A STUDENT-CENTERED GROUP-BASED LEARNING SYSTEM

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(17/SCI01/064)

A PROJECT SUBMITTED TO THE DEPARTMENT OF MATHEMATICAL AND PHYSICAL SCIENCES, AFE BABALOLA UNIVERSITY, ADO-EKITI,

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN COMPUTER SCIENCE

JUNE 2021

DECLARATION

I, Ajibola Okesola, hereby declare that this project was written by me and is a current record of my own research work. It has not been presented in this or any other institution of higher learning. All reviewed literatures are clearly acknowledged by means of reference

_____

AJIBOLA OKESOLA

DATE: _____

CERTIFICATION

This is to certify that AJIBOLA OKESOLA, with matric number 17/SCI01/064 of the Department of Mathematical and Physical Sciences, Bachelor of Science in Computer Science Programme, carried out this project work and this project work has not been presented elsewhere for the award of the degree or any other purpose

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DEDICATION

This project is whole heartedly dedicated to my Almighty God, and to my beloved family for continually supporting me morally, spiritually and emotionally; especially my sisters, Omobolaji and Folakemi, and my brother, Olatoye, who have been my major source of inspiration, motivation and encouragement

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I wish to acknowledge my Almighty God, who has guided, protected and cared for me all through my studies in Afe Babalola University.

I would also like to specially appreciate my project supervisor, the Provost of the College of Sciences, Dr. Adeyemo O.A, for his time, effort, support and guidance in this project and all through my studies in this institution. I also appreciate the efforts of my lecturers, all academic and non-academic staff which contributed positively to my studies in this institution

I would like to acknowledge the Afe Babalola University (ABUAD) Catholic Chaplaincy, especially the members of the Lay Readers Unit, who have been a great source of spiritual and social support for me throughout my studies in this institution

I would like to give specially thanks to my parents and my beloved siblings for all their support and care. I specially thank all my friends who have been a source of joy and motivation before and during my studies in this institution.

Lastly, I would like to appreciate all my roommates within my last three years of study and my friends in this institution for blessing me with amazing and memorable experiences.

ABSTRACT

This work aimed at the development of a student-centered group-based learning system. The system requirements were gathered from relevant literature on pedagogy and WebRTC and also based on the major identified problem with student-centered learning groups such as social loafing and focused on a web-implementation of the system among others. The system was designed using block, architectural pattern, flow-chart, use-case, sequence, class and architectural-context diagrams and the system's application logic was implemented using ASP.NET C#; HTML, JAVASCRIPT and BOOTSTRAP for the front-end and SQL for the database, HangFire and SignalR for the reminder and texting system. SendGrid API for reminders and OpenVidu Media server for video and audio-calling. The system has been tested and proven to be effective in providing different forms of communication and structure to group-learning to reduce social loafing, and can be recommended for tertiary institutions who want to promote a better student-student relationship for improved learning

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CHAPTER ONE

INTRODUCTION

1.1 Background of Study

In the traditional classrooms of colleges and universities, students are usually regarded as passive learners and recipients of educational content. The assessment of students' learning is usually based on their personal work, such as quizzes, exams, and test. Each student competes with his/her peers to obtain the highest score that can be obtained individually. There is very little interaction between students, and they rarely have any opportunity to work together as a team and collaborate in the learning process. Therefore, in this teaching method, the content of education is guided by the teacher, and learning is individualistic. In this case, the content is delivered by the teacher to the learners, and the students mainly rely on the teacher and knowledge experts to obtain knowledge and information. (Neo, 2005)

On the other hand, working as a group can provide learning benefit students. Group work is often referred to as "real group work" or "meaningful group work", which refers to group work where students use the skills of group members and work together to achieve a common goal. (Chiriac, 2014)

Although some students, like myself, may find that they are comfortable with individual learning and training, how students perceive each other and interact with one another is a neglected aspect of instruction. A lot of training time is devoted to helping teachers plan proper interactions between their students and the study materials (i.e., textbooks, curriculum programs) and some time is spent training on how teachers should interact with their students, however the way students should interact with other students is relatively ignored. How teachers structure student-to-student

interaction has a lot to say about how students feel about each other, how well they learn, how they feel about school and the teacher, and how much self-esteem they have. (Singh & Agrawal, 2011)

According to (Johnson & Johnson, 1991), There are three basic ways students can interact with each other as they learn; They can compete to see who is "best", they can work individualistically without paying attention to other students, or they can work cooperatively with great interest in each other's learning as well as their own

Social learning or learning as a group member is an important way to help students gain collaborative experience and develop critical thinking, self-reflection and knowledge building skills. Online learners should not become people with poor social learning ability because they cannot or choose not to come to campus. Access to education should not only mean access to content (which can be obtained directly without formal registration with an education provider); on the contrary, it should mean access to a rich learning environment that provides opportunities for interaction and connection. (Brindley et al., 2009)

Group-based learning creates an environment in which students can practice, gain, and improve soft skills such as leadership, communication, social, and conflict resolution skills; It has been proposed that learning in groups is based in the constructivist theory of learning, in that errors and inconsistencies in learners' current knowledge and schema are identified and corrected through peer discussions (Stockwell et al., 2017) However; specific approaches, such as cooperative, collaborative, or problem-based learning in this case, need to be followed to ensure students properly benefit from group-learning (Cheong, 2010)

Cooperative learning is widely recognized as a pedagogical practice that promotes socialization and learning among students from pre-school through to tertiary level and across different subject

domains. It involves students working together to achieve common goals or complete group tasks (Gillies, 2016); while, Collaborative learning is a situation in which two or more people learn or attempt to learn something together. Put differently, collaborative learning refers to methodologies and environments in which learners engage in a common task where each individual depends on and is accountable to each other (Gjergo & Samarxhiu, 2014).

Research stressing the potential of collaborative learning shows that collaborative learning environments can stimulate and/or enable learners to engage in activities that are valuable for learning. (Kirschner et al., 2008) and have been found to facilitate the learning process as seen in (Kirschner et al., 2009)

Collaborative learning and cooperative learning are two terms commonly used in discussions of how and why to use group activities, and scholars who differentiate the two terms often see collaborative learning as more student centered and cooperative learning as a more teacher centered way to facilitate student-student interaction But (Jacobs G. M., 2015) argues that collaborative and cooperative learning should be seen as synonymous student centric approaches, and that teachers and students, regardless of which of the two terms they use, should and will vary the ways they shape their learning environments in order to best facilitate the cognitive and affective benefits that student-student interaction offers.

Likewise, researchers have demonstrated that learning tends to be the most effective when students are in the position to work collaboratively, express their thoughts, discuss and challenge the ideas of others, and work together towards a group solution to the given problem (Johnson & Johnson, 1989) in (Chiong & Jovanovic, 2012))

From compulsory education to higher education, teamwork is a means of learning at all levels in most education systems. The primary purpose of group work in educational practice is to act as a catalyst for learning. For example, it is believed that students who participate in group activities should "learn something." (Chiriac, 2014)

Each student may retain and process different aspects of the class material and the preparation material, and they can share these different perspectives in a small group environment. It has been proposed that novices may be more effective at teaching novices, as experts can be far removed from the initial challenges in learning information-dense material. Working in groups may encourage students to persist in solving difficult problems beyond the point when they might give us as individuals (Stockwell et al., 2017)

1.2 Statement of the Problem

Group-based learning creates an environment in which students can practice, gain, and improve soft skills such as leadership, communication, social, and conflict resolution skills. However, simply placing students in groups and creating group-based assessment tasks will not necessarily result in students developing and practicing these skills. (Cheong, 2010). Instead, Problems such as social loafing may arise if group-based learning is not properly implemented

We view social loafing as a behavior pattern wherein an individual working in a group setting fails to contribute his or her fair share to a group effort as perceived by group members, but merit from other members' work due to a common grading system for the group. Even just one social loafer can affect the performance of the whole group. (Aggarwal & O'Brien, 2008). Therefore, students cannot just be placed into groups and expected to gain the benefits of cooperative, collaborative, or any other form of group-based learning

(Aggarwal & O'Brien, 2008) presented several hypothesis concerning social loafing which state that the greater the size of the group, the larger the scope of the group-learning and that the less student-formed a group is; the greater the incidence of social loafing

The convenient use of Technology and Social media with this recent generation cannot be heavily relied upon either to assume that they would communicate with each other better in an online setting, because although 'Asynchronous text has been credited in helping introverts and English Language Learners (ELLs) communicate in online courses. In contrast researchers have found face-to-face extraverts and students with low self-regulation skills may become online introverts when text is the medium of communication' (Borup et al., 2013)

Group-based work such as collaborative, project-based or cooperative learning should be performed while considering the opinion of the students to avoid forcing students who already learn significantly well individually and are more comfortable in that manner, and also to avoid forcing introverted or socially anxious students into a form of interaction tasking on their mental health and their personalities which may in turn affect their ability to assimilate and work effectively.

