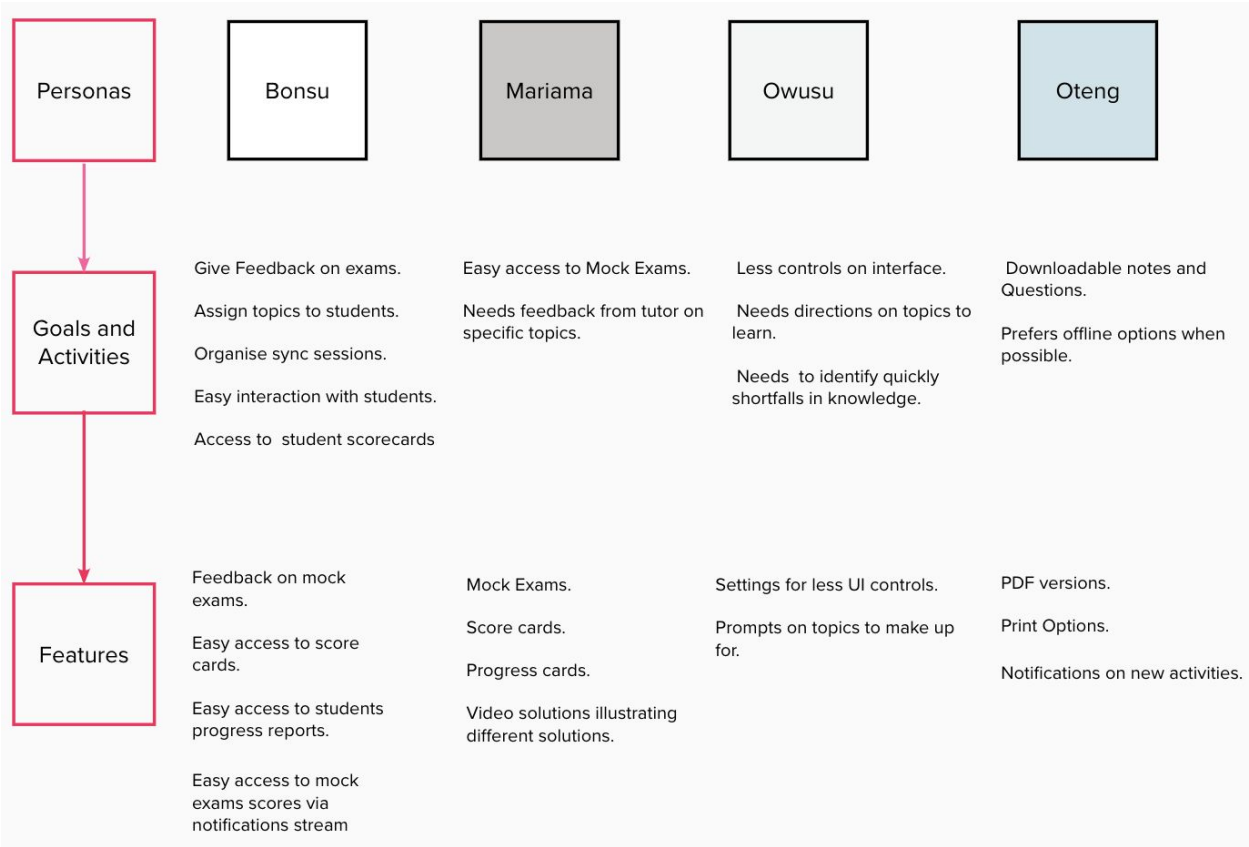


Figure 20 : Mapping personas goals to features.

Additionally, CARE utilizes social presence indicators and as a way to create a sense of community amongst students and enhance easy interaction on the platform. CARE proposes that multiple communication modalities are built into the interface so students and tutors can send text based messages, record audio messages as well as video messages as a means of communication and feedback on the platform. These kinds of multimodal communication mechanisms are today widely available in social media and communication applications and can be integrated into CARE as well.

Since our definition of Remedial education is intended for students remediate failure in post secondary placement examinations, we propose that CARE should have inbuilt mock examinations in the interface to help students practice for their final placement examinations. We propose that these examinations should be downloadable and printable to address the needs of personas who cannot afford financially to connect to the internet all day long, that is, have

limited access to the internet or have to work with poor bandwidth and cannot fully make use of audio visual components of CARE. In addition, we propose in our design that answers to mock examination questions should be of a multimodal nature with textual, embedded images and audio-visual explanations wherever possible.

Lastly, our proposed design has feedback mechanisms such as score cards integrated into the interface for both students and teachers. This helps both students and teachers to understand how much progress they are making in their remediation. Since certain poor score cards may be discouraging and have a negative effect on poor performing students, we propose that CARE applications should allow the tutor to hide this in the settings page of their students and provide other forms of feedback that would be appropriate to students.

4.2 Prototype of CARE concepts

In this session we showcase and discuss our proposed prototype of some of the features of CARE using the Figma[13] design tool. Icons used in this prototype were sourced from Flaticon[14] and the attributing license is in the appendix of this work.

4.2.1 Features: Student Dashboard

The dashboard has access to different menu items namely the Courses, Tutorials and Mock exams. The student dashboard itself has a scorecard which has a breakdown of the learners performance on different topics and mock exams. We propose in the CARE prototype that such feedback features should be under the control of the tutor and that the tutor should evaluate whether the particular student would be demotivated by this type of feedback and turn it off until it adds positive motivation on the students performance.

[13] https://www.figma.com/

[14] https://www.flaticon.com/

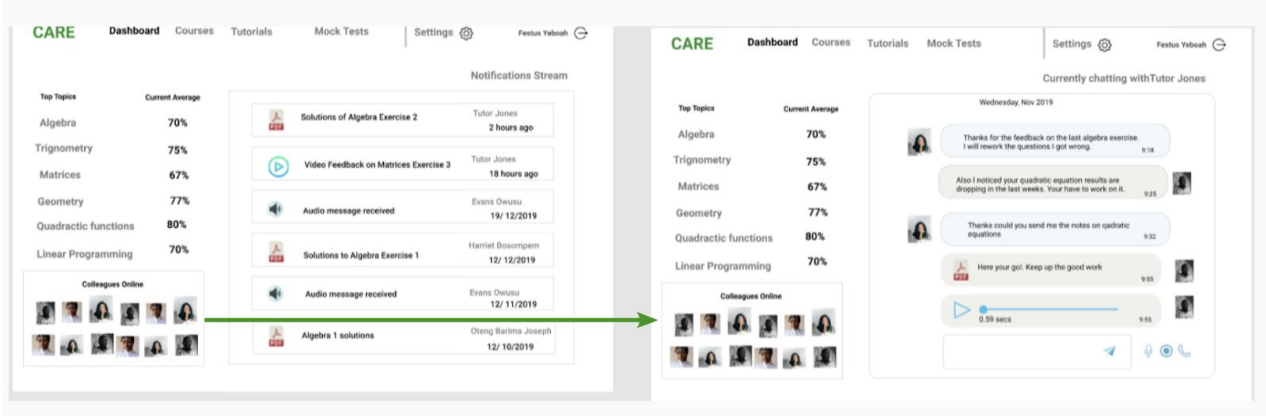


Figure 21: A screenshot showing some transitions of the Dashboard page.

