CM3203 Final Report

Digital Learning – Education of the future

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ABSTRACT

Since the start of the COVID-19 pandemic, Emergency Remote Teaching has become an invaluable tool but despite being widely used for many years, it is not without its challenges. The aims of this project were to discover and document the challenges of Emergency Remote Teaching, to create core design principles and to develop a prototype solution that exemplifies the design principles. The research discovered that Emergency Remote Teaching can present significant challenges for both students and teachers, negatively impacting upon their mental health due to the lack of in-person interaction that it allows them. The findings also suggest that Emergency Remote Teaching can have significant influence upon student engagement and also poses potential privacy and security risks for users. The subsequent remote teaching prototype that was developed to address these issues has been titled Multi-Purpose Online Learning Environment (M-POLE). The M-POLE intends to address some of these concerns and allows both students and educators to access the tools necessary for online learning all within one system.

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Secondly, I would like to thank the participants in the study as this project would not have been possible without them.

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1.0 INTRODUCTION

The COVID-19 pandemic resulted in world-wide disruption to life. Whilst all industries have been negatively affected by the pandemic, some have been hit harder than most. Previously unknown weaknesses in these industries have been exposed and targeted, with the path forward for these sectors becoming clouded with uncertainty.

Arguably, the most important area affected by the pandemic is the education sector. A joint report published by UNESCO, UNICEF and the World Bank states that COVID-19 pandemic-related school closures affected more than 1.6 billion learners, and the current generation of students now risk losing (in present value) $17 trillion in lifetime earnings, approximately 14% of today's global GDP. Asa result of these closures. (The World Bank, UNESCO and UNICEF.2021)

In order to combat this, countries across the world were forced to transfer education from traditional face-to-face learning to a remote learning substitute. The effectiveness and quality of this shift in learning varied greatly, and as an emergency response, most definitely did not reach its educational potential. Emergency Remote Teaching (ERT) is not usually planned in advance, and in the event of an emergency situation (e.g. Coronavirus Outbreak), involves a sudden shift from traditional face-to-face teaching into a remote one. Often, students complain about the inequality in education and the difficulty in accessing educational resources whilst faculties complain about student engagement. (Affouneh et al. 2020)

Currently, most institutions offer a hybrid teaching format, incorporating both face-to-face and online teaching. With the possibility of emergency situations and other industries already shifting to remote working, it is likely online learning will become the new standard.

To avoid the challenges posed by ERT, this report intends to propose a set of core design principles for remote teaching technology (founded on secondary research through reviewing related work) and develop some of these principles into a technical prototype **M-POLE (Multi-Purpose Online Learning Environment)** solution.

As discussed in the initial project plan, the project can be separated into two parts, researching the problem and developing a set of design principles and prototype solution. In order for the project to be successful this report should meet the following revised aims:

- Discover and Document the challenges of ERT
- Using the research, create a set of core design principles for remote teaching technologies.
- Develop a prototype M-POLE solution that exemplifies these design principles

To resolve these aims, the project objectives have been split into revised Research Objectives and Solution Objectives.

Research Objectives:

- To define 'student engagement' and uncover why there is a lack of this 'engagement' from students during remote learning.
- To assess the difference in quality between face-to-face learning and remote learning and the cause of this difference

- To discover what educators require in remote learning technologies to teach at the same standard
- Evaluate the effectiveness of the prototype M-POLE solution

Research is obtained in this report through the literature review section, and the user evaluation of the prototype and aims to resolve the above objectives. In the initial plan, I intended to also acquire user research to supplement the prototype design. Due to time constraints, it was impossible to incorporate this type of research, however in future developments this user research can expand upon the current existing literature and develop the core design principles proposed in this report further.

Solution Objectives

- Using literature based reasoning, develop 4 core design principles for remote teaching technologies that aim to increase student engagement.
- Develop a web-application prototype M-POLE that exemplifies the proposed design principles
- Incorporate database functionality into the web application

The conclusion section of the report discusses if the project was successful in meeting these aims & objectives.

2.0 LITERATURE REVIEW

The COVID-19 pandemic led to the mass disruption of all industries world-wide and brought life to a standstill. Whilst all industries were impacted significantly, it can be argued that the education sector suffered the most. The closure of schools across the globe forced educators to substitute their traditional face-to-face lessons with Emergency Remote Teaching (ERT). ERT can take many forms, with some institutions utlising the technology alone whilst others offer a hybrid of both face-to-face and remote teaching. The success of this transition and the quality of the subsequent teaching has been questioned and investigated by many scholars following the COVID-19 pandemic (Achen and Rudledge, 2022). Despite the recent increase in research into the topic, remote teaching is not a new occurrence and has previously been utilised in many different instances of school closure across the globe including natural disasters, terror attacks and other emergency situations (Trust and Whalen, 2021). Along with the ongoing impact of the COVID-19 pandemic and the increased usage of digital technology, the need for remote teaching will only continue to rise, making this a very pressing topic for research.

2.1 REMOTE TEACHING TECHNOLOGIES: SOCIAL, ETHICAL AND SECURITY RISKS

Several different remote teaching technologies currently exist and were heavily relied upon throughout the pandemic, with the most widely used being Microsoft Teams, Google Classroom and Zoom (Cassidy and Ruday, 2022) Whilst exploring the uses of these technologies, scholars have identified many issues with the options that are currently available, with one of the largest threats being the security risks that are associated with them. As a result of their research, Moorhouse and Konkhe label one of these risks as ‘zoomboming’, referring to the event of an unauthorised person hacking into a live session without access to the meeting link, ID or password (Moorhouse and Kohnke, 2022). In addition to this, scholars widely suggest that online learning has posed threats to the digital privacy of students. In their research, Khlaif, Kouraichi and Salha state that a number of the study’s participants shared that they felt uncomfortable when asked to turn on their webcams or to share their screen during lessons, stating that it was an invasion of their privacy as they were in their home environments (Khlaif, Kouraichi and Salha, 2021). As remote teaching is widely utilised across all age groups, it is vital to ensure that students are protected from these dangers and that their privacy always remains a priority. Despite identifying many of the challenges that these technologies pose to their users, very few studies suggest ways in which these issues can be addressed. The lack of solutions presented by scholars reveals a sizeable gap in the research into remote teaching technologies.

2.2 REMOTE TEACHING: USER CHALLENGES

Following the COVID-19 pandemic, many scholars conducted research into the disruption that the switch to online learning has had on both students and educators (Karakose, 2021; Gleckman-Krut et al, 2021) Trust and Whalen’s research into the sudden switch to remote learning suggests that most teachers did not feel prepared for the change as there was limited

training and resources available to them at such short notice (Trust and Whalen, 2021). Guðmundsdóttir and Hathaway's research states that despite the lack of training accessible, the 'findings show that teachers are both willing and able to cope as online practitioners' (Guðmundsdóttir and Hathaway, 2020), increasing the urgency for reliable training and systems to be put in place. In addition to this, many studies have identified the impact that online learning has had upon the mental health of teachers. (Eddy, Herman and Reinke, 2020) In their 2020 study, Reich at al concluded that throughout the COVID-19 pandemic, many teachers experienced feelings of uncertainty towards the job that they have loved for many years due to the loss of personal connections and professional competence brought about by the introduction of remote teaching (Reich et al, 2020). In addition to this, research conducted by Gleckman-Krut et al suggests that the lack of in-person interaction as a consequence of remote teaching significantly impacted upon their attitude towards their job role as they struggled to establish any sense of personal connection with their students.(Gleckman-Krut et al, 2021) As concluded in much of the research following the COVID-19 pandemic, remote teaching presents both students and teachers with numerous challenges which have yet to be addressed. Throughout this research, scholars have identified many of these challenges but very few present any solid solutions, a gap in the knowledge which this project intends to address.

Multiple scholars have richly explored the influence of online learning and the challenges that it poses to learners. (Shim T and Lee S, 2020; Chaparro-Palaez et al, 2021) In their 2016 study, Alho et al discuss the challenges of using digital technologies within education, identifying their potential to increase feelings of depression and burnout amongst learners. (Alho et al, 2016) Similarly, following the results of their research, Barrot, Llenares and Rosario conclude that 'most students reported that the anxiety, boredom, sadness and isolation that they experienced had adversely impacted the way they learn... Completing their tasks/activities...and their motivation to continue studying' (Barrot, Llenares and Rosario, 2021) These findings were mirrored by Bhattacharya, Carruth and Crowther et al whose research also concludes that feelings of anxiety and stress were rife amongst their participants as a result of the transition to remote learning. (Bhattacharya, Carruth, Crowther et al, 2021). Alongside remote learning increasing these negative thoughts and behaviours, scholars suggest that the lack of in-person teaching also makes it significantly harder for teachers to identify these issues within their students, perpetuating the issue further (Ismail and Ismail, 2021) Alongside the psychological challenges brought about by remote teaching, scholars have also suggested that the inaccessibility of WIFI and technology to be just as troubling. Many students potentially missed out on significant chunks of their education through WIFI connectivity issues a lack of resources, making them unfairly disadvantaged compared to their peers (Bhattacharya, Carruth, Crowther et al, 2021). Although these scholars identify these issues, there have been very few solutions put forward meaning that no progress has been made to improve the effectiveness of remote teaching for students. This reveals a significant gap within the research topic, one which this project intends to fill.

2.3 STUDENT ENGAGEMENT: RELEVANCE AND IMPORTANCE

Student Engagement is often referred to by scholars when discussing the challenges of online learning (Khlaif, Kouraichi and Salha, 2021; Achen and Rutledge, 2022). Trowler defines

student engagement as being 'concerned with the interaction between the time, effort and other relevant resources invested by both students and their institutions intended to optimise the student experience and enhance the learning outcomes and development of students' (Trowler, 2010, p. 3). Student engagement is often connected positively to outcomes considered desirable by educators, such as grades. Many scholars have explored the range of factors that can influence student engagement in both face-to-face and remote learning. Martin and Bollinger's 2018 study suggests that student engagement in online learning environments is significantly limited as they 'seem to have fewer opportunities to be engaged with the institution' (Martin and Bollinger, 2018, P. 206). Shim and Lee argue that remote learning may also limit students' engagement due to the distractions that are readily available to them online such as checking their social media sites (Shim and Lee, 2020). Alongside this, many studies have identified the importance of student-student and student-teacher interactions as they significantly increase student engagement rates and (Gares, Kariuki and Rempel, 2020). Whilst the magnitude of this relationship is not clearly defined, and likely varies between students, Salas-Pilco, Yang and Zhang suggest that student engagement can be converted into academic achievement. (Salas-Pilco, Zhang and Yang, 2022) Whilst traditional education has had centuries to master this conversion, there has been little research into the encouragement and maintenance of student engagement through remote learning.