Taking all this into account, much has been done to increase group collaboration in online learning environments but little has been done to help limit social loafing in Online group-learning environment; Therefore, this work proposes a system which facilitate structuring and various forms of communication amongst small-sized student-formed group learning in order to promote group learning while reducing the incidence of social-loafing

1.3 Aim and Objectives

1.3.1 Aim

The main aim of this project is to design and implement a Student-Centered Group-Based Learning System

1.3.2 Objectives

The objectives are:

a) To design the system using requirements gathered from literature search

b) Implement and test the designed system in (a)

1.4 Scope of Project

In the proposed system for student-centered group-based learning; we will consider the following:

a. Involvement of flexible student-formed group creation

b. Incorporation of various forms of online communication to facilitate communication among students

c. The system will have a web-based implementation

However, the proposed system will system will not cover the following:

a. Pre-determined grouping of students according to any category (i.e., gender, grade level, etc.)

b. Evaluation or review of group's academic progression as the system shall be implementing already researched concepts and not re-establishing them

1.5 Methodology

The design and implementation of this system can facilitate student-centered group-based learning among students using information and communication technology, especially mobile technology since the current pandemic has made the need for non-physical communication very important and in order to achieve this, the following methods are adopted:

a) Collation and analysis of existing literatures
b) Observation of Existing models and systems and implemented systems for group learning
c) Formulation of system's basic requirements and functionalities based on data gathered from the above steps
d) Creating the design model of the system using Structured system design methods and object-oriented design methods
e) In order to make the system as effective as possible; we propose the following development and implementation tools:
    - A real time communication API based on WebRTC technology
    - HTML and CSS are proposed for the front end either in form of the ASP.NET CORE
    - The MVC architectural pattern for structuring the application
    - Relational Database along with a relational database management tool

1.6 Contributions to Knowledge

The society as a whole depends on the advancement in several different fields which can only be achieved through advancements in cooperation among different people, and this is no exclusion to the educational industries who not only value high qualities of learning and training but also

cooperation amongst their members. since advancements in concepts have been achieved greatly through research work built on existing work, grouped studies, or effective sharing of information amongst different studies

This project proposes merging the study of pedagogy that supports group-based learning more specifically cooperative and collaborative study, along with the sectors of information communication technologies. In other to facilitate effective communication and team work amongst students and also improve their abilities to assimilate in a comfortable environment

1.7 Definition of Key Terms

1. Pedagogy: can be defined as learning oriented towards social goals (Hinchliffe, 2001)
2. Group Project: A group project can be defined as "a graded assignment requiring students to work collaboratively across multiple class periods and involving some time outside the normal class meeting" (Ettington & Camp, 2002) in (Aggarwal & O'Brien, 2008))
3. Collaborative learning: Collaborative learning is a laissez-faire approach of student-centered learning in which small-group activities are performed in order to build valuable skills like critical thinking, building knowledge and social (Tu, 2004)
4. Cooperative learning: Cooperative learning is "an instructional paradigm in which teams of students work on structured tasks (e.g., homework assignments, laboratory experiments, or design projects) under conditions that meet five criteria: positive interdependence, individual accountability, face-to-face interaction, appropriate use of collaborative skills, and regular self-assessment of team functioning" (Niculescu & Dobre, 2011)
5. E-Learning: E-learning can be defined as technology-based learning in which learning materials are delivered electronically to remote learners via a computer network (Zhang et al., 2004)

6. Social Loafing: social loafing as a behavior pattern where a member of a group does not contribute their fair share to the group's effort. (Aggarwal & O'Brien, 2008)
7. WebRTC: (Web Real-Time Communication) is an API (MDN contributors, 2019) which supports video, voice, and generic data to be sent between peers, allowing developers to build powerful voice- and video-communication solutions. The technology is available on all modern browsers as well as on native clients for all major platforms. (Google, n.d.)
8. Study Group: A study group is a group in which students invest their time and efforts for the study of academic issues to supplement their course content and material (The Teaching and Learning Unit of Social Sciences, 2009)
9. Group-based Learning: Group-based learning is a form of learning which creates an environment in which students can practice, gain, and improve soft skills such as leadership, communication, social, and conflict resolution skills (Cheong, 2010)

1.8 Arrangement of Project Work

- Chapter One: This provides an introduction to the research work, the statement of the problem, objectives and aims of the system, contribution to knowledge as well as the arrangement of the project work
- Chapter Two: This presents a deep insight into pedagogy and the different pedagogical practices, then dives deeper into student-centered learning, group learning and also different forms of communication including WebRTC
- Chapter Three: This contains the analysis and design of the proposed system as well as several grammatical representations in form of UML diagrams and block diagrams to explain the system

- Chapter Four: This contains information on the system implementation, unit testing and system testing as well
- Chapter Five: This contains the summary conclusion, recommendations and references for the system

CHAPTER TWO

LITERATURE REVIEW

2.1 Pedagogy

Pedagogy is an independent social anthroposophical science. It is an organized science about humans that represents a system of research about education processes as well as main agents of the processes, conditions, results, and factors that determine the education. Pedagogy is the study of the diversity and versatility of education. Pedagogy is a science and theory that serves as the theoretical foundation for teaching and instructional practices because it provides resources for education in various aspects of human life (Doležalová, 2014)

Pedagogy involves the acquisition or development of forms of conduct, practice, knowledge from somebody or something recognized to be a suitable provider and evaluator (Westbrook, et al., 2013)

> In other words, pedagogy is a normative science (formulating norms, rules, principles and guidelines for education and upbringing) and a descriptive science. It is also an explorative science (exploring and studying new educational phenomena), as well as an explanatory science (identifying and explaining processes, results and factors of education), which is an essential activity for pedagogy. And last but not least, it is a projecting science (proposing new and more effective processes, resources or entire programmes). Sometimes, the aforementioned attributes are ale described as functions of pedagogy. Pedagogy is concerned with all forms and means of education (in family, at school, extracurricular and media effects) and pays major attention to anthropogenic factors of education. (Doležalová, 2014, p. 13)

2.2 Approaches to Pedagogy

Pedagogy can be classified according to these core approaches

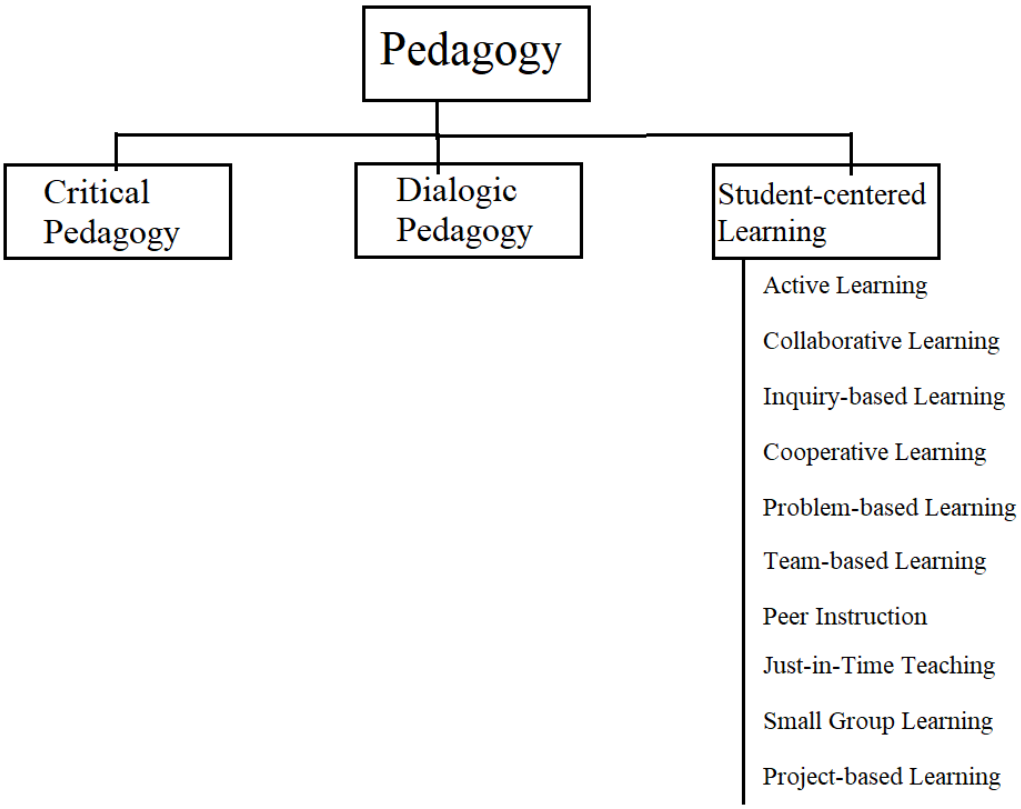

Figure 2.1: Author's Conceptual Architecture of Pedagogy focusing on Student-Centered Learning

2.2.1 Critical Pedagogy

Critical pedagogies originated in Brazil from Paulo Freire in 1972. It aims towards pursuing human and social liberation led by the oppressed through a reflective approach which doesn't require the teacher to be authoritative but instead possess qualities to enable student's critical consciousness of their own oppression and take action in the world in order to change it (Westbrook, et al., 2013)

Critical pedagogy is a way of thinking that transforms the relationship among classroom teaching, formation of knowledge, institution of the school, relations of the community, society and nation at large. It involves teaching and learning so students can gain critical self and social awareness and act against oppressive forces. (Abraham, 2014)

Critical pedagogy is an approach to teaching and learning that humanizes and empowers the learners. It aims at building a just society where people have control of their own lives, whether political, economic, and culturally. (Aliakbari & Faraji, 2011)

A critical teacher or instructor understand that their responsibility supersedes simply preparing their students for their intended profession but also instilling in them the skills, capability and mindset to transform the society and as such, the instructor must also possess a willingness to learn as they teach their students (Abraham, 2014)

2.2.2 Dialogic Pedagogy

Dialogic pedagogy highlights dialogue and its important role in the learning process. Dialogue, itself, is a term used to refer to various –almost any kind of social interactions where some form of information, either words or signs are exchanged between people. Dialogic pedagogy engages students in a sustainable manner of dialogue which enables the listeners and speaker, that is the instructors and learners, to develop on their own and other ideas (Wegerif, 2006)