Since CARE proposes social learning, a learner can see colleagues or people in their learning group that are online. This allows them easy access and learners can initiate communication with the Tutor or the other learners from the dashboard. Students also have access to their communication or Notifications streams where relevant activities such as audio and video feedback, lesson uploads etc can be logged by CARE.

4.2.2 Features: Course Page

CARE proposes a courses page where students can enroll in courses relevant to them. This page comes with a set of filters in case learners want to filter over a large number of courses. Courses in which a learner is enrolled is indicated visually for easy identification of the learner.

4.2.3 Features: Tutorials Page

The tutorials is the main learning page for a learner enrolled in a course. It has a simple sidebar with free text searchable topics and a main section where different multimedia formats and learning tools are displayed. CARE proposes short videos tutorials on topics enriched with descriptions and the ability of the learner to control the speed of videos to suit the learner and close captions.

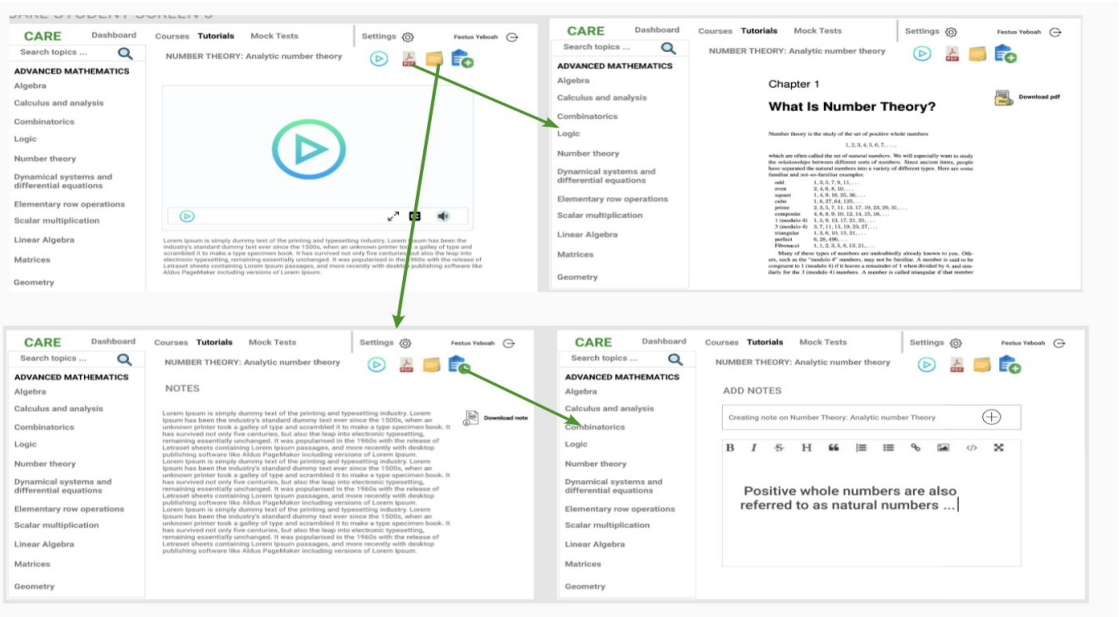


Figure 22: A screenshot showing some transitions of the Tutorials Page

CARE proposes that when appropriate, relevant tutorial sessions materials should be in multimedia formats such as pdf so learners that fit the persona of students with limited access to the internet can download such sections for perusal later on. Learners should also be provided with the opportunity to take notes on sections and these notes can be annotated with the timestamp of the video, a pattern employed by some of the platforms investigated such as Udemy.

4.2.4 Features: Mock Tests Page

The mock examinations page allows the student to simulate exams, this is an important component of CARE since the ultimate aim of learners in CARE is to pass their final examinations and hence providing a simulation environment where they can test the progress is essential. CARE proposes to log the scores for the students in these simulation exams. These mock examinations can be used to provide feedback to both the student and the tutor on which topics to focus on for different topics.

Data analytics and Artificial Intelligence (AI) tools can be run on such accumulated data to further understand the needs of students. AI systems such systems have been proposed and employed already on E-learning systems Potode et al, 2015, Kacalak et al 2009).