Student engagement can be deconstructed to provide a better insight into its components and application. The National Survey of Student Engagement (NSSE) since its launch has had more than 1,500 participating institutions (colleges and universities in the US and Canada), and is a popular resource amongst researchers in this field. The NSSE have developed ten Engagement Indicators (EIs) categorised within four themes to evaluate student engagement, shown in the following table:

Theme	Engagement Indicators
Academic Challenge	Higher-Order Learning Reflective & Integrative Learning Learning Strategies Quantitative Reasoning
Learning with Peers	Collaborative Learning Discussions with Diverse Others
Experiences with Faculty	Student-Faculty Interaction Effective Teaching Practices
Campus Environment	Quality of Interactions Supportive Environment

Figure 2. 3. 1 Table of Engagement Indicators organised within engagement themes (National Survey of Student Engagement. 2014)

Most of the listed EIs can either only be applied in traditional face-to-face learning environments and/or are specifically related to the course content that is being taught, furthermore the EIs have been specifically designed as a metric for evaluating student engagement in higher education. There are however some that can be used to influence the design principles of the M-POLE, these are:

- **Quantitative Reasoning –** the ability to use and understand numerical and statistical information in everyday life.

- **Collaborative Learning** – Collaborating with peers in solving problems or mastering difficult material.
- **Student-Faculty Interaction –** Interactions with faculty can positively influence the cognitive growth, development and persistence of students.
- **Supportive Environment** – Institutions that are committed to student success provide support and involvement across a variety of domains, including the cognitive, social and physical.

(National Survey of Student Engagement. 2014)

These EIs have been developed into core design principles for the remote technologies in the 'Specification & Design' section of the report.

The demand for remote teaching resides at a global level and its necessity will only continue to grow. From reviewing the existing literature on the subject, it can be concluded that despite the abundance of research into the functionality of remote teaching, there are still many challenges that must be overcome for it to function as effectively as face-to-face learning. Remote teaching technologies are not flawless and still pose many potential security and ethical risks for their users. The loss of face-top-face teaching negatively impacts upon the mental health of both teachers and students due to issues of isolation and loneliness brought about by a lack of human interaction. Remote teaching also significantly impacts upon the engagement of students which can have adverse effects on their education. Very minimal research identifies any solutions to the issues that were raised, making this a very relevant and vital topic for further study.

3.0 RELATED WORK

This section of the report examines existing solutions to ERT, assesses their suitability and compares them whilst identifying where opportunities have been missed. The technologies chosen for assessment have been selected due to their high usage as solutions for remote teaching. They have been identified in section 2.0 and/or chosen for their relevance to the field area.

3.1 EVALUATING EXISTING SOLUTIONS

Due to the nature and scale of the problem I am attempting to solve, it is natural that others have also created solutions. This sub-section focuses on identifying and evaluating current existing solutions to ERT, with the aim to develop a greater understanding of the problem. It is important to analyse these solutions before beginning the design & implementation of the M-POLE as I will identify the respective strengths and weaknesses of the solutions, as well as any features consistent throughout the design of different solutions. Overall, this sub-section is imperative to ensure the solution I propose, is the best it can be.

In order to evaluate these solutions, I will be using the following assessment criteria as well as documenting observable strengths and weaknesses.

The criteria have been derived using standard software evaluation metrics, as well as using the WCAG 2.1 design principles, which are part of meeting the U.K. government accessibility requirements. It is important to note, that (unless exempt) all public sector bodies must meet these requirements. Although some of the organisations behind the solutions evaluated may be exempt from these requirements, it is good practice to consider them whilst analysing and developing software.

Criterion	Sub-Criterion
Understandability	Easy to understand software purpose and usage Available software description Available design rationale
Usability	Intuitive design Efficiency of use Personal satisfaction
Accessibility	Perceivable Operable Understandable Robust

Figure 3. 1. 1 Assessment criteria for existing solutions

When considering the pricing, the assumption is made that the customer is an educational institution and as such, requires the most expensive package available.

Microsoft Teams

Microsoft Teams is a cloud-based collaboration software part of Microsoft 365. It is used by a range of educational institutions to support remote teaching, including Cardiff University. The service features audio and video calling, instant messaging and means for web

conferencing. Teams integrates with other Microsoft apps and offers file exchange and collaboration features.

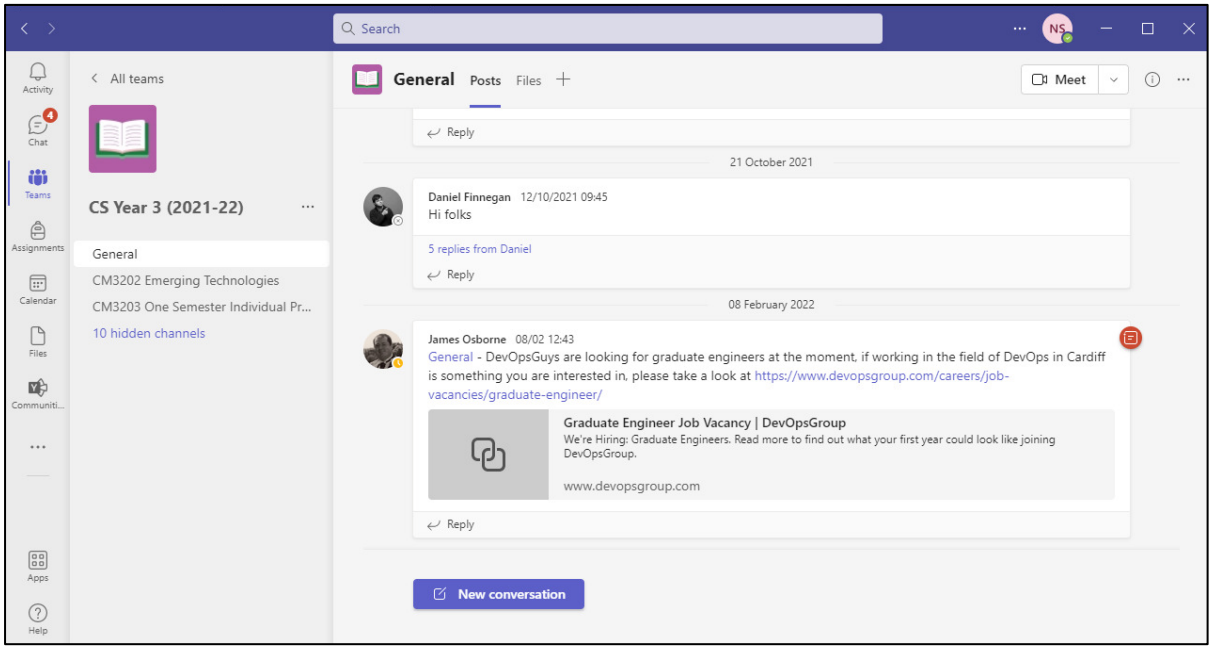


Figure 3. 1. 2 Microsoft Teams UI

Criterion	Sub-Criterion	Notes
Understandability	Easy to understand software purpose and usage	Software purpose is easily understood through UI, software name and features.
	Available software description	Software description available online
	Available design rationale	No available design rationale
Usability	Intuitive design	Navigation through the software is intuitive as well as using functions such as meetings
	Efficiency of use	It is easy to familiarise yourself with use of the software, loading files can be slow.
	Personal Satisfaction	The software is satisfying to use
Accessibility	Perceivable	Strong colour contrast between text and background, Content is structured logically,

		Provide audio transcripts in meetings
	Operable	Most features can utilise keyboard short-cuts for keyboard-only users, Use of descriptive links
	Understandable	Plain, Non-Technical use of English, Features appear consistent and behave as expected
	Robust	Status messages inform users of their presence and purpose

Figure 3. 1. 3 Assessment criteria Microsoft Teams

Microsoft Teams offers a 'Business Standard' plan for £9.40 user/month. This plan includes most of the features the service provides, with increased participant capacity in meetings and increased maximum meeting duration. The plan offers 1 TB per user in file attachments in chat as well as 1 TB per organisation in file storage and increased maximum number of users. The plan also offers phone and web support around the clock.

Zoom

Zoom is a web conferencing platform that is used for audio and video conferencing and offers a range of services/plans for their customers. Zoom for Education allows educational institutions to use Zoom Meeting Services for educational purposes, and holds policies designed to comply with requirements of student privacy laws.

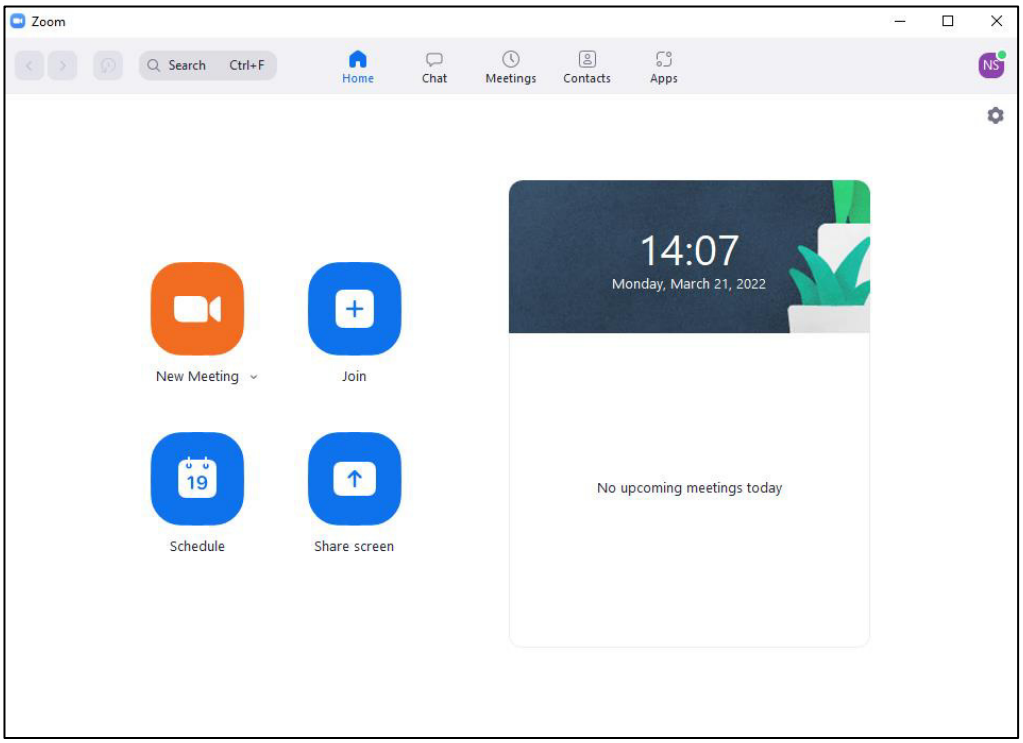


Figure 3. 1. 4 Zoom UI

Criterion	Sub-Criterion	Notes
Understandability	Easy to understand software purpose and usage	Software purpose is easily understood through UI
	Available software description	Software description available online
	Available design rationale	No available design rationale
Usability	Intuitive design	Navigation through the software is intuitive as well as hosting meetings and inviting participants
	Efficiency of use	It is easy to familiarise yourself with use of the software.
	Personal Satisfaction	The software is satisfying to use
Accessibility	Perceivable	Strong colour contrast between text and background, Content is structured logically, Provide auto-generated captions for meetings and webinars
	Operable	Customisable font size of chat and closed captions, Keyboard Shortcuts support for easy navigations
	Understandable	Plain, Non-Technical use of English, Features appear consistent and behave as expected
	Robust	Status messages inform users of their presence and purpose

Figure 3. 1. 5 Assessment criteria Zoom

Zoom for Education is compliant with WCAG 2.1 AA Standards.