Dialogic pedagogy approaches teaching and instruction in a manner that clearly differs from monologue approaches which usually dominate classroom practices (Lyle, 2008)

Dialogic pedagogy is not just about talk in classrooms, it is not limited to speaking of any explicit language in classrooms but takes into consideration other forms of communication, and even other

forms of dialogue that involve personality and tone of voice. Some forms of music, dance, texts can also be dialogue (Wegerif, 2006)

2.2.3 Student-Centered Learning (Pedagogy)

Student-centered pedagogy does not have one universal definition, in spite of the lack of a central definition, there is a principle that has been agreed upon by all proponents and researchers of the Student-centered learning approach and this principle finds its basis in the philosophy that the student or the learner is at the heart of the learning process (Attard, et al., 2010)

The pedagogy is an approach where students influence the outline, activities, pace and content of the learning. The students reside in the center of the learning process while the instructor provides them with the skills needed to learn independently and from one another (Froyd & Simpson, 2008)

It is highly beneficial for students to be the focus of learning, since they are the learners and may have better chance of learning when they're placed at the place of utmost importance

Each student may possess different levels of assimilation, understanding and thus require different methods of learning, analyzing, researching information. Some students may also need more support and attention in other to learn effectively (Attard, et al., 2010)

2.2.3.1 Characteristics of Student-Centered Pedagogy (learning)

According to (Singh N. , 2011), student-centered learning is marked by the following characteristics:

- The student has full responsibility and accountability for their learning
- The role of the teacher is that of a resource or facilitator while the students are expected to exhibit active involvement and participation in learning

- There is mutual understanding, respect and positive interdependence between students and teachers
- Active rather than passive learning is encouraged to foster in depth understanding
- Student-learning materials which have no relevance to their lives is replaced, and instead students are given the opportunity to learn and use knowledge relating to real-life contexts
- Student centered learning allows students to acquire knowledge through communication, critical thinking, inquiry and problem solving

Students that have been exposed to self-regulated learning can usually be identified because of some certain characteristics that they exhibit, it has been observed that students in such situation (Attard et al., 2010; Zimmerman, 2002):

1. Set specific goals for themselves
2. Adopt powerful strategies in order to attain these goals
3. Monitor their own performances
4. Restructure their learning environment to align with their set goals
5. Manage their time effectively
6. Evaluate their methods
7. Attach results to action
8. Adapt future methods

"SCL unfolds a broad spectrum of participation-oriented practices that engage individuals in learning deeply. These practices emphasize positive and supportive student-teacher relationships, which enable students to persist and succeed in academic environments that are challenging, relevant, collaborative, student-directed, and applied to real-life situation" (Hoidn, 2016, p. 440)

(Oinam, 2017) states that Student-Centered learning provides several benefits for students such as enhancing the quality of their higher education, enriching them with important life skills, and making them independent learner who can respond to change and difference

2.2.3.2 Forms of Student-Based Learning

Froyd & Simpson, 2008, highlight that student-learning pedagogical practices have been adopted into various means of learning and teaching. Several different instructors have created their own approaches and named them accordingly, thus creating a broad spectrum of student-centered pedagogy among which include:

a) Active Learning
b) Collaborative Learning
c) Inquiry-based Learning
d) Cooperative Learning
e) Problem-based Learning
f) Team-based Learning
g) Peer Instruction
h) Just-in-Time Teaching
i) Small Group Learning
j) Project-based Learning

A) Active Learning

Active learning is a form of student-centered learning which aims at encouraging students to gain a deep understanding of their educational content by involving them in activities that enable the students to work and reflect upon the presented materials. Research has proved the quality of

learning to improve when the learners concerned are allowed to clarify and question new knowledge (Richardson, 2015)

Active learning is defined as varying activities which require students to perform higher-order thinking but enable them to construct and understand knowledge (Brame, 2016)

Several faculties emphasize that all learning is intrinsically active, and so students are performing active learning even while listening to education content

However, (Fayombo, 2012) states that students should not only be given the role of listening in order to learn in a changing environment. Active learning emphasizes students should not be merely passive learners but learning should involve activities performed by students which aid them to assimilate what they are being taught. This could be in the form of listening practices, to writing exercises or even complex group works which allow students to apply the educational content to real life situations

Although active learning involves course related activities outside the tradition watching, listening and note taking; Active learning is not as simple as lecturing educational content and asking a few questions especially if only the same few students regularly respond or if the activities undertaken only engage a small fraction of the class. In order to properly practice active learning, students have to be given a sufficient amount of time and all students are to participate properly in the activities (Felder & Brent, 2009)

Active learning, although extremely beneficial has not been implemented in some education institutions due to their limited incentives to change and the powerful influence of educational tradition. Also, Active learning may be difficult to implement in large classes; it may require some specific materials, increase the preparation time required for a lecture or provide challenges in

covering the course content in the limited time provided. These general concerns serve as barriers to the implementation of Active learning, however, the greater challenge of all may be that teachers fear they may be criticized for unorthodox teaching methods especially if students do not properly participate (Bonwell & Eison, 1991)

B) Collaborative Learning

Collaborative learning is a form of student-centered pedagogy where more than one person tries to learn together with others. Collaborative learning involves approaches and conditions where learners engage in a common activity where everyone is responsible and dependent on each other. Collaborative learning is most widely used when students work together in groups to gain knowledge, meaning or solutions, or to yield some outcome of their learning (Gjergo & Samarxhiu, 2014)

Collaborative learning is a radical change from traditional teacher or lecturer centered pedagogy in college classrooms. The teaching, lecturing, listening or writing process in collaborative classrooms does not disappear completely, instead it lives close to other activities that are more focused on student communication, active work with course materials. Teachers or lecturers who use collaborative learning methods consider themselves less of experts in simple transfer of knowledge to students and more as experts in designing intellectual experiences for students as coaches (Smith & MacGregor, 1992)

In a Collaborative learning environment, learners share or disseminate knowledge amongst learners as they work towards a common learning goal which could be a common understanding of the current topic or solution to a problem (Brindley, et al., 2009)

However, assigning students to a group in order to collaboratively work will not ensure collaboration. (Johnson & Johnson, 2004) as cited in (An, et al., 2008) specify five basic elements required for effective group collaborations

- Positive interdependence, which is at the heart of effective collaboration, occurs when every member the group recognizes that they will not succeed unless the group works together.
- Promotes Interaction which happens when members of the group act as trusted members by accepting, appreciating, challenging and facilitating each other's efforts
- Individual Accountability which makes sure that every member of the group is actively involved and participates in the group project. This accountability can be achieved when the performance of each group member is evaluated
- Appropriate use of social skills: this requires the group members to build trust within the group and to have social experience and ability to clearly communicate and resolve conflict constructively
- Group Processing: this involves evaluating the work of all the members to ensure the quality of the work, facilitate social interaction and ensure collaboration so the group members can work well together

Collaborative learning places students in an active position where they have to learn from each other and work properly together in groups. It possesses the following advantages in the high education process (Gjergo & Samarxhiu, 2014):

1. It promotes positive relationship between students and faculty
2. It helps develop collaboration among students

3. It promoted active learning
4. It provides prompt feedback
5. It emphasizes the importance of time and time management in tasks
6. It promotes student self-esteem and fosters high expectations
7. It highlights diversity in methods of learning

(Chiong & Jovanovic, 2012) also stress that collaboration, particularly in small groups, benefits students. They are able to communicate more easily and quickly identify and correct their misconceptions in order to understand the topics being studied

C) Inquiry-Based Learning

"Inquiry is the dynamic process of being open to wonder and puzzlements and coming to know and understand the world" (Galileo Educational Network, 2004)

Inquiry based learning is the process by which students actively participate in their own learning by formulating questions, researching broadly and building new meaning and knowledge which can be used to answer questions, support a vison or point of view, or develop a solution. This new knowledge is presented others to incite some kind of action (Alberta Learning, 2004)

Inquiry-Based learning was born out of a series of dialogue concerning different methods of teaching and learning especially the work of Jean Piaget, Lev Vygotsky, and David Ausubel, which was formulated into the philosophy of constructivism to formulate instructional materials (Chowdhury, 2017). Inquiry based learning promote personal discovery in the students by guiding them to inquire or create relevant questions and to create or discover appropriate solutions through critical thinking (Ismail, 2006).