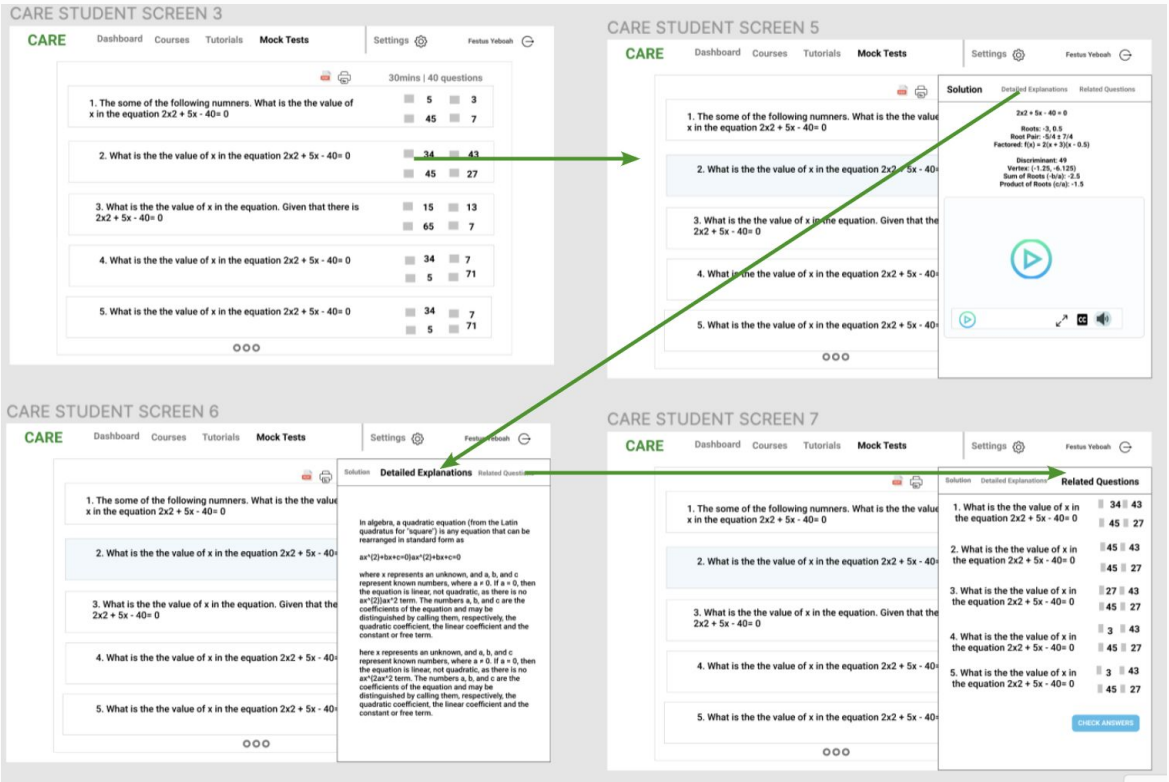


Figure 23: A screenshot showing some transitions of the Mock Tests Page.

The solutions to mock exams when completed can be viewed on a side panel that opens up on clicking that particular question. Side panel contains the solution to the questions which CARE proposes can be in a multimedia format that is a combination of text based solutions as well as for example embedded videos that walk through the solutions with the student. In addition the side panel can contain related questions so the student can work through similar questions to reinforce their understanding of that particular topic topic.

4.2.5 Features : Teacher / Tutor Pages

According to CARE's persona to user story mapping the teacher should be able to quickly give feedback on learners examinations, we propose that a teacher should be able to visit every learners dashboard with detailed scorecards showing the learners deficiencies and strengths. This will enable the teacher to easily assign topics to students to learners where they have deficiencies.

We propose easy access to communication tools such as integrated chat / messaging systems where recorded audio and video feedback can be given as is more natural. Furthermore, we propose an integrated live lesson functionality like webinar software allowing the tutor to quickly organise the ability to quickly organise sync sessions for students for easy interaction with students. The tutor can generate quick feedback through the use of polls for instance to understand from students what topics should be treated. Such polls aside giving feedback also increases learner engagement. The associated pages for the teachers view are in the appendix of this work.

4.2.6 Usability testing scenarios

The proposed prototype of CARE was then taken through a usability testing testing session with seven participants. We employed a mixture of methods using semi structured interview techniques together with Think-Aloud Method and also collected data from using the SUS. We tested 3 scenarios representing what the most important tasks of our student personas.

1. Owusu is a 32 year old Building Construction Supervisor with over 10 years experience . He wants to take some remedial courses so he can get a degree in Civil Engineering and Construction Management which in the future increases his chances of getting promoted. As he has a full time and a family, he learns only on the weekends and in the evenings. He therefore requires quick feedback from his remedial tutor on areas to improve. Thus, he needs an application where feedback is integral. Since he uses a lot of communication tools like Whatsapp, Zoom, Skype and social media like Facebook and LinkedIn he expects the same level of communication in an E-learning environment. After work, he logs in to CARE, an E-learning platform for Remedial education, he sees his notifications feed and sees that his Mathematics tutor has given him some feedback. He opens the communication stream with his tutor.
2. Mariama is a 20 year old who just completed high school. She had excellent grades in all subjects but not in Physics and Mathematics. She wants to improve these two subjects so that she can enrol for a degree in Electrical and Electronics Engineering. She therefore wants to practise as many mock examinations for these subjects as possible. The feedback from the mock exams helps her to improve in areas where she is lacking. She

therefore would like an application that also suggests to her which areas to improve on because feedback from the tutor is not immediate.

3. Oteng is a 22 year old and works as a Mechanical apprentice. He dropped out of school and is using the remedial system to study part time . He already passed half the exams needed to get him into a mechanical engineering degree. He doesn't always have access to the internet and so when he goes on the internet, he wants to download as much multimedia materials as possible. These materials include questions and answers and tutorial sessions and his notes. He therefore appreciates that he can see what content is new in his notifications stream and then visit these items and download them.

4.2.7 Feedback from usability testing

The first two tests were conducted face to face as a pilot and changes were then made based on the feedback received from these two test participants. The rest of the tests were conducted remotely. The following summarizes notes taken, questions and suggestions from the usability testing:

1. Scenario 1:
    a. There is no clear indication of who is a tutor and who is not.
    b. How would a user contact a tutor who is offline since only online tutors are available on the dashboard?
    c. It will help if the pictures of colleagues and teachers come with their names as well.
    d. Add an icon to indicate that clicking on a tutor will open a chat.
2. Scenario 2:
    a. Users would be interested in how other students solved the problems he / she got wrong and so it might be beneficial to integrate a forum-like interaction on every question.
    b. Perhaps a start button and a countdown clock on the Mock exam questions will help the user to track time and progress on the questions session they are working on.
    c. Perhaps there is no need for a modal dialog to show the score and the score can be shown on top of the questions page.

d. Some context should be provided to the user when downloading PDF or printing out from the mock exams about what would be downloaded or printed out. This would help learners who belong to student persona 3 and do not have a good internet bandwidth and hence want minimal downloads.
e. I want to immediately see which questions I got wrong.
f. I want to be retake the exam again

3. Scenario 3:
    a. Make a clear distinction between sub navigation buttons and action buttons when using displaying multimedia items to learners.
    b. Move the navigation buttons from the level of the current to within the topic so that is is clear
    c. Download buttons could be at the same place for videos, pdf and notes and additionally, we could use the same icon with the label changing to “download pdf”, “download notes” etc.

The completion of the first scenario of contacting the tutor was difficult for first time users, it was not obvious where to click in the first version. Suggestions included adding the names of the people online and having a different section for tutors. Marked improvement was gained when this was fixed after the pilot and the scenario was retested.