Zoom for Education standard meetings plan is priced at £1,280 per account annually. It allows hosting of meetings for up to 300 participants. It allows single sign-on and recording transcripts. It also allows educational institutions to use their institute domains to add users to the account automatically and allows for school branding

Google Classroom

Google Classroom is a web-service comprised of online tools that allows teachers to create and set assignments, allow work to be submitted by students and allow this work to be marked and graded by teachers. Its core purpose is to simplify the process of sharing files between educators and students. Google classroom works with Google Docs, Sheets, Calendar etc.

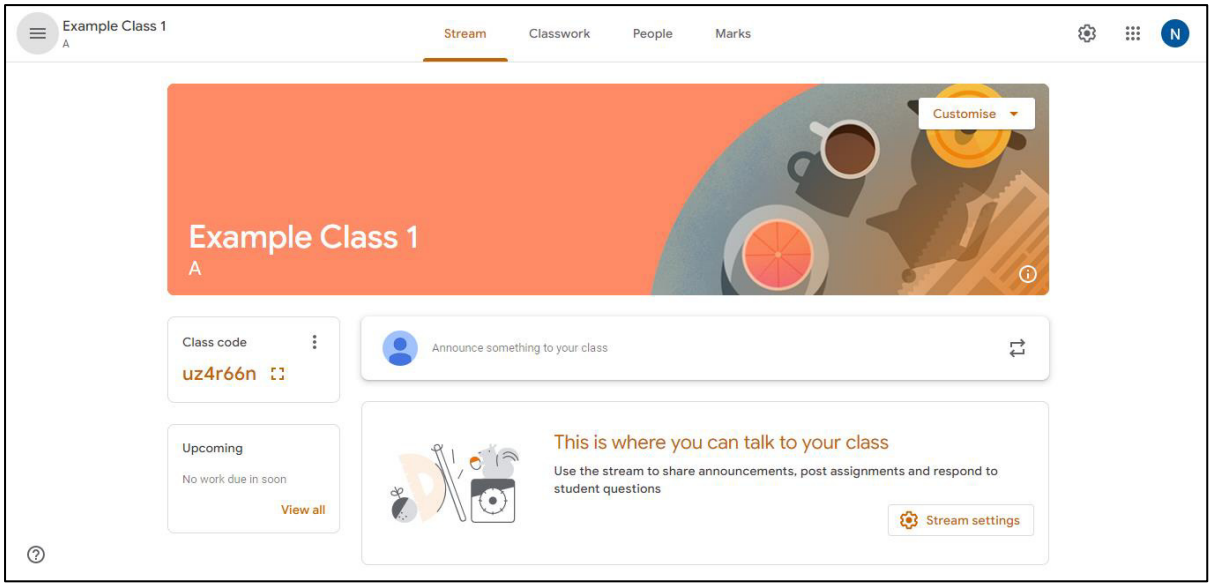


Figure 3. 1. 6 Google Classroom UI

Criterion	Sub-Criterion	Notes
Understandability	Easy to understand software purpose and usage	Software purpose is easily understood through the software name
	Available software description	Software description available online
	Available design rationale	No available design rationale
Usability	Intuitive design	Navigation through the software is intuitive as well as creating classes and classwork
	Efficiency of use	It is easy to familiarise yourself with use of the software and its features.
	Personal Satisfaction	The software is satisfying to use

Accessibility	Perceivable	Strong colour contrast between text and background, Content is structured logically, Provides text alternatives for non-text items.
	Operable	No flashing content, All functionality is operable solely using keyboard and has keyboard shortcuts
	Understandable	Contains descriptive page titles, Plain, Non-Technical use of English, Features appear consistent and behave as expected
	Robust	Status messages inform users of their presence and purpose

Figure 3. 1. 7 Assessment criteria Google Classroom

Google Classroom is part of the Google Workspace for Education Fundamentals package and is free for qualifying institutions, there are other priced Google Workspace for Education plans. The most expensive plan is the Google Workspace for Education Plus, which costs $5 per student, per year. This plan allows for international dial-in access to meetings, live streams with up to 100,000 viewers in Google Meet and Syncing rosters from School Information Systems to Google Classroom.

Comparison

With regard to video streaming, (which in the case of remote teaching typically would involve faculty meetings and class learning sessions), Zoom is undoubtedly the best. Educators can invite students to meetings through links or through the zoom application, and allows for meetings to be recorded and saved. Google Classroom on the other hand, is the best option for the creation, submission and grading of assignments and is advantageous in its existence solely as web-application, meaning no software needs to be installed. Microsoft Teams combines (to an extent) the features of both Zoom and Classroom making it in my opinion, the most suitable remote teaching technology currently available. On top of this, teams offers greater security than both Zoom and Google Classroom due to the encryption of shared documents.

Why are these solutions flawed?

The current solutions work well and are comprehensive in design, offering a variety of features that assist users with remote working/meeting. The main reason these technologies as solutions are flawed, is that they have not been designed specifically for remote teaching and are currently being used as a viable substitute. This is easily understandable from a business perspective, as the organisations that created these technologies want to maximise

profit and growth, and by unspecifying the design of the software increase the potential user base. Google Classroom, targeted for remote teaching does not fully address the challenges ERT poses. Whilst it enables the creations, submission and grading of assignments it does not expand upon that limiting its effectiveness as a technical solution to ERT.

As identified in the literature review section, educators' unpreparedness for remote teaching necessitates a targeted technological solution, so that educators can be adequately equipped for ERT. As these current solutions are so generic, and often vary from institute, effective training for educators cannot be provided. This means not only are educators currently using technologies that do not fully satisfy their requirements, but a similar teaching standard to face-to-face teaching can not be achieved due to a lack of training.

What has been identified here, is not that there are specific features educators require that are lacking in existing technology, but rather that they are scattered amongst different applications. This is not ideal if remote teaching is to match the teaching standard of face-to-face, as in a school environment all teaching resources are located within school property, as such the same should be the case for a virtual teaching environment.

An example of a missing feature in teams and zoom is the creation of an assignment/assessment. Whilst the systems allow file-sharing, they often can be slow in performance and allow for generic uploads. Google Classroom allows the creation of quiz assignments, but lacks video communication features limiting its suitability significantly.

My contribution to the existing knowledge regarding remote teaching and technical solutions is the creation of core design principles that solely serve as the foundation of remote teaching technology. The idea is that developers can implement these principles into their own work and expand upon them, in effect growing into a completely comprehensive, scientifically approved and peer-reviewed design framework. These design principles are utilised alongside identified missing features in existing solutions to design the M-POLE.

4.0 APPROACH

This section of the report discusses the approach taken to satisfy the project aims and objectives, it includes a detailed justification for the chosen methodology and tools/techniques that the project utilises.

4.1 AGILE DEVELOPMENT METHODOLOGY

The roots of agile development methodology can be traced back to the agile manifesto (2001), in which agile principles were expressed. These principles served as the foundation of what is considered today to be agile software development framework. In this 21 years that have since followed, extensive research has been conducted by the software development community to affirm the credibility and suitability of the development methodology.

In the article 'A decade of agile methodologies: Towards explaining agile software development', software development agility is defined as;

> the software team's capability to efficiently and effectively respond to and incorporate user requirement changes during the project life cycle.

This design methodology encourages practices that accommodate change to requirements and heavily involves users in the development process. (Torgeir et al, 2012)

The iterative approach of the methodology is suitable for my project, as it allows flexibility and adaptability of requirements. Deciding upon this methodology was critical, due to the nature of the project and my inexperience with developing web applications. Typically, a project of this ambition would require an extensive design and implementation stage, utilising a team of developers and product versions to ensure a strong system is created. As this project is completely solo, the scope of what I am able to achieve is considerably limited. As such, adopting this methodology ensured I was able to maximise the quality of work I produced.

On top of this, the significance of the prototype system I am proposing can not be overlooked. The M-POLE prototype is intended to exemplify some of the core design principles of remote teaching technology this report defines. The system proposed should alleviate the challenge of educators feeling 'unprepared' for remote teaching, by providing a centralised solution of features that can facilitate remote learning. Because of this it is crucial that user requirements are heavily considered through the development process, so the M-POLE can be continually refined and improved.

The initial project plan included a Gantt chart, that detailed the project timeline. The project had been divided according to Design Thinking process, with the system development stage split into iterations to accommodate the agile development methodology. The timeline includes milestones and deliverables with estimated completion dates. The timeline put forward acts only as a rough guideline, it is common knowledge that development processes almost always fail to meet the initial work plan, nevertheless it is still good practice to create a timeline and stick to it as much as possible.

The Gantt chart received approval from the project supervisor.

4.2 FLASK FRAMEWORK

Flask is a web application micro framework for python, based on the Werkzeg WSGI toolki and Jinja2 template engine. As it only implements core functionality such as routing, and leaves advanced functionality to extensions, it is a suitable tool for use in this project as it has a simple setup but lots of flexibility.