Although Inquiry promotes the intellectual skill of students and provides them with skills to acquire knowledge, it does not develop only the intellectual abilities of the students but also provides emotional and skill development (Andrini, 2016)

Classrooms where teachers have emphasized inquiry-based learning usually exhibit the following characteristics (Drayton & Falk, 2001):

- Inquiry is usually centered on real-life problem within the scope of the academic curriculum or community
- Inquiry focuses on the curiosity of the students
- Data and Information are discussed, interpreted, refined, digested and actively used
- Both students and teachers collaborate
- Inquiry connects the community and the school
- Students take high responsibility of their own learning
- Teacher and Students interact more actively than in traditional teaching approaches
- There is a definite time for inquiry-based learning
- The teachers promote the process of collecting and presenting data

According to (Alberta Learning, 2004): Inquiry-based learning provides opportunities for students to:

- develop real life skills
- learn how to approach questions which may not have obvious or direct solutions
- handle and embrace change and challenges to understanding
- model their search for solutions

D) Cooperative Learning

Cooperative learning is a form of student-centered pedagogy which involve individuals learning in small groups with the help of each other. Human society consists of several cooperative groups such as families, political parties, clubs, work-groups. Cooperative activities should be emphasized in schools since cooperation is such an important part of life (Singh & Agrawal, 2011)

Several scholars have argued that cooperative learning, although similar, is not the same as cooperative learning. Such scholars insist that groups implementing collaborative learning work together on different aspects of their group project while groups in cooperative learning work on different aspects of a project as the tasks are divided vertically (Chandra, 2015)

Cooperative learning is popularly recognized pedagogical practice which encourages social interaction and learning among students from pre-school to tertiary levels of education. In this practice, students work together to complete group tasks and achieve common goals which they may not be able to achieve on their own (Gillies, 2016)

Although Cooperative learning covers several group-based learning methodologies, it covered the following principles (Cheong, 2010):

1. Positive interdependence: The achievements of one person is associated with the achievements of every member of the group
2. Accountability: Individual grading and testing encourages accountability for each group member while group evaluation holds the group accountable
3. Team formation: Teams or Groups can be formed in different ways, either randomly by student interest or through teachers using specific criteria
4. Team size: Groups or teams that work best are usually smaller than seven members

5. Cognitive Development: This is the main objective of cooperative learning.
6. Social Development: Group or team members can develop important social skills

Although Cooperative learning should promote social skill, high-functioning students could monopolize the tasks assigned to the entire group and throw the structure of the learning groups into dysfunctional in balance, classroom space and material constraints are also objects of concern with cooperative learning; However, (Cornelius-Ukpepi, Aglazor, & Odey, 2016), highlight several advantages:

1. Personal level of interaction promotes positive student-teacher attitude
2. Alternate forms of assessments such as inter-group assessment which reduce work load for the teacher, can be implemented
3. Students can achieve a deeper level of understanding using different learning styles due to proper Teacher-student interaction
4. Self-development for both the teacher and students is promoted

E) Problem-Based Learning

Problem based learning is a learner (or student) centered teaching and curriculum method that enables learners to conduct research, integrate theory, and practice and use knowledge and skills to provide feasible solutions to a specific problem. The key to the success of this method is to select interdisciplinary problems with the wrong structure and have a tutor guide the learning process and make a comprehensive report at the conclusion of the learning experience (Savery, 2006).

There are also set of characteristics which are essential to general problem-based learnings such as (Savery, 2006): Students have responsibility of their own learning, collaboration is necessary,

the problems selected in problem-based learning must be ill-structured to allow for free inquiry; wide ranges of disciplines should be integrated into the learning; knowledge acquired by students during their self-directed learning must be re-applied to the problem with reanalysis and resolution. It is essential to conduct a detailed analysis of the knowledge acquired, the problem and discussions of concepts and principles. Self-assessment and peer assessment should be performed after each question is completed and at the end of each course unit. Problem-based learning activities must be valuable in the real-world; Student exams must measure student progress in achieving problem-based learning goals and, problem-based learning must be the teaching foundation of the curriculum, not part of the teaching curriculum

Problem based learning uses problems as the center point for obtaining new knowledge. It is effective in content acquisition and strengthening of existing knowledge through the use of problems which help achieve these objectives (Lambros, 2004).

Problem based learning offer several benefits to the students such as (Aksela & Haatainen, 2019):

- Learning discipline, goal setting, independence and discipline
- Development of personal interests which help purse deeper learning
- Encouraging modern skills of communication, negotiation and collaboration

Problem-based learning requires students to work in small groups to achieve their learning objectives amongst diversify learning needs. Because these small groups become the focus of the classroom learning situation, teachers must assume different roles, sometimes even unfamiliar roles. Now, the teacher is no longer the only content authorizer to guide the learning process, but the facilitator or coach of each group. (Lambros, 2004)

(Aksela & Haatainen, 2019) also highlight some common obstacles to effective implementation of Problem-based learning such as: Teachers' resistance to student-centered learning due to the assumption that they may be giving up 'control' of the class. Teachers may also confuse inquiry-based instruction with hands-on-activities, students lacking motivation to work with problems or in collaborative groups, high level of difficulty of developing authentic assessment and; students' resistance to critical thinking

F) Peer Instruction:

Peer instruction is a well-researched student-centered active learning technique in which the instructor will ask questions with discrete options and give students the opportunity to consider and record their answers individually, usually using clickers to vote. Then, the students discuss their answers with their neighbors, explain the reasons, and then have the opportunity to vote again (Knight & Brame, 2018)

Unlike traditional practices of asking informal questions during lectures which usually only engages a few high-functioning students; Peer instruction engages students during class activities through a structured questioning process of PI which involves every student and requires them to apply the concepts presented and explain those concepts to their fellow students (Crouch & Mazur, 2001); (Crouch, Watkins, Fagen, & Mazur, 2007)

In Peer instruction, a class is divided into a several short presentations, each focusing on a central point, followed by a conceptual question known as 'ConcepTest' which tests the students' understanding of points presented earlier. Students formulate individual answers to the questions within an allotted one or two minutes and report their answers to their instructor before discussing their answers with other students around them for about two or four minutes in order to convince

them of the correctness of their own answers by explaining the reasoning behind them. After this discussion is ended, the instructor prompts students for their answers again, which may have changed based on information gained during the decision. The instructor then moves on to another topic after explaining the answer (Crouch & Mazur, 2001)

Peer instruction promotes conceptual understanding and problem-solving skills amongst students (Knight & Brame, 2018)

G) Team-based Learning

Team-based learning (TBL) is a teaching strategy developed by Dr. Michaelson in a business school environment in the early 1990s with the aim of conducting small group learning in large classes. TBL is a learner-centered and lecturer-led (instructor-led) strategy that can be used for active learning in small groups in a large group education environment (Parmelee, Michaelsen, Cook, & Hudes, 2012)

(Michaelsen, Davidson, & Major, 2014) stated that the keys to Team-based learning effectiveness are:

1. that Team-based learning shifts focus to the students being actively in activities that allow them to solve problems rather than focusing on teachers as disseminators of information, and;
2. that every aspect of a course which employs Team based learning intends on promoting self-managed learning teams by encouraging students to actively work together to solve real problems by applying core course concepts

Team-based learning promotes accountability in the learners, as they are expected to prepare outside class and work with team members to solve real problems and make decisions in class (Parmelee, Michaelsen, Cook, & Hudes, 2012)

However, implementing Team-based learning is no easy task; the roles of the students and teachers need to be changed and the following essential elements need to be implemented in a course for student groups to become cohesive learning teams (Michaelsen, Sweet, & Parmalee, 2009):

- Groups: Properly formed and managed groups
- Accountability: Individual accountability for the students and group accountability is required
- Feedback: Feedback received by students must be timely and frequent
- Assignment design: Learning and team development must be the main objectives of group assignments

Team-based learning promote deep-learning and understanding of concepts, proper decision-making skills, good work ethic, true appreciation of the importance of team work and a sense of responsibility to and for members of their team (Michaelsen, Davidson, & Major, 2014)

H) Just-in-Time Teaching

Just-in-Time Teaching (JiTT) is a form pedagogy that makes use of the World-Wide-Web (WWW) to enhance learning in the classroom centered. It was originally developed for introductory physics classes taken by engineering majors at IUPUI and the US Air Force Academy but has since been adapted into various other fields and institutions (Gavrin, Watt, Marrs, & Blake, 2003). Just-in-Time Teaching (JiTT) innovatively promotes students' engagement and interaction in the

classroom by creating a feedback look between the classroom setting time and the students' work at home (Gavrin A. , 2006)

Just-in-Time Teaching (JiTT) makes use of web-based assignments to prepare students a few hours before the class. The students complete and submit these assignments electronically while the faculty organize and adjust the classroom lessons based on the student submissions "Just-in-Time"; thus, creating a feedback loop between the web and the classroom (Gavrin, Watt, Marrs, & Blake, 2003)

This pedagogically method fuses high and low technological elements; the high technological elements focus on the usage of the World Wide Web to promote communication between faculty and students and deliver course content, while the low-technological side emphasizes classroom interaction among faculty, students and student mentors. The purpose of this is to enable faculty to enable faculty to implement quick adjustments to the course content to adjust students' problems using the feedback from the Web (Gavrin A. , 2006)

The two most popular forms of JiTT exercises are warm-up exercises which are designed to introduce new concepts and simulate discussions in the class; and puzzle exercises which are designed to integrate several concepts and evaluate the students' knowledge. An effective JiTT question is on which promote proper student engagement and encourage students to examine theit knowledge and experiences and provide an answer which cannot be easily looked up (Abreu & Knouse, 2014)

In JiTT courses, work is done at home by students in order to manage the time spent in class. The web is used as a communication tool. The key is a series of assignments called "warm-up exercises." Generally, some materials should be read by students before the given class time. The

warm-up exercise is an online pre-class assignment that requires students to solve some flexible theoretical questions about the material that the instructor will deliberate in class. Even in mathematics or Physics courses, "warming up" should be a conceptual question that requires a written answer, not a mathematical calculation (Gavrin A. , 2006)

I) Small Group Learning

Small group learning can be defined as a group of learners with three common characteristics. Active participation, specific tasks and reflection. Although individual members of the group may not be able to participate equally, successful group learning requires the active participation of all members (R.W.Jones, 2007)

Group teaching is a student-centered approach where all students can participate in free discussions on specific topics and learn actively. Properly designed group learning activities can create a positive and safe learning environment and provide beneficial opportunities for communication among peers (Agnihotri & Ngorosha, 2018)