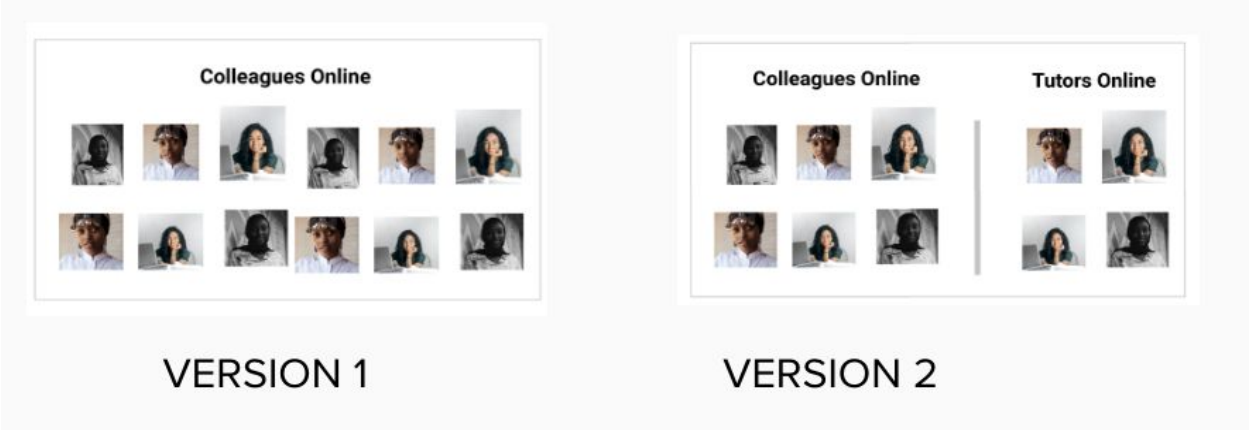


Figure 24: Two versions of the online presence indicator before(1) and after(2) the pilot usability testing session.

Feature improvements suggested from the first test included adding contextual information and filtering capabilities on the examinations sections and the addition of tooltips and text labels in cases when the iconography was not clear. Iconography was clearly most confusing to the testers in the pilot. This could be fixed by adding a label to the icon and also highlighting the multimodal section selected.

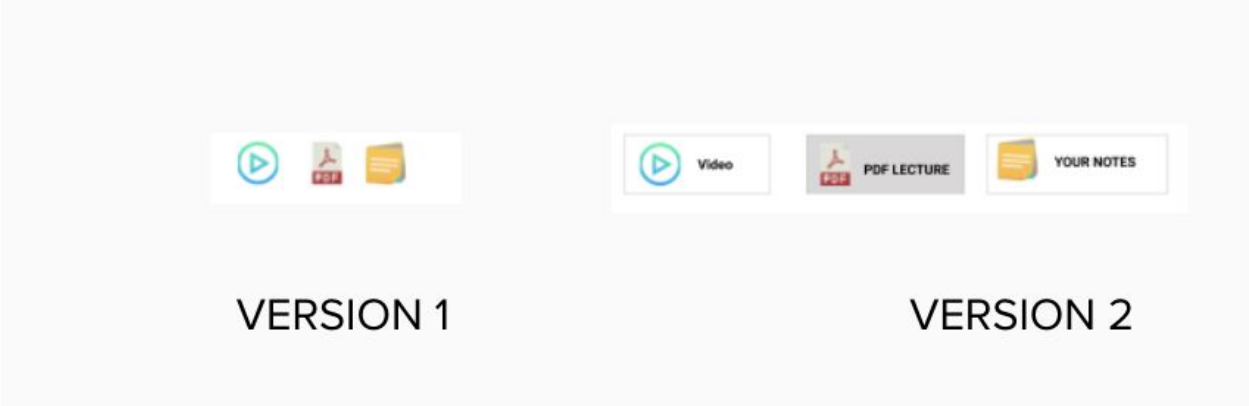


Figure 25: Usability improvements in version 2 with added text labels to accompany icons.

The information architecture of the tutorials section was also questioned. Information architecture is obviously crucial when implementing multimedia interfaces as too many modes can overwhelm the learner. In this case the fix was to add more contextual information to menu items. In the mock exams section, users were overwhelmingly interested in seeing not only the score but the tickers indicating which answers they got wrong. In addition testers were interested in getting immediate feedback of which questions they got wrong not just on their total score. The design was modified from a complete overlay to a partial one as illustrated in the Figure 26 below

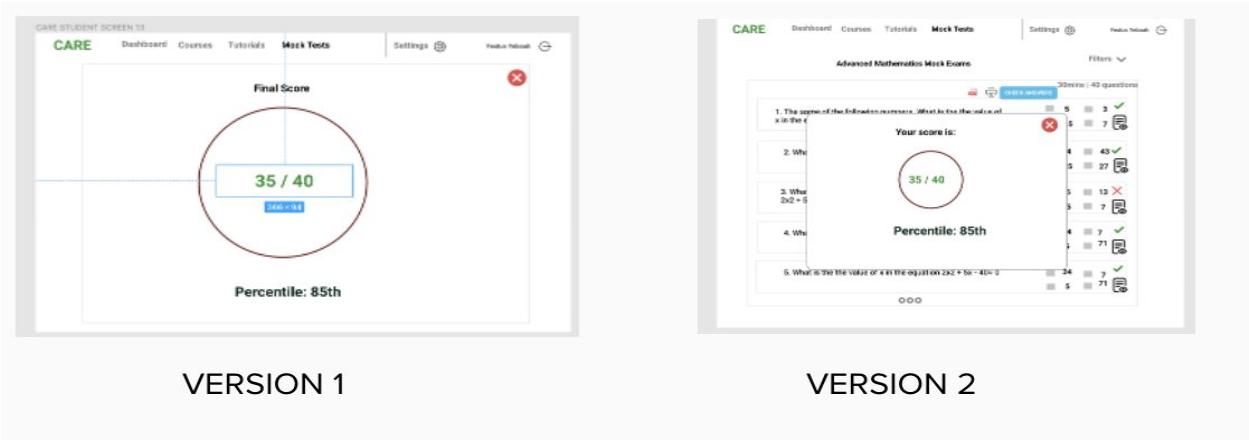


Figure 26: Two versions of the scorecard before(1) and after(2) the pilot usability testing session.

Five of the test participants wanted the ability to retake exams immediately if they did not do well. These participants liked the idea that they could work through questions related to the questions they got wrong but still wanted the ability to repeat the entire exam again. All testers appreciated the multimodal solutions to mock examination questions although some doubted the feasibility of having audio-visual explanations for every question. At least one participant thought the solutions to the questions could also benefit from a forum like discussion where learners could interact with each other and share ideas on their approach to solving the problem. The table 15 below summarizes the results of the standard SUS questionnaire by the 7 participants.