Another alternative framework that was considered was Django. Django is a full-stack web application framework for python, and has existed for a longer time than Flask (meaning it likely has more support forums and documents). Whilst a case can be made for Django superiority in this regard, Flask was the clear choice for me to make. Django typically requires more written lines of code for the same functionality in flask, which would tremendously increase the workload and potentially compromise the project success. On top of this, Django does not provide as much flexibility as Flask and is not suitable for projects that have requirements that can change spontaneously. This in effect would cancel out the benefits and reasons for choosing the agile development methodology, completely ruling Django out as a framework option.

Another reason for choosing the Flask framework was that I have some experience using it to develop a web application from my first university year. I developed a simple e-commerce website, and believe that this past experience will be of benefit to me in this project. I also know it is possible to deploy Flask applications on Cardiff University's OpenShift servers which will be beneficial to the demonstration of the M-POLE.

4.3 MYSQL DATABASE

I had to decide upon a data storage method for the application, as this would be fundamental for demonstrating the system's functionality. All data inputted needed to be stored in a database, so that the app could update and present relevant data to the users.

I had some experience using MySQL with Flask in the past and compared it to alternatives such as SQLite. MySQL is one of the most popular database management systems, and is capable of handling large volume of data. As the final vision for the M-POLE is for it to be a recognised and popularly used software by educational institutes, I thought it would be important to choose a database management system that provided scalability as complications could arise later if the database management system needed to be upgraded. On top of this, it would be more appropriate to use a database management system that required a database server for interactions with the client, as this is how most current market software handle data.

As it is almost impossible to predict what types of data users would need to store, due to the diverse range of filetypes educators utilise, it was clear that MySQL would be more suitable than SQLite. This was due to the greater amount of data types MySQL supports.

Most importantly, MySQL allows for User Management, and the creation of different users with different permissions and roles. This advantage is crucial for the M-POLE system, as in future developments users will need to be categorised as student or educators, both of which can be deconstructed even further.

5.0 SPECIFICATION & DESIGN

This section of the report contains information regarding the specification and design of the M-POLE. The section begins by presenting the core design principles of remote teaching technologies, that I have derived using the Engagement Indicators identified int the literature review section. The section also presents the user requirements, developed from the design principles and evaluation of existing solutions.

It was at this stage of the project that it became clear that I would not be able to deliver on the expectations I had set for myself. This was due to ambition of the project and constrained even further due to developments in the adverse personal circumstances I was facing. These circumstances and the full impact they had on the project are discussed further in the reflection on learning section of the report.

In order to salvage the project and satisfy as much aims and objectives as possible, I had to make the decision of focusing solely on the design and implementation of the educator-side interface. This was a disappointing decision to make as this was a passion project of mine, but was necessary so that I could have some implementation to evaluate and discuss. I chose to focus on the educator-side interface as it meant that I could incorporate a user evaluation of the prototype and would satisfy the agile methodology by receiving feedback from potential users. This sacrifice also limited most of the desired functionality of the prototype, as I could no longer incorporate student-side inputs for educators. In order to overcome this, I decided that in order to present some of the functionalities, I would hard-code demonstrative examples into the system to give the look and feel of a student-interface implementation.

These time constraints also unfortunately meant I had to entirely skip the prototyping of the M-POLE stage entirely, this massively disadvantaged me during implementation as I had no basis to develop on except the design principles and functional requirements. If I had opted to complete the full design process, it is likely the implementation of the prototype solution would have been considerably lacking and poor. As this would effect my user evaluation, I came to the conclusion that the evaluation would be more imperative to further developments of the prototype at this stage than a sophisticated design plan. Unfortunately, in situations like this there is no right or wrong choice, I had to make a decision and stick to it for what I believed served the project aims the most.

5.1 REMOTE TEACHING TECHNOLOGIES: CORE DESIGN PRINCIPLES

One of the project aims was to develop a set of core design principles for remote teaching technologies, based on engagement indicators obtained in the literature review section of the report. The intent of these design principles are to act as my contribution to the knowledge of remote teaching technology, with others expanding and developing them through research and implementation. Ideally these core principles will act as a foundation for a future remote teaching design framework, that will be the culmination of work from various researchers and developers, and serve as the building blocks for remote teaching technologies of the future.

The following list are the 4 core design principles I am presenting for an effective remote teaching technology:

- **Maximise the use of quantitative reasoning skills –** Developing the use of numerical and statistical information is a key indicator that a student is engaged

with their learning. Where possible, aim to provide students with relevant data regarding their performances and behaviour. Allow students to draw their own conclusions, and teach them the advantages of statistical reasoning for the basis of their personal development.

- **Encourage Collaboration –** Rarely has anyone ever accomplished something great alone, almost always behind the greatest innovation and advancements in human history is a team effort. Collaboration with peers in the learning of difficult concepts or problem solving is a key indicator that a student is engaged with their learning. Include features such as discussion boards, chat rooms and encourage peer-review of assessed material. This design principle is fundamental in simulating the face-to-face teaching environment and promotes greater understanding of topics and the importance of teamwork.
- **Simple, Clear and Accessible communication between Students-Faculty –** a key engagement indicator is the interaction between faculty and students, these interactions can positively influence cognitive growth, development and persistence of students. To promote this, there should be a clear feature in which educators can broadcast messages to students. On the other hand, students must be able to easily make requests to educators. Examples of how this can be implemented is through live-chat or notification messages.
- **Provide a supportive environment –** the effects of remote learning on students' mental health and wellbeing are documented extensively in existing literature and is briefly discussed in the literature review section of this report. Decline in mental health leads to a decline in student engagement, as such in order to improve student success institutions must provide adequate support. This principle can be implemented through clearly accessible support and wellbeing communication lines, prompting students with check-ins, and tracking metrics such as attendance and participation in sessions.

In order to maximise student engagement, and in effect improve the teaching standard of remote teaching, these design principles should be implemented into the remote teaching technologies.

5.2 M-POLE: FUNCTIONAL REQUIREMENTS

To ensure the M-POLE prototype is suitable for a user evaluation, I constructed a list of functional requirements the prototype should meet. I intended to test these requirements using test cases, as well as define a list of non-functional requirements however due to time constraints this was simply impossible.

These requirements have been derived with influence from the design principles and missing features identified in the related work section.

MUST HAVE FUNCTIONAL REQUIREMENTS:

- Users must be able to register an account with the system
- Users must be able to broadcast a message to other users
- Users must be able to view messages other users have broadcasted

- Users must be able to log in and out of the system
- User must be able to navigate between different web pages
- Users must be able to create an assessment and attribute a deadline
- Users must be able to view their created assessments

6.0 IMPLEMENTATION

This section of the report details some relevant features of the M-POLE prototype solution. As previously mentioned, due to time constraints, it was only possible to implement one of the user interfaces (Educator/Student). The decision was made to implement the educator-side prototype interface, due to the user evaluation of the prototype by participating teachers.

It is important to note that this version of the M-POLE is a prototype, intended to implement the remote teaching design principles, as opposed to being a fully functional solution. Whilst it would have been ideal to prototype both interfaces, the symmetry of the system design allows the educator-side interface to represent the student-side interface to some degree, as there is a cross-over of features.

The styling of the system was handled mainly using an external CSS stylesheet.

6.1 INSIGHTS: DYNAMIC PROGRESS CIRCLES

Quantitative Reasoning, identified as a key engagement indicator in the literature review section, is one of the core remote teaching design principles proposed in this report. In order to facilitate this principle, the M-POLE system should be able to present students with useful metrics and visualised data regarding their performances, encouraging the development and maintenance of quantitative reasoning skills.

This design principle was implemented through the use of insight cards in the M-POLE's home/dashboard page.

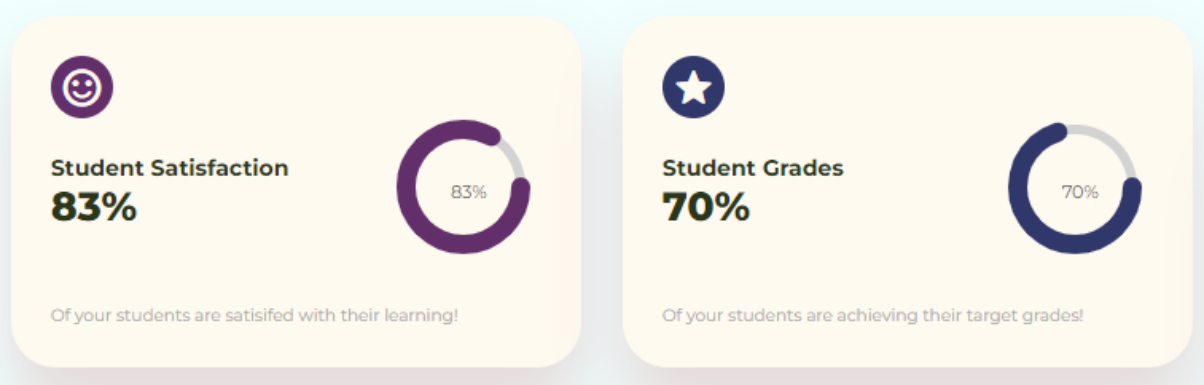


Figure 6. 1. 1 Dynamic progress circle cards

The insight cards are used to visualise and return useful data to the user through dynamic progress circles. In the educator-side interface, the metrics being tracked are 'Student Satisfaction' and 'Student Grades'. Identical cards would appear in the student-side interface, and track performance indicators such as attendance, assignment completion, average assessment score etc.