The communication and cognitive skills of the instructor and the student are the basis for effective group learning, not the method used (Edmunds & Brown, 2010)

Small-group learning provides the following benefits for the students (R.W.Jones, 2007):

- Group members have a greater chance of identifying what they do not know
- It promotes deep learning of course content rather than surface learning
- It promotes self-motivation and active participation of group members
- It enables group members to acquire important skills such as time management, task prioritization, team work and maintenance of interpersonal relationships

There is no ideal small-group teaching method. Different types of methods can promote different types of student participation and learning opportunities. Some important methods of group teaching are tutorials, seminars, workshops, problem-based learning (PBL), team-based learning (TBL) and tutoring (self-help group) (Agnihotri & Ngorosha, 2018)

Small-group learning promoted meaningful learning by engaging students; However, it takes a lot of work to successfully and implement it. There are the following problems associated with small-group learning (R.W.Jones, 2007)**:**

- It may not be easy to implement when some students do not prefer to learn in groups
- It may require higher investment of resources
- Small group tasks are best facilitated by a 'facilitator' which are rare

J) Project-based Learning

A project is an intensive experience that allows students to participate in activities that are interesting to them and important to the course of study. They may involve community members and settings, and usually result in exhibitions or productions for real-world purpose or audience (Fleming, 2000)

Project-based learning (PBL) is a teaching method based on learning activities and practical tasks. These activities and challenges usually reflect the type of learning and work that people do in their daily lives outside of the classroom and challenge students to solve them. (Goodman & Stivers, 2010); Project based learning promotes good relationship between teachers and students, this improves the motivation of students and promotes a deeper understanding of the topics taught by exposing students to practical work.

Project based learning can be adapted in various ways but all adaptations usually possess the following characteristics (Goodman & Stivers, 2010):

- The teacher assumes the role of a facilitator rather than a leader
- It is usually centered around a challenge or problem without predetermined solution
- It requires problem solving, collaboration, various forms of communication as well as critical thinking
- The process of solution is designed by the students
- The students learn to accept responsibility and work independently
- The students reflect regularly on what they are doing
- The classroom accepts and tolerates error and change
- A final product, material or immaterial, is produced and its quality is evaluated

2.3 Group Learning

Group-based learning is a form of learning that creates an environment in which students can practice, learn and improve soft skills such as leadership, communication, social and conflict resolution skills (Cheong, 2010)

In the traditional classrooms of colleges and universities, students are usually regarded as passive learners and recipients of educational content. The assessment of students' learning is usually based on their personal work, such as quizzes, exams, and quizzes. Each student competes with his/her peers to obtain the highest score that can be obtained individually. There is very little interaction between students, and they rarely have any opportunity to work together as a team and collaborate in the learning process. Therefore, in this teaching method, the content of education is guided by the teacher, and learning is individualistic. In this case, the content is delivered by the teacher to

the learners, and the students mainly rely on the teacher and knowledge experts to obtain knowledge and information. (Neo, 2005)

On the other hand, working as a group can provide learning benefit students. Group work is often referred to as "real group work" or "meaningful group work", which refers to group work where students use the skills of group members and work together to achieve a common goal. (Chiriac, 2014)

First, in such a group, students have the opportunity to explain to each other the gaps in the background knowledge necessary to understand and apply classroom materials; secondly, each student can retain and handle different aspects of the course materials and preparation materials, and can work in a group environment share these different points of view. Third, it has been suggested that novices may be more effective in teaching novices because experts may not understand the initial challenge of learning information-intensive materials. Fourth, group cooperation may encourage students to persist in solving difficult problems beyond the level of personal abandonment. (Stockwell, et al., 2017)

However, simply placing students in groups and creating group-based assessment tasks will not necessarily result in students developing and practicing these skills; The following challenges may be faced:

Firstly, some students may prefer to study alone and may feel uncomfortable in a group learning environment. Second, in a group environment, students with poor performance may not have the opportunity to learn, while students with higher performance are responsible for the work of the group. Third, the team may be dysfunctional and be troubled by battles and disagreements

(Farland, et al., 2013) and Finally, there may be one or more social loafers in a group who have failed to contribute their fair share to group (Aggarwal & O'Brien, 2008)

2.4 Communication

Communication is a dynamic, constantly changing process by which we understand and then try to be understood (Garg, 2018). Communication is the process of disseminating information and mutual understanding from one individual to another (Keyton, 2011). The word "communication" may also derived from the Latin verb "communicare", meaning " to make common" or "share" (Garg, 2018). It is also derived from the Latin word "communis", which means "common" (Lunenburg, 2010)

There is a misconception that communication is simply an activity when in fact, it is a process. The process of communication involves transmission of emotions, ideas, information, knowledge, and skills through the use of symbols, words, graphs, figures, pictures, drawing, etc. (Garg, 2018); Every communication exchange involves two common elements: The sender, which is an individual who desires to convey an idea or concept to others by encoding the idea in a message composed of words, symbols, and gestures; and the Receiver, which is an individual the message is directed to. The medium or channel used to send the message is the carrier and the Receiver decodes the message into meaning information and may provide feedback by responding to the sender's message (Lunenburg, 2010)

2.4.1 Communication Systems

Communication systems transmit information from one point to another through physical channels that propagate electromagnetic waves, sound waves, particle density, or other waves. This information is usually expressed as voltage or current. "These may be continuous (often called

analog) variables with an infinite number of possible values, or they may be discrete (often called digital) variables with a limited number of known possible values" (Staelin, 2003)

(Sasson, et al., 1984) classifies communication systems into the various categories such as:

a. Digital Systems: Telegraph, Teletypewriter (Telex), computers
b. Audio Systems: Telephones and Radios
c. Video Systems: Facsimile, Smart Phones, Televisions

- Telegraph: The telegraph works by interrupting the current flowing through wires. Morse designed a system for short and long interruptions, allowing skilled operators to encode and decode messages. The nature of the technology means that only one message can be sent at a time, multiple cables are required to connect busy routes, and rules for when messages can be sent in each direction are specified so as not to interfere with other messages being processed. Multiplexing technology was developed in 1870, and it allows multiple messages to be transmitted on one line by using electric currents of different frequencies. Therefore, the telegraph system is labor-intensive locally and capital-intensive in the way of transmission between locations (Richardson A. J., 2015)
- Teletypewriter: A teletypewriter (TTY) is an input device develop Teletype Corporation that allows alphanumeric characters to be entered, usually one at a time, and then sent to a computer or printer. It was an early interface with computers
- Computers: A computer is a machine that can accept, store and process information. Most computers rely on a binary system using two variables 0 and 1 to complete tasks such as storing data, calculating algorithms, and displaying information. (The Editors of Encyclopaedia Britannica, 2020)

- Telephones: Telephone is a device used to transmit and receive human voice at the same time. The phone is cheap, simple to operate, and provides its users with instant, personal-type communications that are not available through any other media. As a result, it has become the most widely used telecommunications equipment in the world (Borth, 2021)
- Radios: The radio is a device that enables sound communication via radio waves. It enables the transmission of music, news and other types of programs, from a single radio station to many individual listeners equipped with radio receivers (Sterling, 2011)
- Facsimile: Electronic fax are machines which usually use special paper to transmit images of documents (such as text, drawings or photos) to a remote location where other fax machines receive and print (Law Enforcement Standards Laboratory; National Engineering Laboratory; National Bureau of Standards, 1983)
- Televisions: Television (TV) is a telecommunications device used to transmit moving images in monochrome (black and white) or color, two-dimensional or three-dimensional, and sound for advertising, entertainment, news and sports. (Wikipedia, 2021)

2.5 WebRTC (Web Real Time Communication)

WebRTC is a free open-source project that provides real-time communication (RTC) functionalities for audio (voice call), video chat, and data (file sharing) through browser-to-browser communication. It allows browsers to communicate directly with each other in a peer-to-peer manner, which is different from conventional browser-to-web server communication

A web server with WebRTC capabilities mediates the creation of the communication link. WebRTC (Web Real Time Communications) does not rely on a standardized signaling infrastructure, but uses the Web JavaScript environment and standardized browser APIs. This allows for various implementations ranging from simple audio communication between two

people to video conferences with multiple participants, which are out-of-the-box functions of conventional browsers. Therefore, WebRTC involves at least three participants: a web server and two browsers (Bos, et al., 2014)

2.5.1 Basic Concepts in WebRTC

1. RTCPeerConnection API: The RTCPeerConnection API is the center of the peer-to-peer connection between WebRTC enables browsers. The API is usually implemented through the use of an RTCPeerConnection object which is created using the RTCPeerConnection constructor. The constructor requires a configuration variable with at least one key named 'iceServers' (i.e., an array of URL objects that contain information about TURN and STUN server used during the candidate finding phase) (Mason, 2013)
2. STUN: STUN stands for Session Traversal Utilities for NAT. Before WebRTC communication can be established, some certain information is necessary. STUN servers are used by peers to determine their ports and public IP address. They are usually freely available such as (stun.l.google.com) and are used to obtain an API key (Edim & Bakwa, 2017) and to obtain an external network address (Feher, Sidi, Shabtai, Puzis, & Marozas, 2018)
3. TURN: TURN stands for Traversal Using Relays around NAT. TURN servers provide the same functionalities that STUN servers do however, they work by relaying traffic between peers and tend to be more costly that STUN servers, they are usually used as a safety alternative in case the STUN server fails in the establishment of the Peer-to-Peer connection (Edim & Bakwa, 2017)
4. ICE: ICE stands for Interactive Connectivity Establishment. It is a protocol designed to establish connection between end points for Network Address Translation (NAT)

traversals by enabling each endpoint to generate a list of local candidates representing a port and IP address which may be used to reach the endpoint (Grozev, 2019)