SUS Calculation											
Participant	**q1**	**q2**	**q3**	**q4**	**q5**	**q6**	**q7**	**q8**	**q9**	**q10**	SUS Score
P1	4	1	1	1	4	1	5	1	3	1	**80.0**
P2	4	1	4	1	3	3	4	1	4	3	**75.0**
P3	4	2	4	1	4	4	5	4	4	1	**72.5**
P4	5	1	5	1	3	1	5	1	4	1	**92.5**
P5	5	1	4	1	4	1	5	1	4	1	**92.5**
P6	5	2	5	1	5	1	5	1	5	1	**97.5**
P7	4	1	5	1	5	3	5	1	4	1	**90.0**

Table 15: Results for SUS testing

It is interesting to note that after the changes suggested in the first two tests were applied, subsequent testers did not highlight these and the SUS score generally increased suggesting that there was improved usability after the changes were applied. Indeed, with the exception of the third participant(P3) higher SUS scores of more than ninety were obtained after the fixes were applied showing that a significant usability increase of the design was made after the pilot testing.

4.2.8 Summary of results

It is clear from the results of the usability test that, when designing multimodal interfaces, a clear information architecture when navigating between different modalities should be employed. In addition, proper use of iconography should be used to avoid confusing the user when switching between modalities. Proper labelling and the use of information triggers like tooltips and popups should be integrated to aid the user as well differentiate between different modalities.

The results of the test for the Mock Exams suggest that when designing such interfaces some level of control should be given to the user / learner for instance an integrated stop watch to monitor the time spent on exam sessions was suggested. The need for control over the interface can also be seen in the fact that five of the seven participants wanted the ability to retake exams when they did not perform well. Lastly, the participants expected immediate feedback when checking the results of the mock exam suggesting that immediacy is important in such interfaces.

The test was executed with seven (7) testers. All seven testers were familiar with E-learning and had used an E-learning platform before the exercise. Four (4) of the participants had knowledge of Remedial Education while the other three(3) participants had no knowledge of Remedial education. It would be interesting if this research is done with users familiar with Remedial education and hence a more representative user base of this system.

5. Discussion

In this thesis we explored a number of research themes addressing the question of what multimodal methods and interaction techniques are used in existing E-learning platforms and what multimodal interface techniques could be used to enhance E-learning based Remedial learning platforms.

This was done through a comprehensive document analysis of ten existing E-learning platforms coupled with a literature review to identify the critical success factors in E-learning and Remedial education.

A second phase of applying multimodal and multimedia design principles and the CSFs of E-learning and Remedial education to design a novel user interface to enhance E-learning based remedial learning was done. A conceptual prototype was developed incorporating the best practises found in the document analysis and literature review.

Lastly, this prototype was further taken through usability testing to identify usability issues and opportunities for improvement of the concept. A number of usability pain points were discovered in the usability testing phase and remedies for these pain points were found and fixed.

Answers to the research questions

In this section, we briefly discuss some of the answers to our research questions.

Q1: The result of this review revealed that the technique of combining video, audio and textual transcripts as the most common multimodal technique in the E-learning platforms studied. Another noteworthy commonality is the use of text based Q&A or forum-like medium as the main means of giving feedback and communication. This thesis proposes that, given that tutor and peer interaction and feedback interaction are critical success factors for Remedial education, multimodal feedback mechanisms such as audio and video chat should be incorporated into the user interfaces for E-learning based Remedial education.

Some form of video instruction has been integrated in all platforms under study. The predominant feedback and interaction mechanism between learners and and between tutors and learners is through text based discussion forums or commenting sections in the course. One of

the language learning platforms, Busuu allows learners to send and receive audio and video to peers and tutors for feedback on their language skills. In addition, some form of social interaction or social presence indication was found on all platforms indicating that social learning is commonly built into existing E-learning interfaces.

Lastly, when the integration of complex multimodal tools such as code IDE's are necessary, E-learning platforms resort to the use of third party integrations to deliver content.

Q2: The usability testing of the proposed prototype shows that the use of multimodal communication tools such as chat, audio and video messaging is promising as all test participants gave positive feedback on the feature. When such multimodal communication is implemented though, two important information architecture problems of findability and discoverability should be handled for the user to easily locate tutors and hence a clear separation of learners / peers and tutors should be made.

The multimodal patterns of the tutorial section also received positive feedback. Information architecture issues were found in this section as well further highlighting the fact that when multiple modalities or multimedia content are used, a clear information architecture and contextual information should be given to the user to easily navigate the interface.

When downloadable multimedia artefacts are allowed, it would be important to give the user some context on what would be downloaded in this way, users with limited data bandwidth will know beforehand how much data they would be consuming.

Lastly, the interface patterns proposed for the mock exams and quizzes also received positive feedback, users however wanted immediate feedback on their exam scores and the ability to repeat or retake such quizzes if they deemed the scores to be low.

Limitations

We identified a number of limitations of the study namely the small sample sizes of E-learning platforms, the small samples size of test participants and the non representative nature of the test participants. Firstly, given the large number of E-learning platforms available today, our sample of ten is a relatively small sample size. Though this sample includes popularly used academic

platforms, there are many proprietary or corporate E-learning platforms such as Docebo[15], Canvas LMS[16], TalentLMS[17] etc that may have advanced multimodal features but were not considered in this study because they are behind paywalls or are costly to install in terms of time and resources. Secondly, the E-learning platforms were reviewed and the feature sets prototypes were done purely from the user interface perspective of the learner and not the teacher / tutor. Lastly, the usability testing was conducted with participants in Germany. Although all participants had knowledge of E-learning, only four participants had knowledge of Remedial Education. It would be interesting to test the prototype with a testing audience in Ghana who would be more familiar with the concept of Remedial education as defined by (Oduro-ofori et al., 2014).

Future work

It is hoped that the findings help to further the field of multimodal interface design particularly in the area of E-learning and open new research directions by identifying a number of points that require further investigation. Future works could increase the scope of this work by increasing the number of test participants and finding more representative test participants as indicated above in the limitations of this work. Furthermore, future work could concentrate on analysing the multimodal features of some of proprietary and commercial products mentioned above to find out how multimodalism is built into these products.

Additionally, the concept developed in this work was developed for a web based e-learning interface but given the higher mobile penetration in Ghana(GSMA, 2020), future work could concentrate on m-learning(mobile learning) interfaces for Remedial Education.