The progress circles are created using the SVG <circle> element, with a track circle and a progress circle being created, the application utilises an external stylesheet to colour the strokes of these circles respectively, as well as defining other style elements such as stroke-width, display etc.

```
<!-----------CARD START---------------------->
<div class = "student-satisfaction">
  <span class="material-icons-round">sentiment_satisfied</span>
  <div class="center">
    <div class="left">
      <h3>Student Satisfaction</h3>
      <h1>83%</h1>
    </div>
    <div class = "completion">
      <svg>
        <circle cx='38' cy ='38' r= '36' class = "track"></circle>
        <circle cx='38' cy ='38' r= '36' class = "progress1"></circle>
      </svg>
      <div class = "num">
        <p>83%</p>
      </div>
    </div>
  </div>
  <small class="text-muted"> Of your students are satisifed with their learning! </small>
</div>
<!---------------------CARD BREAK------------------->
```

Figure 6. 1. 2 HTML5: Dynamic progress circle cards

The progress circles are made dynamic using a JavaScript function, that modifies the stroke-Dasharray and stroke-Dashoffset CSS attributes. The function works by first calculating the circle circumference (using the radius value and Math.PI property in 2ΠR equation), and uses it to update the stroke-Dasharray property. The function then takes percentage variables and calculates the stroke-Dashoffset attribute, that displays the percentage onto the progress circles. The percentage variables defined in the function will be able to take inputs from MySQL database in future development, meaning that percentage metrics (personalised to each user) can be calculated server-side and returned in the dashboard.

```
// DYNAMIC PROGRESS BARS

let progressCircle1 = document.querySelector(".progress1");
let radius = progressCircle1.r.baseVal.value;
let circumference = radius * 2 * Math.PI;
progressCircle1.style.strokeDasharray = circumference;

let progressCircle2 = document.querySelector(".progress2");
progressCircle2.style.strokeDasharray = circumference;


//percentage
setProgress1(83);
setProgress2(70);


function setProgress1(percent) {
  progressCircle1.style.strokeDashoffset = circumference - (percent / 100) * circumference;
}
function setProgress2(percent) {
  progressCircle2.style.strokeDashoffset = circumference - (percent / 100) * circumference;
}

```

Figure 6. 1. 3 JavaScript: Dynamic progress circle

6.2 BROADCAST MESSAGES

Another engagement indicator identified and developed into a remote teaching design principles in this report, is Student-Faculty Interaction. The importance of these interactions (highlighted in the Student Engagement section of the literature review), due to their influence on student persistence, development and cognitive growth , meant that representation of this design principle in the M-POLE prototype was essential.

The design principle was met through notification boxes appearing on every webpage of the system, presenting 'Recent Correspondence' and 'Student Queries' to the user.

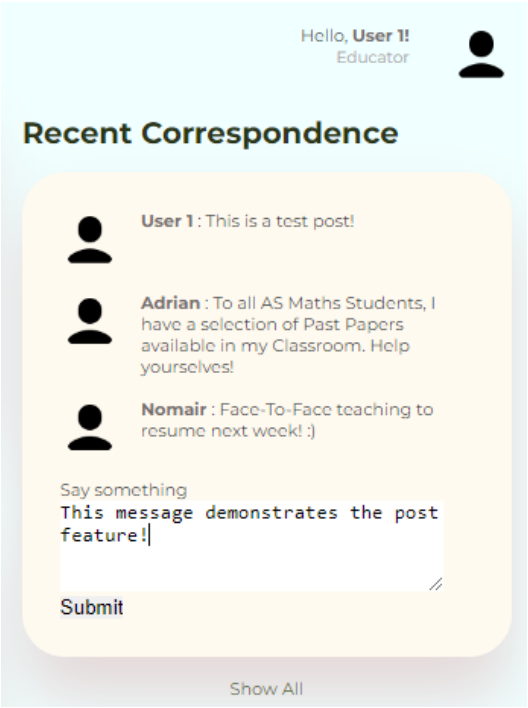


Figure 6. 2. 1 Recent Correspondence: new message

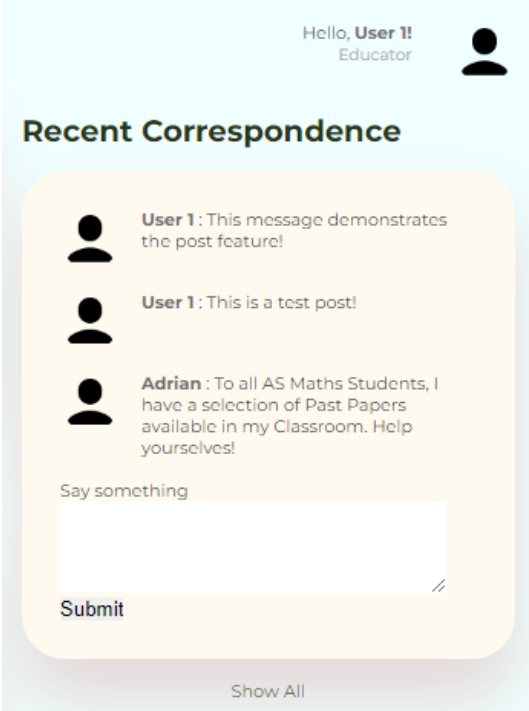


Figure 6. 2. 2 Recent Correspondence: new message (posted)

The 'Recent Correspondence' card allows teacher to broadcast messages to the entire user-base and displays other teacher broadcasts. As the system currently stands, any user can make a post which is returned to all users but can be advanced further in future development. Different user types can be made to have different posting permissions, and different post channels could also easily be implemented, displaying only relevant posts to each individual user.

The post message system works by utilising two MySQL tables, 'User' & 'Post', defined in models.py using Flask-SQLAlchemy shown below:

```
class User(UserMixin, db.Model):
    id = db.Column(db.Integer, primary_key=True)
    first_name = db.Column(db.String(20), nullable=False)
    last_name = db.Column(db.String(30), nullable=False)
    email = db.Column(db.String(120), index=True, nullable=False, unique=True)
    password_hash = db.Column(db.String(128))
    posts = db.relationship('Post', backref='author', lazy='dynamic')
    uploads = db.relationship('Upload', backref='uploader', lazy='dynamic')

    def __repr__(self):
        return f"User('{self.first_name}', '{self.last_name}' ,'{self.email}')"
```

Figure 6. 2. 3 *'User' table*

```
class Post(db.Model):
    id = db.Column(db.Integer, primary_key = True)
    body = db.Column(db.String(140), nullable=False)
    timestamp = db.Column(db.DateTime, index=True, nullable=False, default=datetime.utcnow)
    user_id = db.Column(db.Integer, db.ForeignKey('user.id'), nullable=False)

    def __repr__(self):
        return f"Post('{self.body}')"
```

Figure 6. 2. 4 *'Post' table*

The created classes inherits from db.Models, and defines multiple fields as class variables. The fields take the fieldtype as an argument, and other arguments that allow me to define which fields are unique (such as email) and indexed. In the 'Post' class the 'timestamp' field is indexed, which allows the system to present the posts in 'Recent Corresspondence' in chronological order, with the most recent post as the first. The 'user_id' field is prepared as a foreign key to 'user.id', allowing it to reference an id value from the 'User' table. This is essential for associating posts with specific users, and is completed by the 'posts' field in the 'User' class that attributes a one-to-many relationship between 'User' and 'Post'.

The M-POLE contains a query in routes.py that returns the 3 most recent posts in the 'Post' table from my MySQL database. The limit is set to 3 to prevent the 'Recent Correspondence' card from becoming overly populated with posts, and in future development, will be able to be customised by each user:

```
64      posts = Post.query.order_by(Post.timestamp.desc()).limit(3).all()
```

Figure 6. 2. 5 Posts query

The M-POLE presents these posts in the 'Recent Correspondence' box, utilising jinja delimiters. It returns the body of the post as well as the first name of the user who made the post, and attributes a default 'profile picture' to the user. Currently the system does not return the time of the post, but this can be easily implemented.

```
94          <div class="notifications">
95              {% for post in posts %}
96              <div class="notification">
97                <div class="profile-picture"><img src="{{url_for('static', filename='img/blank-photo.png')}}"></div>
98                <div class="post"><p><b>{{ post.author.first_name }}</b> : {{post.body}}</p></div>
99                <!---<small class="text-muted">{{ post.timestamp }}</small>--->
100             </div>
101             {% endfor %}
```

Figure 6. 2. 6 HTML5: Presenting posts

The M-POLE system utilises Flask-Login and Flask-WTF to allow the user logged in to the system to create and share their own posts.

```
27  class PostForm(FlaskForm):
28      post = TextAreaField('Say something', validators=[DataRequired(), Length(min=1, max=140)])
29      submit = SubmitField('Submit')
```

Figure 6. 2. 7 Post form

```
102             <form action="" method="post">
103               {{ form.hidden_tag() }}
104               <p>
105                 {{ form.post.label }}<br>
106                 {{ form.post(cols=32, rows=4) }}<br>
107                 {% for error in form.post.errors %}
108                 <span style="color: red;">[{{ error }}]</span>
109                 {% endfor %}
110               </p>
111               <p>{{ form.submit() }}</p>
```

Figure 6. 2. 8 HTML5: Post form

The view function handles and creates the form. The 'user_id' is attributed using the backreference 'author' and is set to the current logged in user.

```
57      form = PostForm()
58      if form.validate_on_submit():
59          post = Post(body=form.post.data, author=current_user)
60          db.session.add(post)
61          db.session.commit()
62          flash('Your post has been shared!')
63          return redirect(url_for('home'))
```

Figure 6. 2. 9 Post form view function

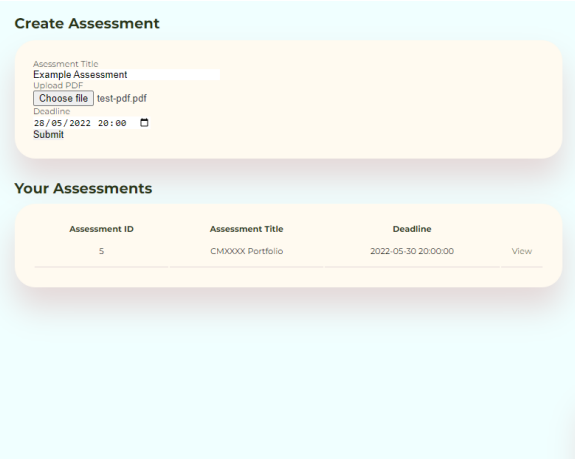
After processing the form data, the request ends with a redirect to the page the user made the post from. This is to satisfy the web development design pattern Post/Redirect/Get, reloading the page to avoid multiple form submissions.

6.3 CREATE ASSESSMENTS

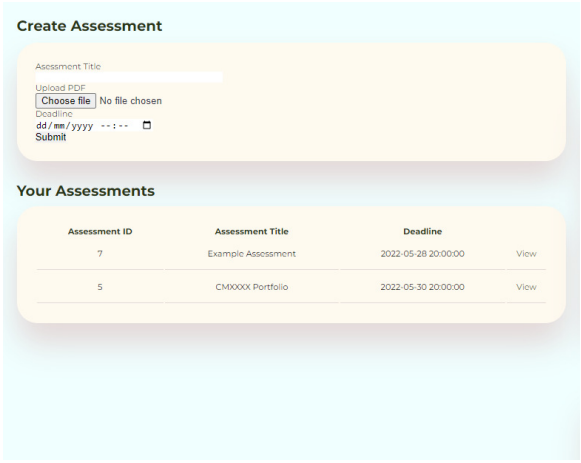
The report previously identified that an issue with existing solutions to ERT (Teams and Zoom specifically) is that they have not been specifically designed for the problem. The products serve as general remote working technologies, as from a business perspective provides the greatest ROI due to the increased potential userbase. Whilst these technologies include file-sharing features, there are no specific assessment or deadline-driven functionalities, which is something I wanted the M-POLE prototype to address.