5. SDP- SDP stands for Session Description Protocol. This protocol holds the basic metadata about a browser (endpoint) before the peer connection. The new sessions are announced by invitation, initiation and exchanging of information which includes codecs information, IP addresses and port numbers, media capabilities, available bandwidth, name, secure RTP Peer-to-Peer data transmission protocol, etc. (Edim & Bakwa, 2017)

2.5.2 WebRTC (Web Real Time Communication) process

The process of Communication in WebRTC can be classified into two main activities which are: Signaling and then the communication

2.5.2.1 Signaling Phase

(Feher, Sidi, Shabtai, Puzis, & Marozas, 2018) explain the signaling process with the aid of the Figure 2.2

Client A and B are represented as Alice and Bob respectively, therefore, when Alice wants to communicate with Bob, the following steps must occur

Process 0: Both Alice and Bob send requests for authentication to the signaling server and receive their Authentication responses, the authentication had to be successful for the process of communication to commence

Process 1: Alice starts a local listening connection channel and sends a request to the signaling server in order to communicate with Bob. The request Alice sends has various information about her such as unique session ID, starting and ending time for the session, ICE values, media stream identification

Process 2: When the signaling server receives the communication request from Alice, it sends the request to Bob

Process 3: If Bob approves the request, then Bob starts- a listening local connection and sends his response to the signaling server

Process 4: The signaling server received Bob's response and sends it to Alice

Process 5: Alice receives the response that Bob has accepted her request and then they can exchange direct communication information which consists of IP addresses, ports, connection type, etc.

Process 6: The direct communication channel is opened between the users and it is secured by the TLS (Transport Layer Security) protocol or the Datagram TLS (DTLS)

2.5.2.2 Communication Phase

After the establishment of the direct communication channel, both clients must revalidate each other by sending their information which had already been sent in the signaling stage since it is a new connection. After Bob and Alice have revalidated each other, they can exchange information directly (Feher, Sidi, Shabtai, Puzis, & Marozas, 2018)

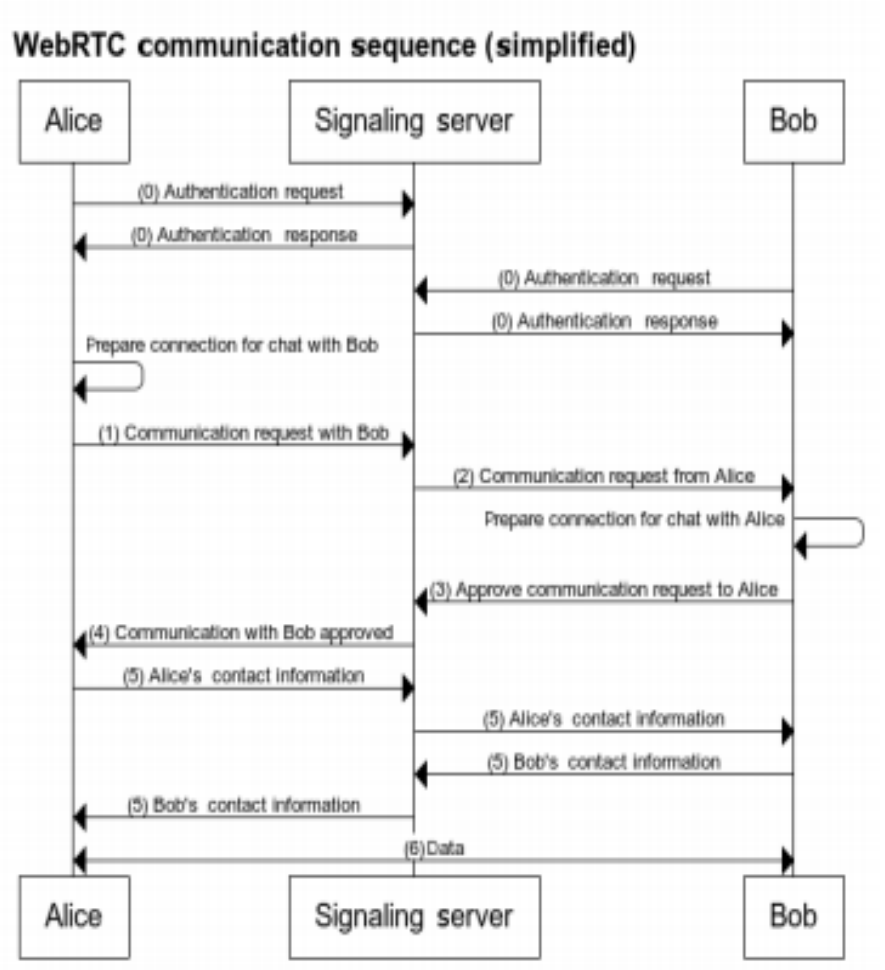

Figure 2.2: WebRTC Communication Sequence

2.5.3 Scaling WebRTC

WebRTC Provides several functionalities and benefits in regards to communication, however it was designed for peer-to-peer connections meaning that with simple WebRTC, it is very easy to design and implement a one-to-one video call, audio call or data channel but to design and implement one for a group of several different users would require a higher level of complexity to scale up.

However, (Dialogic, 2016) identified three main topologies that could be implemented when creating more complex WebRTC applications requiring multiple participants as: Peer-to-Peer Mesh topology, Multi-point Control Unit Topology, and Selective Forwarding Unit Topology

A) Peer-to-Peer Mesh

This topology does not make use of any centralized media server but instead each and every participant must receive and decode every other participants' media stream, and in most cases, must also send its own media stream for other participants to receive and decode. (Dialogic, 2016)

The advantages of this model or topology include (Grozev, 2019):

- End-to-End latency is minimized
- End-to-End encryption can be easily achieved
- It easier and cheaper to deploy

However, decoding each and every media stream for each participant in a two or three user room may work, but when the users in a particular room increase; the work load for each user's personal computer increases exponentially as well. For example, in a video conference of fifty (50) users; each of the fifty users will need to accept and decode the media of all the other Forty-nine (49) users while simultaneously sending their own media stream to all the other Forty-nine (49) users

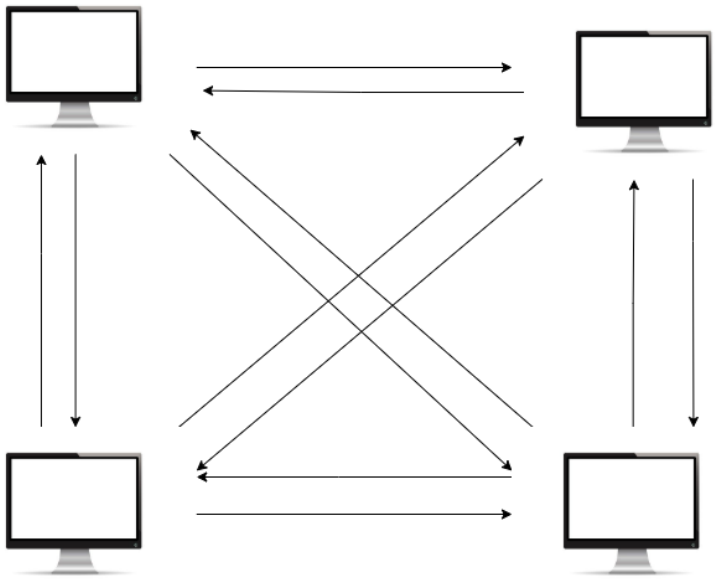

Figure 2.3 Mesh Peer-to-Peer Topology

B) Multi-Point Control Unit

According to (Kandari, 2016); The MCU (Multi-point Control Unit server receives all the streams sent from the clients, decodes the media stream obtained and then encode and converge all the video and audio streams received into a single stream and sends it back to all the clients where they are connected to a single port; Due to the presence of the server, it reduces the workload on the personal computers of the users, however there is an increase in the server's workload as the number of users increase

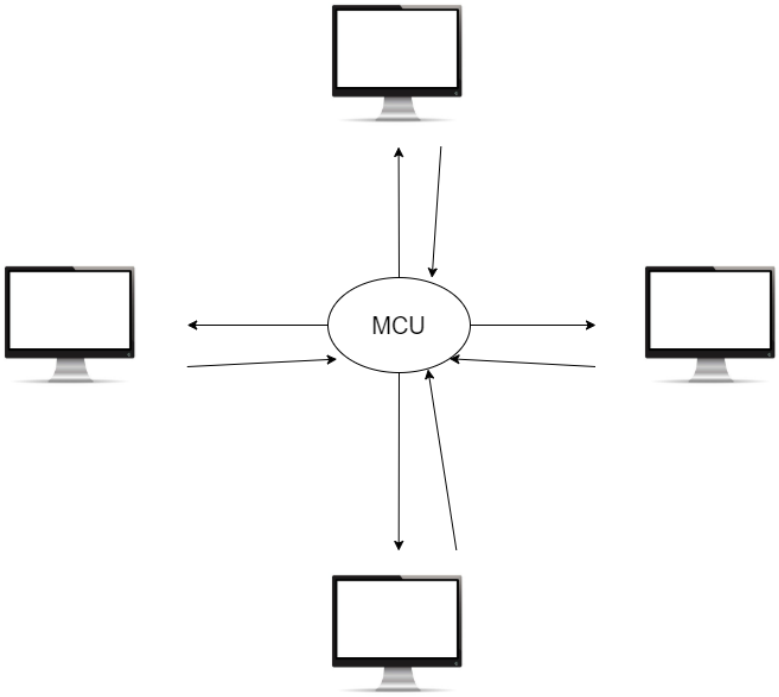

Figure 2.4: Multi-point Control Unit Topology

C) Selective Forwarding Units

Selective Forwarding Units (SFU)s are also known as video routing. SFU is a topology which allows WebRTC clients to send their encoded media stream to the centralized media server, the server then receives and forwards or routes the media stream back to other WebRTC clients (Dialogic, 2016).