Lastly, this work focused on the analysis and design of multimodal and multimedia user interfaces for Remedial education from the learners perspective. Work in the future research could focus on the teacher / tutor view of the interface as the

[15] www.docebo.com
[16] https://community.canvaslms.com/
[17] https://www.talentlms.com/

Conclusion

In conclusion, until recently, there was little work on E-learning user interfaces as noted by Faghih (Faghih et al, 2014). There has been an increasing interest in this field in the last five years. This study focused on applying the existing knowledge base of Remedial education, E-learning and Multimodal theory to design user interfaces for E-learning based Remedial education and testing the usability of a conceptual prototype developed. The results of this study adds to the increasing knowledge base of User Interface Design for E-learning systems and contributes additional insights into applying Multimodal theory of user interactions when applied to the context of E-learning based Remedial education. It is a starting point in that searching across scientific literature databases did not yield any existing research efforts in this specific direction.

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6. Appendix

6.1 Usability testing Interview Script and Scenarios

6.1.1 Introduction for Usability Testing Participants

Hello _____ and welcome to this usability testing session for CARE. Thank you very much for participating in this research. Before we commence, I would like you to know that you can ask to stop this interview at any time should you wish to stop or feel uncomfortable and it will not be a problem. If you need to take a break, please let me know.

In addition, please remember that there is no need to rush so take your time and think about your answers while we walk through the prototype. Also, please keep in mind that there are no wrong answers to the questions I ask and all feedback from you is valuable for this research.

With your permission, the interview will be recorded and your answers will only be used for the purposes of research. If you do not want for the interview to be recorded, you are still welcome to participate. I will be taking notes during our conversation instead.

Upon completion of this interview, you may decide to withdraw and your request will be honored. The data collected will be kept for the study phase of the project and then destroyed.

I will ask you to sign a consent form accepting that the interview be recorded and the findings to be used for the study purposes. The interview will not take longer than 35 minutes and I will keep an eye on the time to ensure that.

Do you have any questions before we start?

6.1.2 Description

This interview is to evaluate the design of a web based e-learning application for remedial education. Though there are many general purpose e-learning platforms, there are no e-learning platforms specifically designed to address the needs of remedial education. This study aims to address that problem. This testing is aimed at testing the main functionalities described in the scenarios below for our three main personas.

6.1.3 Scenarios

1. Owusu is a 32 year old Building Construction Supervisor with over 10 years experience . He wants to take some remedial courses so he can get a degree in Civil Engineering and Construction Management which in the future increases his chances of getting promoted. As he has a full time and a family, he learns only on the weekends and in the evenings. He therefore requires quick feedback from his remedial tutor on areas to improve. Thus, he needs an application where feedback is integral. Since he uses a lot of communication tools like Whatsapp, Zoom, Skype and social media like Facebook and LinkedIn he expects the same level of communication in an e-learning environment. After work, he logs in to CARE, an e-learning platform for remedial education, he sees his notifications feed and sees that his Mathematics tutor has given him some feedback. He opens the communication stream with his tutor.
2. Mariama is a 20 year old who just completed high school. She had excellent grades in all subjects but not in Physics and Mathematics. She wants to improve these two subjects so that she can enrol for a degree in Electrical and Electronics Engineering. She therefore wants to practise as many mock examinations for these subjects as possible. The feedback from the mock exams helps her to improve in areas where she is lacking. She therefore would like an application that also suggests to her which areas to improve on because feedback from the tutor is not immediate.
3. Oteng is a 22 year old and works as a Mechanical apprentice. He dropped out of school and is using the remedial system to study part time . He already passed half the exams needed to get him into a mechanical engineering degree. He doesn't always have access to the internet and so when he goes on the internet, he wants to download as much multimedia materials as possible. These materials include questions and answers and tutorial sessions and his notes. He therefore appreciates that he can see what content is new in his notifications stream and then visit these items and download them.

6.1.4 System Usability Scale(SUS)

For each of the following statements, please mark one box that best describes your reactions to Computer Aided Remedial Education today. Please don't overthink about each statement. Make

sure you respond to every statement. If you are not sure how to respond , simply check the middle box (“3”).

	Strongly disagree				Strongly agree
	1	2	3	4	5
I think that I would like to use Computer Aided Remedial Education frequently.					
I found Computer Aided Remedial Education unnecessarily complex.					
I thought Computer Aided Remedial Education was easy to use.					
I think that I would need the support of a technical person to be able to use Computer Aided Remedial Education.					
I found the various functions in Computer Aided Remedial Education were well integrated.					
I thought there was too much inconsistency in Computer Aided Remedial Education.					
I would imagine that most people would learn to use Computer Aided Remedial Education very quickly.					
I found Computer Aided Remedial Education very cumbersome (awkward) to use.					
I felt very confident using Computer Aided Remedial Education.					
I needed to learn a lot of things before I could get going with Computer Aided Remedial Education.					

6.1.5 Questions Guide

Before testing:

Are you familiar with the concept of remedial or developmental education?

Follow up questions:

Do you use any e-learning platforms?

Do you know any e-learning platform designed purposely for remedial education?

What do you think of the idea of e-learning for remedial education? Is it relevant?

What has been your experience with e-learning platforms?

During testing:

From the dashboard.