The 'Create Assessment' web page, allows users to upload a pdf file, attribute an assessment title and set a deadline. The webpage then displays the created assessment to the user, and allows them to download the pdf file.

It is important to note that typically pdf files would not be stored in a database, for a variety of reasons. This could lead to efficiency issues with the database, and possible future complications should the database engine change. In future developments, the database table would only include fields that mapped pdf file information (e.g. filename, uploader, description etc.) and the files would be stored elsewhere.



6. 3. 2 Create Assessments



6. 3. 1 Create Assessments: created

The M-POLE returns the assessments the user has created in order of earliest deadline, and displays the 'Assessment ID', 'Assessment Title' and 'Deadline'. If the user clicks on 'view' the webpage downloads the pdf file. As the student interface has not been created, currently each user is only able to see their created assessments. In future development, users will be

able to assign assessments to students and the selected students will be able to view the created assessment.

In the ‘User’ table shown in Fig 6. 2. 3 a one-to-many relationship is established with the ‘Upload’ table shown below:

```
class Upload(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    assessment_title = db.Column(db.String(50), nullable=False)
    filename = db.Column(db.String(50), nullable=False)
    data = db.Column(db.LargeBinary(length=(2**32)-1))
    deadline = db.Column(db.DateTime, index=True, nullable=False, default=datetime.utcnow)
    user_id = db.Column(db.Integer, db.ForeignKey('user.id'), nullable=False)
```

6. 3. 3 *‘Upload’ table*

The table is created similarly to the ‘User’ and ‘Post’ tables discussed earlier, with one notable difference. The ‘data’ field is given the field type of LargeBinary, which is used to store large binary byte data. The fieldtype corresponds this to the target platform, in the case of MySQL it is BLOB. The MySQL BLOB type accepts a length, so the length is set to the equivalent of LONGBLOB to allow for maximum field storage potential.

The M-POLE contains a query in routes.py that returns the created assessments in order of earliest deadline from my MySQL database, specific to the logged in user.

```
    uploads = Upload.query.filter_by(user_id=current_user.id).order_by(Upload.deadline.asc()).all()
```

6. 3. 4 uploads query

The M-POLE presents the assessments to the user in a table, and references the download function defined in routes.py for the ‘View’ button.

```
<div class="created-assessments">
  <h2> Your Assessments </h2>
  <table>
    <thead>
      <tr>
        <th> Assessment ID </th>
        <th> Assessment Title </th>
        <th> Deadline </th>
        <th></th>
      </tr>
    </thead>
    <tbody>
      {% for upload in uploads %}
      <tr>
        <td> {{ upload.id }} </td>
        <td> {{ upload.assessment_title }} </td>
        <td> {{ upload.deadline }} </td>
        <td class="tertiary"> <a href="{{ url_for('download', upload_id=upload.id) }}"> View </a> </td>
      </tr>
      {% endfor %}
    </tbody>
  </table>
</div>
```

6. 3. 5 HTML5: Created Assessments

The download function takes the upload.id as a variable and sends the file to the user attributing the filename to the stored filename in the database.

```
@app.route('/download/<upload_id>')
def download(upload_id):
    upload = Upload.query.filter_by(id=upload_id).first()
    return send_file(BytesIO(upload.data), attachment_filename=upload.filename, as_attachment=True)
    return redirect(url_for('page1'))
```

6. 3. 6 download function

The M-POLE system utilises Flask-Login and Flask-WTF to allow the user logged in to the system to create an assessment.

```
class UploadForm(FlaskForm):
    assessment_title = StringField('Asessment Title', validators=[DataRequired()])
    data = FileField('Upload PDF', validators=[DataRequired(), FileAllowed(['pdf'], 'PDF only!')])
    deadline = DateTimeLocalField('Deadline', format='%Y-%m-%dT%H:%M', validators=[DataRequired()])
    submit2 = SubmitField('Submit')
```

6. 3. 7 UploadForm

The UploadForm specifies a FileField for the data entry and accepts only pdf files. This requirement is set only for the prototype purpose, and can be changed to allow different file types such as images, word docs etc. The form also defines a specific format for the deadline entry, this is to align with the DateTime fieldtype attributed to the deadline field in the table. The submit field entry is named submit2 due to the webpage containing the form also containing other forms.

The DateTimeLocalField presents the user with a calendar to select the assessment deadline.

```
    <form action="" method="POST", enctype="multipart/form-data">
      {{ form2.hidden_tag() }}
      <p>
        {{ form2.assessment_title.label }}<br>
        {{ form2.assessment_title(size=32) }}<br>
        {% for error in form2.assessment_title.errors %}
        <span style="color: red;">[{{ error }}]</span>
        {% endfor %}
      </p>
      <p>
        {{ form2.data.label }}<br>
        {{ form2.data() }}
        {% for error in form2.data.errors %}
        <span style="color: red;">[{{ error }}]</span>
        {% endfor %}
      </p>
      <p>
        {{ form2.deadline.label }}<br>
        {{ form2.deadline() }}
        {% for error in form2.deadline.errors %}
        <span style="color: red;">[{{ error }}]</span>
        {% endfor %}
      </p>
      <p> {{ form2.submit2() }} </p>
    </form>
```

6. 3. 8 HTML5: UplaadForm

The html form enctype is set to “multipart/form-data” to allow for file uploads.

```
    form2 = UploadForm()
    if form2.submit2.data and form2.validate_on_submit():
        file = form2.data.data
        assessment_title = form2.assessment_title.data
        filename = file.filename
        data = file.read()
        deadline = datetime.strptime(str(form2.deadline.data), '%Y-%m-%d %H:%M:%S')

        upload = Upload(assessment_title=assessment_title, filename=filename, data=data, deadline=deadline, uploader=current_user)
        db.session.add(upload)
        db.session.commit()
        flash('Your Assessment has been created!')
        return redirect(url_for('page1'))
```

6. 3. 9 Upload form view function

The view function handles and creates the form. The ‘user_id’ is attributed using the backreference ‘uploader’ and is set to the current logged in user. The deadline input is converted from a string into the datetime type, and the filename and data are taken from the FileField entry. As the webpages extend from layout, the form2 variable needed to be used, and the request ends with a redirect.

6.4 DATABASE: ER DIAGRAM

The below diagram shows how the active tables in the system database relate to each other;

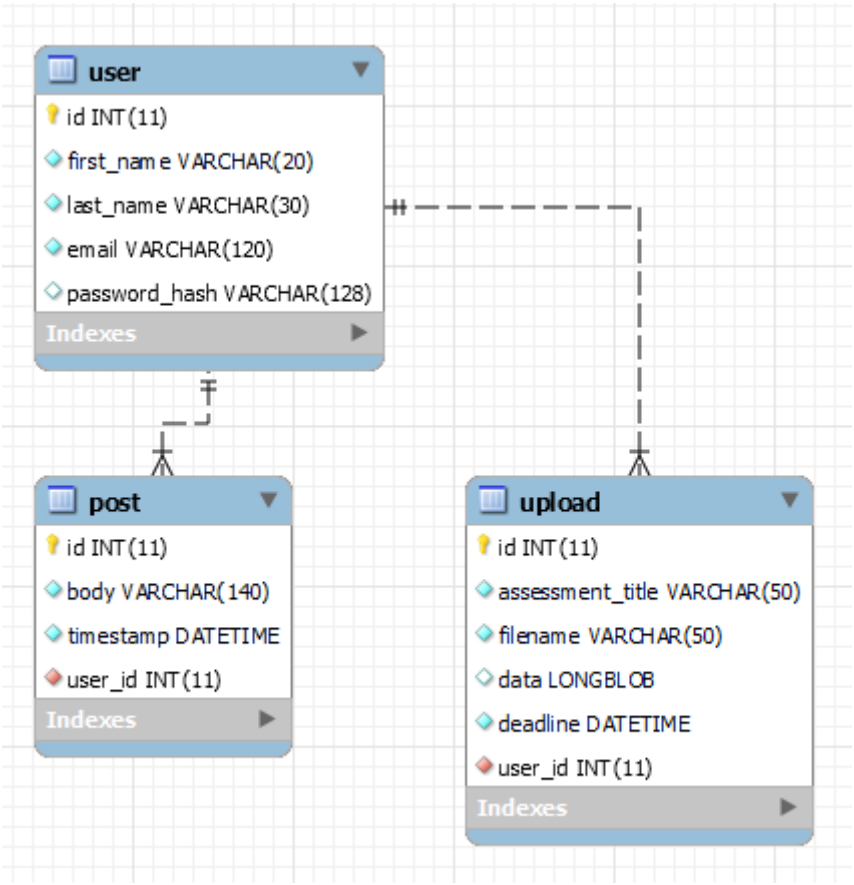


Figure 6. 4. 1 Database ER Diagram

7.0 USER EVALUATION

As the design of the prototype was based on original design principles, and followed the agile development methodology, I decided that the most appropriate method of evaluating the prototype was through user research. This was to ensure that future developments of the prototype had considered user requests, as the importance of user-centered design for the M-POLE has been stressed throughout this report. I applied for ethical approval from the Computer Science School Ethic Committee for semi-structured interview sessions with willing participants, and received favourable opinion. The selection criteria for participants were that they must have taught at secondary school level, inclusive of the years 2019-2021. I was able to conduct two of these interview sessions, the findings of which are discussed below.

The results of the investigation were collected from the responses to interviews that were conducted with two secondary school teachers. Participant A is a relatively new teacher, having only begun their career just before the pandemic and participant B is a semi-retired teacher with decades of experience. Both interviews were semi-structured, guided by a set list of prompt questions that can be found in the appendices (Appendix A). Both interviews were conducted in-person, as I was unable to host the M-POLE on Cardiff University's OpenShift servers. Each interview lasted for approximately 30 minutes, with 5-10 minutes of the time spent using the prototype, and 20 minutes reserved for the interview questions. Both participants responded well to the questions and provided the study with a broad range of invaluable data and insights.