SFUs address the issue of scalability quite efficient because the centralized server can split an encoded stream to produce a set of streams with different characteristics without needed to re-encode them. The server then forwards only a selected subset of the streams to the WebRTC clients (Grozev, 2019)

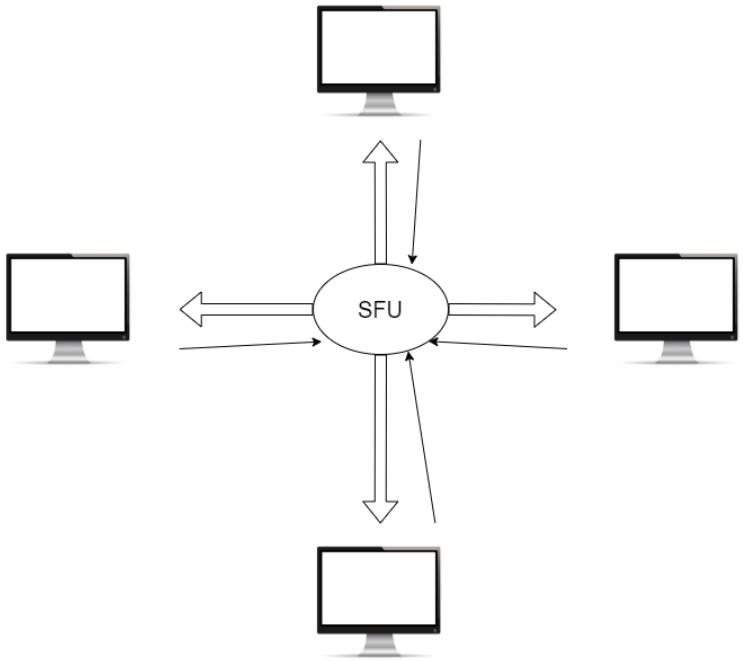

Figure 2.5: Selected Forwarding Unit Topology

2.6 Review of Related Works

The following related works have been reviewed

1. WebRTC Based Remote Collaboration System was implemented and optimized by (Kandari, 2016). The project was centered on the idea that collaborative teams are required to achieve development of complex products, and such collaborative teams could effectively exchange ideas and feedbacks through all the stages of product development using interactive aids and systems. Research on existing collaborative tools to see existing technologies and architecture was carried out. Research on the various WebRTC architectures and selection of the best WebRTC architecture with a very low latency and high throughput was also carried out The Mesh topology was used to scale the peer-to-peer architecture in order to enable multiple participants. Node.js was chosen as the framework and the signaling server used was XSockets and OrigoDB was chosen as the databased

though it uses RAM memory for storage, it was suitable because the prototype was assigned a time period for storage. Due to the WebRTC SDP protocol at that time affecting the scalability and performance of the system; tracking.js was used to detect faces so that when the minimum number of faces are detected, the video resolution id decreased to 320x180, and when maximum number of faces is detected, the resolution is increased to 1280x720. The languages used to design the front end were HTML, CSS and JavaScript. It was advised that any security issues of the system could be solved by an encryption method implemented in the WebRTC and that though WebRTC was supported by many browsers at that time, there may still be issues during cross-browser communications

2. Intranet Video Conferencing System Was Implemented by (Lala, O.J., & Adeyemo, 2014). The project was motivated by the need to reduce cost by eliminating the use of costly hard-wired intercoms and PABX (Private Automatic Branch Exchange) through the use of LAN and multimedia computers which can provide a service for transmitting text, video, and voice over a data network instead of the use of cable and voice networks while eliminating the use of database. Related literatures and existing systems were reviewed; shortcomings in existing systems were highlighted to develops system requirements and design of system using architectural diagrams, flow-chart and data-flow diagrams was done. The system was developed using NetBeans 7.2.1 and Eclipse Kelper as the IDE (Integrated Development Environment), socket programming was also used for text chatting. The system was implemented over an Intranet (LAN). JMF (Java Media Framework) and RMI (Remote Media Invocation) were embedded into Java to invoke the media functionalities and make conferencing possible. The system was implemented over an Intranet (LAN); however, it

was recommended that the system could be enhanced to work on a WAN or even the Internet. It was also recommended to include file transfer and other interactive features

3. Virtual Machine Video Conferencing Application was designed and implemented by (Adewale, John, & Ike, 2014). This project was motivated by the need to create a seamlessly working multimedia teleconferencing room for end-to-end video conferencing to solve the problems surrounding the traditional ways of conducting meetings**.** Design of the system using block, flow-chat, use-case, and class diagrams was carried out. The virtual machine used is Vmware workstation and Apache 2.0 was selected as the application's server. Shockwave flash was used as a format for multimedia, Red 5 Media server was employed as the media streaming server and Java Open Document Converter was used to convert files from one format to another. The implemented system was capable of video calling, file uploading for presentation, it also possessed a platform for questions, could record the meeting and also share the desktop with various users. However, the system supports for 1-25 simultaneous users and also requires that a user have java installed in their browser in order to join a meeting
4. Video Conference Platform Based on WebRTC by (Mahmood & Ercelebe, 2018). The system was motivated by the desire to create a video conferencing website which allows users to join from any geographical location in the world without needing to install any software and performs secure streaming to users for the prevention of security threats. The system was built on ASP.Net frame work using the Client-Server architecture and was programmed using C# and JavaScript. It used a SSL (socket server layer) to encrypt all connections between client and server. WebRTC was also used as the Real time communication framework and a SQL database was used to store user information. The

system has functionalities for text chatting, audio calling and video calling. For security, the system has a two-level authentication of guest and members to allow only authorized members to create or join video calls. The system was tested on multiple operating systems and internet browser found to compatible with most; However, the quality and streaming speed of the system is highly depended on the speed of clients and the streaming bandwidth of the server

5. Videoconference System Based on WebRTC With Access to the PSTN by (Rosas & Martínez, 2016). The project was motivated by the need to provide communication solutions for cases where the internet connection of a user may not be available or suitable for a proper conference. This project proposes the usage of internet with a conventional phone call that connects to the web application. Literature research on existing systems was carried out to develop system requirements. The system was then designed using block and schematic diagrams. It made use of WebRTC with the mesh topology for real time and video and voice communication and configured Asterisk as its IP PBX system in order to establish a communication between the Web browser and PSTN. The application is provided by a web server built on Node.js. The System's overall objectives were achieved. However, it is possible to establish a clear video conferencing and telephone audio among just three users, unless a user is added with Telephone audio which would make it four; also, it was necessary to use Asterisk 11 with CentOS 6 Operating System in order to use the SIP agent for the telephone audio from a web browser
6. P2p Audio and Video Calling Application Using WebRTC by (Majid, Samah, Yusuf, DewiNasien, & Cheah, 2016). This project was motivated by the desire to reduce students' data usage and to reduce the cost of audio and video calling. Comparison and analysis of

existing systems was carried out to develop requirements. System architecture design, database design and interface design were developed from requirements generated. It made use of WebRTC for audio and video communication and WebSocket with Node.js for the signaling server. The system had video, audio, file-sharing and text messaging functions. However, the system can only be used by two students per session and the file-sharing is only available during an audio or video call and not as a standalone

7. Virtual Classroom Solution with WebRTC in a Collaborative Context in Mathematics Learning Situation by (Faye, Gueye, & Lishou, 2018). This work was motivated by the difficulties of distance learning on practical work rooms and laboratories since students are usually physically remote from the laboratories, they must use to obtain these skills. Literature research on WebRTC and review of related works were carried out to develop system requirements. The system design was created using system requirements with architectural and scenario diagrams. The system uses WebRTC for real time media communication, GhostScript is used and analyzing and translating to other formats. ImageMagick was used to convert a PDF document into images to facilitate handling the presentation and Apache served as the container of the application. The system was created with audio, video and text messaging functionalities and also the ability to host presentations in real time and let the participants input their mathematical functions. However, it was observed that the system needs a more structured user interface
8. Real Time Collaborative Platform for Learning and Teaching Foreign Languages by (Osipov, Prasikova, & Volinsky, 2015). This work was motivated by the desire to encourage self-learning to promote interaction and collaboration based on the principles of project-based learning**.** The system was designed interaction, function and user-interface

schematic diagrams. The server side was programmed in PHP along with the MySQL database. It used WebRTC for audio-visual real time connection. The system allows real time video and audio communication. It can also track the student's progress and allows students to rate their instructors; However, new users have problems understanding the system and it also requires the use of a personal computer