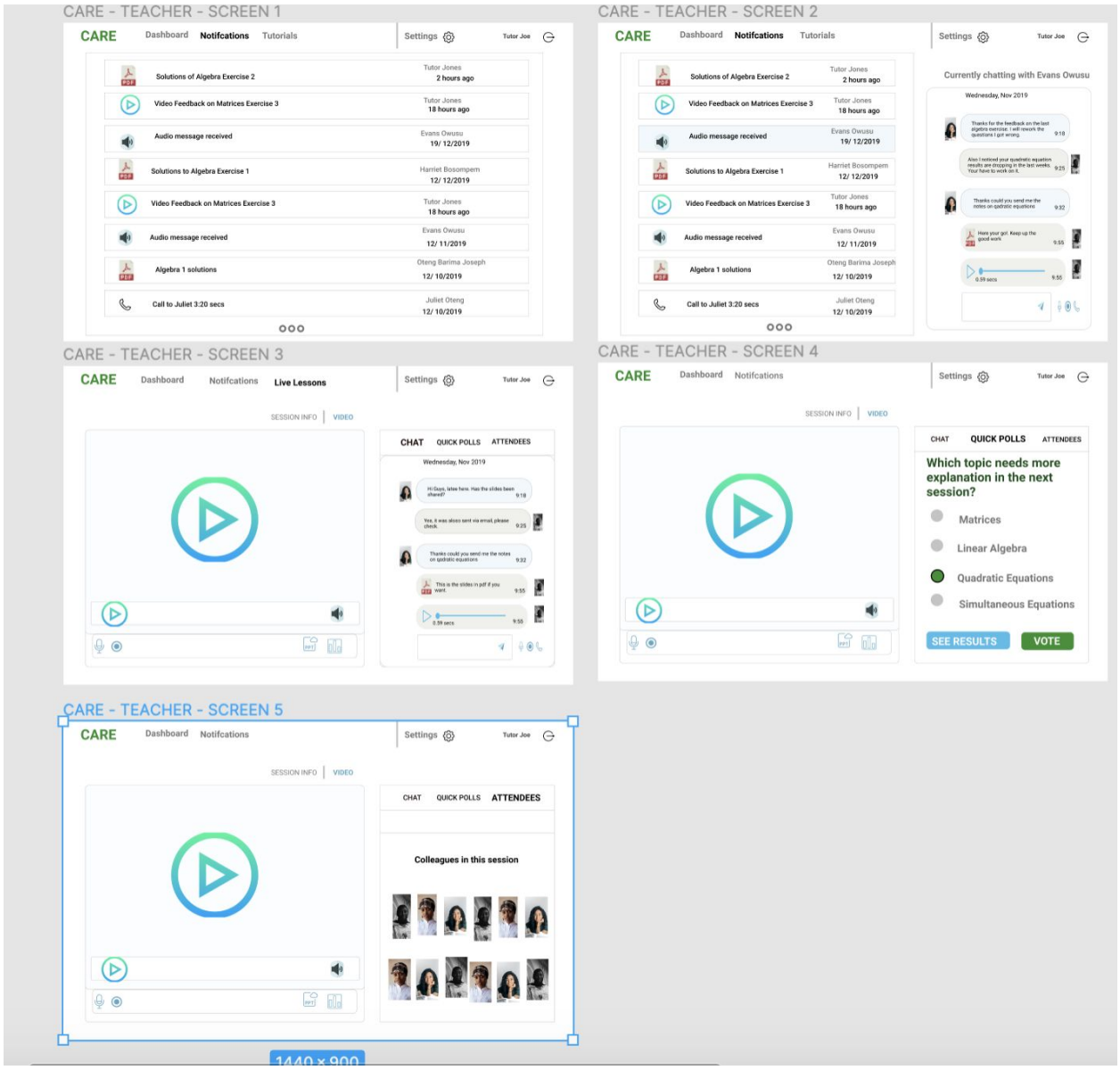
1. Can you click to contact your tutor?
    a. What did you expect when clicking on the photo?
    b. What can be improved to help you easily contact your tutor?
2. Could you please navigate to the mock exams page?
    a. Was it easy to identify the mock page?
    b. How would you finish a mock exam?
    c. What did you expect after completing the exam?
    d. What would you like to do next?
3. Complete and check your answers?
    a. Was this your expectation?
    b. What can be improved?
4. What would you do after checking your exams?
    a. What can be improved?
5. Navigate to the solutions page? What would like to do on the solutions page?
    a. What can be improved?
6. Imagine you wanted to download some questions and tutorial items, where would you navigate to?
7. What can be improved?

Final remarks:

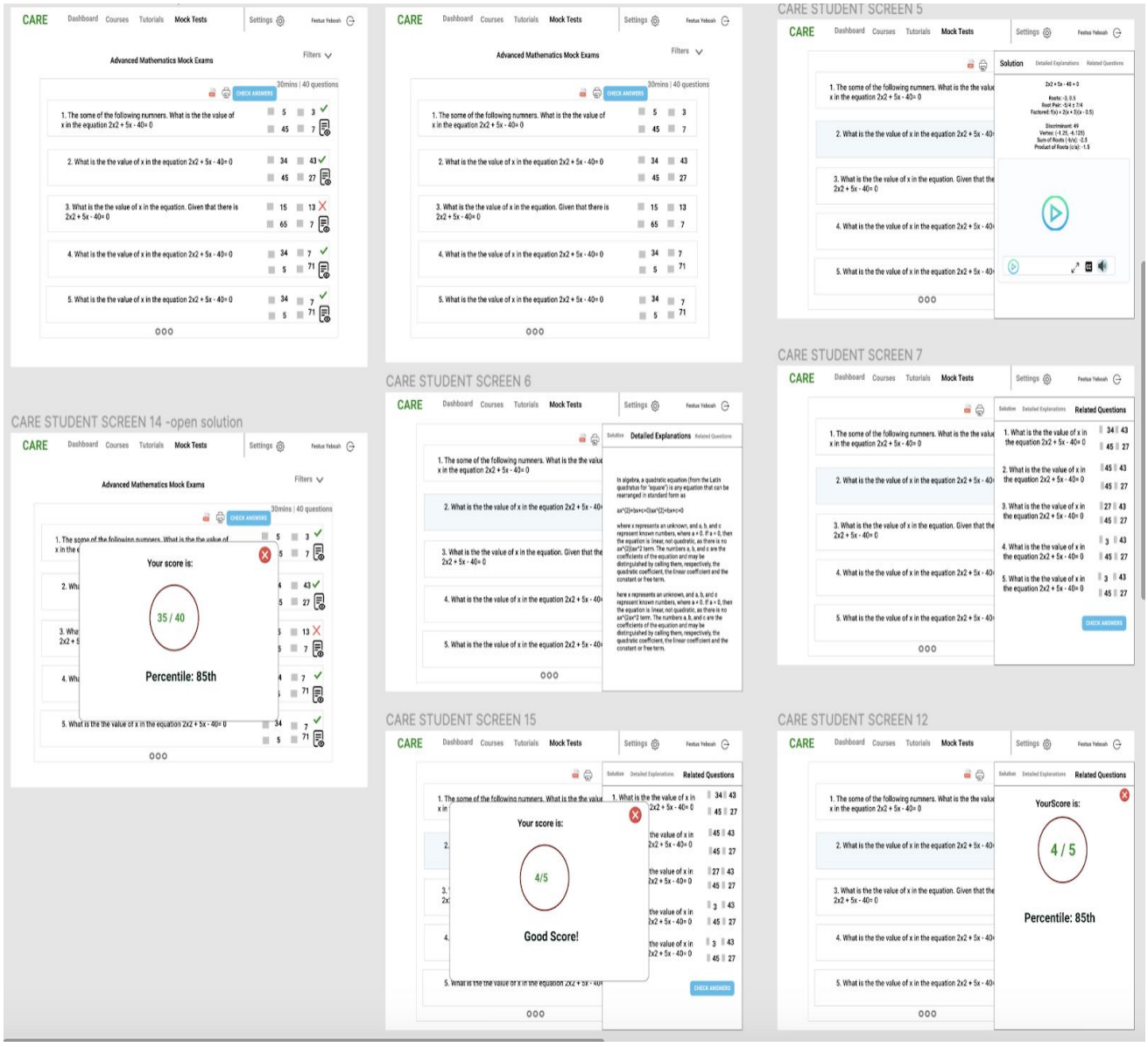
Thank you very much for your time and effort! This has been really helpful. Before we finish, do you have any questions or concerns? Or is there anything that you feel you should have said?