7.1 USER EVALUATION: PARTICIPANT FEEDBACK

When using the M-POLE, both participants identified multiple elements of the system's design that they liked. Participant A stated that they really liked the 'Create Assessments' feature as it was different to other remote teaching systems that they have used previously. Other remote teaching solutions such as Zoom and Microsoft Teams do not offer a way to distinguish assessment files from other general learning materials. Having a separate section for assessment uploads allows assessments to be easily identified and to be easily accessed by students all in one location. Participant B identified the dashboard as being a distinguishing feature for them. They stated, "as I am a very data driven individual, being able to track metrics such as student attendance and target grades in a visual manner is useful in making decisions about my teaching methods and approaches." Both participant A and B identified the general layout of the M-POLE as being a feature that they appreciated. Participant A stated that, "due to the simplicity of the layout of the system, it is easy to navigate and to locate the tools that are required." Similarly, participant B, acknowledged the colouring used across the M-POLE. The participant shared that, "the consistent use of green tones throughout the colour scheme keeps the system looking clean and simple."

Despite much of the feedback on the M-POLE being very positive, the participants did identify a few features that they believe could be improved. Participant A suggested that they did not like the location of the 'log out' button. The participant stated, "I couldn't locate the log out button as I initially expected it to appear in a menu when selecting the user icon as it

appears on similar systems." In addition to this, participant B stated that they did not like that the webcam began to broadcast as soon as the 'Online Session' webpage was selected, stating, "I was surprised to see myself on the screen as soon as I selected the online session tab because I didn't think that it would happen automatically." The participant suggested that they would rather be given the opportunity to begin the broadcast after the initial webpage has been loaded. Despite this, however, both participants acknowledged that the current M-POLE system is unfinished and is just a demonstrative prototype so believe that it would be unfair to judge any of their dislikes too harshly.

7.2 USER EVALUATION: PARTICIPANT SUGGESTIONS

Within the interview discussions, both participants offered some insightful suggestions on how they believe that the M-POLE system could be improved in future versions. Participant A suggested that they would benefit from an 'Upload Files' webpage to be implemented into the system. The participant stated that this would be beneficial as it would "allow teachers to upload learning materials so that they are easily accessible to students to assist them in their studies when they are not present in the classroom." In addition to this, participant B suggested that a 'Live Chat' feature would be very beneficial to educators, as it would allow them to interact with their students and their colleagues directly and in real time.

7. 3 USER EVALUATION: PROSPECTIVE FUTURE DEVELOPMENT

From the results of the interviews, it can be concluded that although it is just a demonstrative prototype, the current version of the M-POLE is a very solid foundation for the future development of the system. The current prototype is easy for users to navigate and possesses many desired features such as a detailed dashboard and a specific assessments tab, both features that many other remote teaching technologies are missing. Despite this, the addition of a few new features will likely increase the productivity and user satisfaction of the system. In addition to this, future versions of the M-POLE would benefit from having an 'Upload Files' webpage to further build upon the ways that the system can assist educators. The results of the interview findings also suggest that the inclusion of a 'Live Chat' feature will improve upon the system's usability. The addition of this feature will also address the challenges of loneliness and isolation discussed by Barrot, Llenares and Rosario, by providing both students and educators with a way to directly communicate with their peers. (Barrot, Llenares and Rosario, 2021) Finally, it is also important that future versions of the M-POLE do not stream the webcam as soon as the 'Online Session' webpage is opened but users are instead presented with an option to start the session. This change is vital to ensure that the privacy of the system's users is consistently upheld throughout its use. This amendment directly addresses the work of Khlaif, Kouraichi and Salha, who discuss the severity of the privacy issues that can be brought about by the use of webcams in remote teaching technologies. (Khlaif, Kouraichi and Salha, 2021)

7.4 USER EVALUATION: LIMITATIONS

Despite the ultimate success of the project and the M-POLE prototype, it is important to acknowledge the limitations of the study. As the result of limited time constraints, it was only

possible to conduct interviews with a total of two participants. Despite the invaluable data that these interviews provided to the project, conducting more interviews of this kind would help to further justify the study's conclusions.

8.0 CONCLUSIONS AND FUTURE WORK

This section of the report discusses if the project was successful in meeting the aims defined in the introduction, it also serves to explain and acknowledge the omissions of expected inclusions in the report.

8.1 PROJECT LIMITATIONS

The limitations of the project have briefly been discussed in their relevant sections throughout the project. This section intends to succinctly summarise these limitations as a whole. The time constraints that I was under significantly limited the potential success of the project. The narrow time limits for the project meant that I was unable to incorporate the functionality that I wanted, and I was forced to completely omit the implementation of the student-side of the prototype solution meaning that the prototype was severely limited. In addition to this, during the coding process, I completely lost all connection to the Cardiff University MySQL database servers. Alongside this, I was also unable to deploy the M-POLE onto the OpenShift server, both of which lost me valuable time. Due to these time restrictions, it was only possible to interview two participants for the study. Although the data collected from these interviews was invaluable to the project, increasing the sample size of participants used would have helped to further justify the conclusions that were drawn from this study.

Whilst working on this project, I was faced with severe, unforeseen circumstances which I had to face. These circumstances meant that I had additional responsibilities to attend to which required a large amount of my time. As I was unable to dedicate all of my available time to the project, this severely impacted upon the overall quality of my work throughout and was the core reason behind the omissions.

8.2 AIM 1: DISCOVER AND DOCUMENT CHALLENGES OF ERT

The challenges of Emergency Remote Teaching were identified and documented within the literature review. The findings of the literature review discovered that there are three key areas of Emergency Remote Teaching that pose problems to users, and these are the social, ethical and security risks of the technology, the user challenges of the technology and their impact on student engagement.

The literature review concludes that existing remote teaching technologies such as Zoom, Microsoft Teams and Google classroom all pose potential privacy and security risks for their users. The possibility of unauthorised individuals accessing live sessions poses a concern for technologies used within education as it is essential to protect young people from these risks. In addition to this, these technologies have the potential to invade the privacy of users through the use of microphones and webcams.

The existing work analysed suggests that Emergency Remote Teaching poses a range of challenges for both students and educators. Teachers have struggled to adapt to the change to online learning due to the lack of training and resources that are available to them. Emergency Remote Teaching has also had a severe impact upon the mental health of educators due to the lack of personal connections that they have been able to make with the lack of in-person interaction. Alongside this, Emergency Remote Teaching has created many challenges that students have had to face. Much of the research suggests that students have

experienced feelings of loneliness and isolation which has had an adverse effect on their mental wellbeing which in turn, has impacted upon their studies.

The findings of the literature review conclude that the loss of student engagement is a prominent impact of online learning. Due to the lack of personal connections with both their teachers and their peers and their limited engagement opportunities, students struggle to remain engaged with material whilst learning remotely.

The project was successful in meeting its first aim.

8.3 AIM 2: CREATE CORE DESIGN PRINCIPLES

The literature review identified key engagement indicators that I developed into the core design principles. The selected engagement indicators were; Quantitative Reasoning, Collaborative Learning, Student-Faculty Interaction and Supportive Environment. These four design principles were my proposed contribution to the knowledge of this field, and I believe the project was successful in meeting this aim.

8.4 AIM 3: DEVELOP A PROTOTYPE SOLUTION THAT EXEMPLIFIES THE DESIGN PRINCIPLES

Unfortunately I can not conclude that the project was fully successful in satisfying this project aim, whilst I have developed a prototype it does not have enough functionality to comprehensively exemplify the core design principles I created. On top of this, the lack of foundational design process severely limits the prototype, as I have not been able to test the functional requirements.

As it currently stands the project was unsuccessful in meeting this aim.

8.5 FUTURE WORK

Through the course of this report, I have identified where future developments of the project are possible in their relevant sections. This sub-section aims to define an overall plan moving forward if I were to continue development.

Firstly, I believe that this project itself is severely limited due to the lack of design process. Whilst I firmly believe that this was an unavoidable consequence of my personal circumstances and feel severely disappointed within myself for not being able to meet basic design requirements and evaluation techniques such as testing the functional requirements, I must recover from this and propose a suitable recovery plan.

The first future development that is necessary is a complete re-design of the educator interface, this time I can utilise the findings of my user evaluation to produce a more succinct extensive list of functional and non-functional requirements (and acceptance criteria) for a more relevant and appropriate design. From here I will utilise the current version of the m-pole as the design prototype and expand upon it with a complete design process (inclusive of use cases, network diagrams and wireframing). This will culminate in the next version of the M-POLE being a more respectable, strongly founded design.

After the educator-interface is refined this second time, I would then restart the entire design process for the student-interface, ensuring the design concept is as optimised as possible.

After completion, I can then begin working on the interactions between the two interfaces through the system database, and evaluate this as a functional prototype.

There are specific features that will need further development, for example the online session webpage currently returns the user camera. As this is for demo purposes it currently serves its role, however the concept behind the M-POLE is that it is a one system solution that incorporates all the respective features and strengths of the discussed current solutions.

Finally, I would hope to demonstrate this prototype to an organisation that provides funding for tech start-ups. The incorporation of extra resources will assist in the development of the tool to its maximum potential.

9.0 REFLECTION ON LEARNING

I have gained a great deal of knowledge throughout the completion of this project which I believe will be of great benefit to me in my future endeavors. As it was my first time completing a project of this scale, the vital importance of time management soon became very apparent to me. As the project was split between coding a solution and report writing, it was essential to find the balance between working on these sections and to identify how much time to allocate to each in order to maximise my productivity. Alongside this, I found it a challenge to balance the intense workload from this project whilst still enjoying and maintaining a healthy social life away from my studies. Although it took some time, I believe that by the end of the project, I had adopted a very healthy equilibrium between these factors. Learning effective time management is an essential skill which I will be able to transfer across into many other areas of my life such as in my postgraduate studies and in my future career.

The scale of this project stressed the importance of thorough research and the difference that it makes to the outcome of the final piece of work. In previous projects, I attempted to begin writing before completing the necessary research that is required to do so, which made the process far harder than it needed to be. Whilst conducting research for the project's literature review, I identified many gaps in the current research on the subject area which I subsequently decided to address in my work, making the project more valuable to the field than it would have been previously. Once the sufficient amount of research had been completed, I found the writing process to be far easier, as I was more knowledgeable on the topic that I was writing about. In addition to this, I found that extensive research into the topic helped me to identify the ways in which my project adds to the existing literature on the topic area.

Working on this project provided me with a greater appreciation of the importance of effective teamwork. In comparison to my past projects which have allowed me to work within a group, the workload for this assignment felt far heavier with the knowledge that I had to complete all of the tasks alone. Working in a team allows the group to distribute project responsibilities so that the workload does not feel as overwhelming. Effective teamwork also allows for peer reviewing to take place, a detail that I feel I would have benefitted from throughout this project. This project has greatly helped me to build upon my problem solving and critical thinking skills. During the implementation process I lost all access to the Cardiff University MySQL database servers, due to unintentionally filling the entire temporary queue space with a single query, losing a weekends worth of coding time as the application could not launch and the issue could not be resolved until the following Monday. this meant I was unable to complete my work in the order that I wanted to due to time constraints. In response to this, I had to begin writing the report before I had fully completed the coding of my remote teaching technology (the M-POLE), further building upon my adaptability.

During the first semester of this year, I received the news that a very close family member of mine was battling cancer. Due to the strains that this news put on both myself and my family, balancing this reality alongside this project was an almost impossible challenge. Alongside the personal strain that this news had on me emotionally, the resulting consequences of these circumstances further impacted upon the project's time-management, as it meant that I had unavoidable responsibilities which demanded a large amount of my time. Balancing these circumstances with the expectations that are set on me was very challenging and taught me the harsh truth that despite what tribulations one may suffer, the world continues to move

10.0 BIBLIOGRAPHY

Achen K, Rutledge D. 2022. The Transition from Emergency Remote Teaching to Quality Online Course Design: Instructor Perspectives of Surprise Awakening Closing Loops and changing Engagement. Community College Journal of Research and Practice. Available at: https://www-tandfonline-com.abc.cardiff.ac.uk/doi/full/10.1080/10668926.2022.2046207 [Accessed: 17.5.22]

Affouneh S, Salha S, Khlaif ZN. Designing Quality E-Learning Environments for Emergency Remote-Teaching in Coronavirus Crisis. Interdisciplinary Journal of Virtual Learning in Medical Sciences. 2020;1(2):1-3.

Alho K, Hakkarainen K, Lonka K, Salmela- Aro K, Upadyaya K. 2016. The Dark Side of Internet Use: Two Longitudinal Studies of Excessive Internet Use, Depressive Symptoms, School Burnout and Engagement Among Finnish Early and Late Adolescents. Journal of Youth and Adolescence. Volume 46. Pp. 343-357. Available at: https://link-springer-com.abc.cardiff.ac.uk/article/10.1007/s10964-016-0494-2 [Accessed: 20.5.22]

Balijepally V, Dingsøyr T, Moe N, Nerur S. 2012.A decade of agile methodologies: Towards explaining agile software development. Journal of Systems and Software. Volume 85 (6). Pp. 1213-1221. Available At: <https://www.sciencedirect.com/science/article/pii/S0164121212000532> [Accessed: 20.5.22]

Barrot J, Llenares I and Rosario L. 2021. Students' Online Learning Challenges During the Pandemic and How They Cope with Them: The Case of the Philippines. Education and Information Technologies. Volume 26. Pp. 7321- 7338. Available at: https://link.springer.com/article/10.1007/s10639-021-10589-x [Accessed: 20.5.22]

Bhattacharya S, Carruth L, Crowther K, Denton R, Edwards O, Esmat T, Gurvitch R, Langdon J et al. 2021. "This Wasn't Pedagogy, It Was Panicgogy" : Perspectives of the Challenges Faced by Students and Instructors during the Emergency Transition to Remote Learning Due to COVID-19. College Teaching. Pp. 1-17. Available at: https://www-tandfonline-com.abc.cardiff.ac.uk/doi/full/10.1080/87567555.2021.2018395 [Accessed: 19.5.22]

Cassidy J, Ruday S. 2022. Remote Teaching and Learning in the Middle and High ELA Classroom. New York, NY: Routledge

Chaparro-Palaez J, Hernandez-Garcia A, Inglesias-Pradas S, Prieto J. 2021. Emergency remote teaching and students' academic performance in higher education during the COVID-19 pandemic: A case study. Computer in Human Behaviour. Volume 119. Available at: https://www.sciencedirect.com/science/article/pii/S0747563221000352?via%3Dihub [Accessed: 17.5.22]

Eddy C, Herman K. C, Reinke W. M. 2020. Advances in Understanding and Intervening in Teacher Stress and Coping: The Coping- Competence-Context Theory. Journal of School Psychology. Volume 78. Pp. 69-74. Available at: https://www.sciencedirect.com/science/article/pii/S0022440520300017 [Accessed: 17.5.22]

Gares S, J Kariuki, Rempel B. 2020. Community Matters: Student-Instructor Relationships Foster Student Motivation and Engagement in an Emergency Remote Teaching Environment. Volume 97. Pp. 3332-3335. Available at: https://pubs-acs-org.abc.cardiff.ac.uk/doi/10.1021/acs.jchemed.0c00635 [Accessed: 16.5.22]

Gleckman-Krut M, Hess K, McAuliffe E, Shapiro S. Learning from 2020: How the Challenges of Remote Teaching Reinforce the Need for Care-Informed Pedagogy. Teaching Sociology. Volume 50 (1). Pp. 3-16. Available at: https://journals-sagepub-com.abc.cardiff.ac.uk/doi/10.1177/0092055X211060344 [Accessed: 18.5.22]

Gudmundsdattir G. B, Hathaway D. M. 2020. "We Always Make it Work." Teachers' agency in the time of crisis. Journal of Technology and Teacher Education. Volume 28 (2). Pp. 239-250. Available at: https://www.researchgate.net/publication/341881696_We_Always_Make_It_Work_Teachers'_Agency_in_the_Time_of_Crisis [Accessed: 20.5.22]

Guðmundsdóttir G, Hathaway D. 2020. "We Always Make it Work": Teachers' Agency in the Time of Crisis. Journal of Technology and Teacher Education. Volume 28 (2). Pp. 239-250. Available at: https://www.researchgate.net/publication/341881696_We_Always_Make_It_Work_Teachers'_Agency_in_the_Time_of_Crisis [Accessed: 18.5.22]

Ismail S, Ismail S. 2021. Teaching Approach Using Microsoft Teams: Case Study on Satisfaction Versus Barriers in Online Learning Environment. Journal of Physics: Conference Series. Volume 1874 (1). Pp. 12020. Available at: https://iopscience.iop.org/article/10.1088/1742-6596/1874/1/012020/pdf [Accessed: 18.5.22]

Kahnke L, Moorhouse B. 2021. Emergency Remote Teaching With Technology During the COVID-19 Pandemic: Using the Whole Teacher Lens to Examine Educators' Experiences and Insights. Educational Media International. Volume 58. Pp. 145-160. Available at: https://www-tandfonline-com.abc.cardiff.ac.uk/doi/full/10.1080/09523987.2021.1930479 [Accessed: 19.5.22]

Karakose T. 2021. Emergency Remote Teaching Due to COVID-19 Pandemic and Potential Risks for Socioeconomically Disadvantaged Students in Higher Education. Education Process: International Journal. Volume 10 (3). Pp. 53-61. Available at: https://www.edupij.com/files/1/articles/article_228/EDUPIJ_228_article_60ee4111a43cc.pdf [Accessed: 16.5.22]

Kemery D, Serembus J. 2020. Creating Dynamic Learning with Zoom. Nurse Educator. Volume 45. Pp. 291-293. Available at: https://oce-ovid-com.abc.cardiff.ac.uk/article/00006223-202011000-00002/HTML [Accessed: 19.5.22]

Khlaif Z, N, Kouraichi B, Salha S. 2021. Emergency Remote Learning During COVID-19 Crisis: Students' Engagement. Education and Information Technologies. Volume 26. Pp. 7033-7055. Available at: https://link.springer.com/article/10.1007/s10639-021-10566-4 [Accessed: 18.5.22]

Martin F, Bollinger D, U. 2018. Engagement matters: Student perceptions on the importance of engagement strategies in the online learning environment. Online Learning. Volume 22 (1). PP. 205-222. Available at: https://files.eric.ed.gov/fulltext/EJ1179659.pdf [Accessed: 22.5.22]

Moorhouse B, Kohnke L. 2022. Facilitating Synchronous Online Language Learning Through Zoom. RELC Journal. Volume 53 (1). Pp. 296-301. Available at: https://journals-sagepub-com.abc.cardiff.ac.uk/doi/10.1177/0033688220937235 [Accessed: 19.5.22]

National Survey of Student Engagement. (2014). Bringing the Institution into Focus – Annual Results 2014. Bloomington, IN: Indiana University Center for Postsecondary Research.

Reich et al. 2020. *What's last, what's left, what's next: Lessons Learned from the Lived* Experiences of Teachers during the 2020 novel coronavirus Pandemic. Available at: https://www.researchgate.net/publication/343144101_What's_Lost_What's_Left_What's_Next_Lessons_Learned_from_the_Lived_Experiences_of_Teachers_during_the_2020_Novel_Coronavirus_Pandemic [Accessed: 20.5.22]

Salas-Pilco S, Yang Y, Zhang Z. 2022. Student Engagement in Online Learning in Latin American Higher Education During the COVID-19 Pandemic: A Systematic Review. British Journal of Educational Technology. Volume 53 (3). Pp. 593-619

Shim T, Lee S. 2020. College Students' Experience of Emergency Remote Teaching due to COVID-19. Children and Youth Services Review. Volume 119. Pp. 105578-105578. Available at: https://www.sciencedirect.com/science/article/pii/S0190740920320016?via%3Dihub [Accessed: 17.5.22]

The World Bank, UNESCO and UNICEF (2021). The State of the Global Education Crisis: A Path to Recovery. Washington D.C., Paris, New York: The World Bank, UNESCO, and UNICEF.

Trowler V. (2010). Student engagement literature review. New York: The Higher Education Academy

Trust T, Whalden. 2021. K-12 Teachers' Experiences and Challenges with Using Technology for Emergency Remote Teaching During the COVID-19 Pandemic. Italian Journal of Educational Technology. Volume 29 (2). Pp. 10-25. Available at: https://ijet.itd.cnr.it/article/view/1192/1114 [Accessed: 20.5.22]

11.0 APPENDICES

11.1 APPENDIX A – INTERVIEW QUESTIONS

Questions about teaching experience

1) Briefly describe your experience as an educator, how long have you been a teacher? What is your teaching speciality?

Evaluating the prototype

2) What was your first impression of the M-POLE (Multi-Purpose Online Environment)? Do you consider the design to be intuitive (e.g. navigation, features)?
3) What features stand out about the M-POLE compared to other remote teaching software?
4) What do you like about the M-POLE?
5) What do you dislike about the M-POLE?
6) Do you see yourself using a full-developed version of this tool?

Future Developments

7) What features do you think are missing in the M-POLE?