6.2 Prototype Screenshots

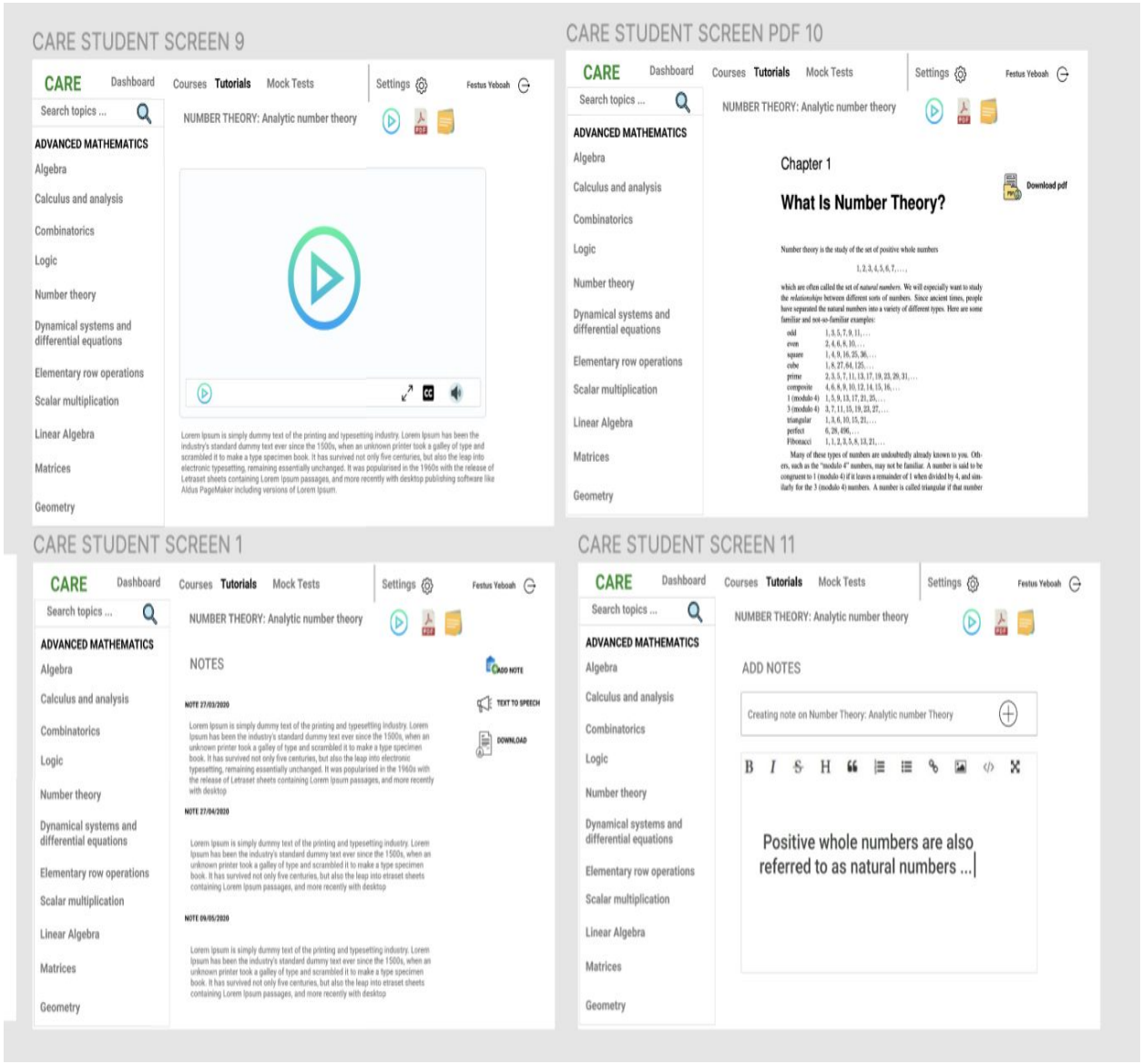
6.2.1 Teachers / Tutor Views



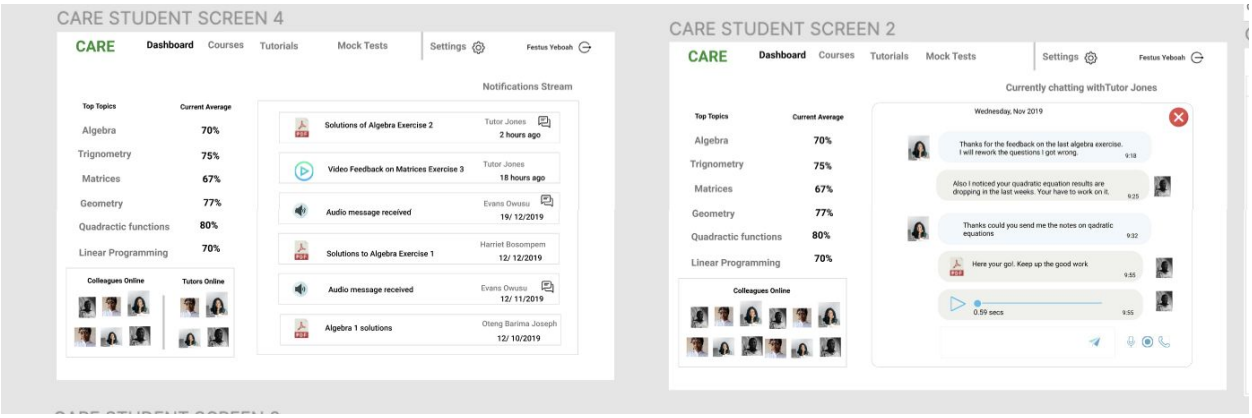
6.2.2 Mock Tests Page Views



6.2.3 Tutorials Page Views



6.2.4 Dashboard Page Views



6.2.5 Flaticon License

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