9. A Web-based Learning System using Project-based Learning and Imagineering by (Chatwattana & Nilsook, 2017). This work was motivated by the desire to promote creativity and ability in learners by encouraging self-learning, interaction and cooperation based on the concepts of project-based learning and Imagineering learning. The conceptual framework for the web-based learning system using project-based learning and Imagineering was analyzed and synthesized; then the system was designed using use case diagram, system architecture and system structure. The system was built using PHP and MySQL for the database. It adopted Email, WebBoard and Social share as it's communication tools. The system also Had Learning Management System, Content Management, Test Management and Delivery Management. The system was tested using black-box texting technique. Evaluation of the quality, efficiency and the suitability on the design of instructional activities and practical use of the web-based learning system using project-based learning and Imagineering was performed. However, it was observed that the User Interface could be improved upon
10. Development of a Web-based Active Learning System and Its Application and Evaluation in Faculty Development by (Yoshida, 2019). The system was motivated with the desire to facilitate active learning and group work in an online setting and to examine the feasibility of implementing online active learning in faculty development as well as the system's

usefulness by conducting an online faculty development workshop that makes use of the system and obtaining evaluations of the system and workshop from its participants. The system was built on PHP and uses Node.js and WebSockets for real time communication, the client side was designed using HTML and JavaScript. Group calling is enabled through the use of WebRTC and Google Docs is used to make the Group Work Sheet function possible. The system was successfully used to facilitate a faculty's development workshop. Examination of the feasibility of implementing effective active learning that incorporates online group work by using the system to facilitate a faculty's development workshop was also carried out; However, the voice call functionality could be further extended to improve the system's aid to interaction

11. Design and Implementation of Web Based Collaborative Learning Model for ICT Course of College Student in Bangladesh by (Islam, Rahman, Galib, Uddin, & Bashir, 2014).This project was motivated by the desire to make students more efficient learners in the ICT academic field and reducing the burden of memorization**.** It aimed at designing and implementing a web-based collaborative learning model for ICT courses of college students in Bangladesh. Research and analysis of traditional class-based learning system; Data collection from different regions of Bangladesh was carried out. Addressing collaborative learning with students who are unfamiliar with it was performed. The system was then designed using structural and flow chart diagrams. The system runs on a window server and has a web server built with Apache and MySQL as the database. The system features text messaging for collaboration, it allows self-assessment, and also provides audio, video and image explanations for better understanding for the topics; However, the

system exhibits no audio or video calling functionalities which would be highly beneficial for collaborative learnings

Table 2.1: Review of Related Works (Tabular Form)

S/N	Title and Author(S)	Purpose	Methodology	Result	Challenges
1	WebRTC Based Remote Collaboration System Was Implemented and Optimized by (Kandari, 2016)	Their main goal was to develop a web-based collaboration tool which had optimum performance and could satisfy their users' requirements	The Front End was designed with HTML, CSS and JAVASCRIPT. The database used was OrigoDB which uses RAM; the system was designed with Node.js and XSockets as the signaling server and it used the Mesh topology to implement	The final Prototype of the system 'MERCO' was successful at supporting the concept of Remote collaborations with better user experience, usability and conference stability	It was recognized that security issues could be addressed by an Encryption Method in WebRTC and at that time, WebRTC could still have cross-browser communication issues

			WebRTC for video calling		
2	Intranet Video Conferencing System Was Implemented By (Lala, O.J., & Adeyemo, 2014).	The system was designed to provide a service that would transmit text, voice, video over a data network instead of voice and cable networks meant for voice or video calls only	JMF (Java Media Framework) and RMI (Remote Media Invocation) were embedded into Java to invoke the media functionalities and make conferencing possible. NetBeans 7.2.1 and Eclipse Kelper were used as the IDE. Socket programming	The system was successfully created with functionalities for voice and video conferencing, text messaging	it was recommended that the system could be enhanced to work on a WAN or even the Internet. It was also recommended to include file transfer

			was also used for text chatting		
3	Virtual Machine Video Conferencing Application Was Designed and Implemented By (Adewale, et al., 2014).	The project was motivated by the need to propose a fully integrated multimedia teleconferencing room to create quality end to end video conferencing	The virtual machine used is VMware workstation and Apache 2.0 was selected as the application's server. Shockwave flash was used as a format for multimedia, Red 5 Media server was employed as the media streaming server and Java Open Document Converter was	The implemented system was capable of video calling, file uploading for presentation, it also possessed a platform for questions, could record the meeting and also share the desktop with various users	the system supports for 1-25 simultaneous users and also requires that a user have java installed in their browser in order to join a meeting

			used to convert files from one format to another		
4	Video Conference Platform Based on WebRTC by (Mahmood & Ercelebe, 2018).	The system was motivated by the desire to create a video conferencing website which allows users to join from any geographical location in the world without needing to install any software	The system was built on ASP.Net frame work using the Client-Server architecture and was programmed using C# and JavaScript. It used an SSL (socket server layer) to encrypt all connections between client and server. WebRTC was also used as the	The system has functionalities for text chatting, audio calling and video calling. For security, the system has a two-level authentication of guest and members to allow only authorized members to create or join video calls.	However, the quality and streaming speed of the system is highly depended on the speed of clients and the streaming bandwidth of the server

			Real time communication framework and a SQL database was used to store user information.	The system was tested on multiple operating systems and internet browsers found to be compatible with most	
5	Videoconference System Based on WebRTC With Access To The PSTN By (Rosas & Martínez, 2016).	The system was motivated by the desire to create a unique communication system that interacts with telephone networks directly from the browser during a video conference.	Makes use of WebRTC with the mesh topology for real time and video and voice communication and configured Asterisk as its IP PBX system in order to establish a communication	The System's overall objectives were achieved	it is possible to establish a clear video conferencing and telephone audio among just three users, unless a user is added with Telephone audio which would make it four; also, it

			between the Web browser and PSTN. The application is provided by a web server built on Node.js.		was necessary to use Asterisk 11 with CentOS 6 Operating System in order to use the SIP agent for the telephone audio from a web browser
6	P2P Audio and Video Calling Application Using WebRTC by (Majid, et al., 2016).	The system aimed at reducing students' data usage and reduces the cost of video and audio calling	It uses WebRTC for audio and video communication and WebSocket with Node.js for the signaling server	The system had video, audio, file-sharing and text messaging functions.	The system can only be used by two students per session and the file-sharing is only available during an audio or video call and not as a standalone

7	Virtual Classroom Solution with WebRTC In A Collaborative Context in Mathematics Learning Situation by (Faye, et al., 2018).	The system was motivated by the difficulty of distance learning on practical work rooms and laboratories	The system was motivated by the difficulty of distance learning on practical work rooms and laboratories. The system uses WebRTC for real time media communication, GhostScript is used and	The system was created with audio, video and text messaging functionalities and also the ability to host presentations in real time and let the participants input their	it was observed that the system needs a more structured user interface

			analyzing and translating to other formats. ImageMagick was used to convert a PDF document into images to facilitate handling the presentation and Apache served as the container of the application	mathematical functions	
8	Real Time Collaborative Platform for Learning and Teaching Foreign Languages By (Osipov, et al., 2015).	The system was designed to be a social-network based educational resource for learning foreign	The server side was programmed in PHP along with the MySQL database. It used WebRTC for audio-visual	It can also track the student's progress and allows students to rate their instructors	new users have problems understanding the system and it also requires the use of a personal computer

		languages in real time	real time connection. The system allows real time video and audio communication		
9	A Web-Based Learning System Using Project-Based Learning and Imagineering by (Chatwattana & Nilsook, 2017)	The system was designed with the aim to encourage self-learning to promote interaction and collaboration based on the principles of project-based learning.	The system was built using PHP and MySQL for the database. It adopted Email, WebBoard and Social share as it's communication tools.	The system also Had Learning Management System, Content Management, Test Management and Delivery Management Systems	it was observed that the User Interface could be improved upon
10	Development of A Web-Based Active Learning System and Its Application and Evaluation in	The system was motivated by the desire to facilitate active learning and	The system was built on PHP and uses Node.js and WebSockets for	The system was successfully used to facilitate a	the voice call functionality could be further extended to

	Faculty Development By (Yoshida, 2019)	group work in an online setting.	real time communication, the client side was designed using HTML and JavaScript. Group calling is enabled through the use of WebRTC and Google Docs is used to make the Group Work Sheet function possible	faculty's development workshop.	improve the system's aid to interaction
11	Design and Implementation of Web Based Collaborative Learning Model for ICT Course of College Student in	The project was motivated by the need to aid to students to become more efficient learners in ICT and reduce the	The system runs on a window server and has a web server built with Apache and MySQL as the database	The system features text messaging for collaboration, it allows self-assessment, and also provides	the system exhibits no audio or video calling functionalities which would be highly beneficial for

	Bangladesh by (Islam, et al., 2014)	burden of memorization		audio, video and image explanations for better understanding for the topics	collaborative learning

CHAPTER THREE

METHODOLOGY

Introduction

This chapter focuses on a thorough analysis and design of the online group-learning system as well as all of its sub systems. The SDLC architecture chosen is explained and other system architectures and topologies chosen for the system are comprehensively explained with several diagrams to aid understanding

3.1 Analysis of the system

The system is a web-based application for student-centered group-based learning. The goal of the system is to provide easy structuring and communication among student-learning groups in order to combat the deep issue of social loafing and promote equal participation and learning amongst all students in the group. The system possesses basic authentication which requires user registration and Login before the benefits of the system can be accessed. The online-group learning system is also divided into a number of main sub-systems

After thorough review, the development model selected for the system is the Waterfall Model. The Agile model was initially intended for the system but after the planning stage and brief requirement analysis of the system; it was discovered that the system's current requirements could be easily detected and so the Waterfall Model was quickly selected as the development model for the system due to the clarity of the System's requirements gathered from previous literatures and research done on group-learning.

The block diagram of the system's development model in Figure 3.1 displays the activities involved in the development of the system which include: Preliminary Investigation, Requirements Specification, System design, System implementation and testing, and maintenance.

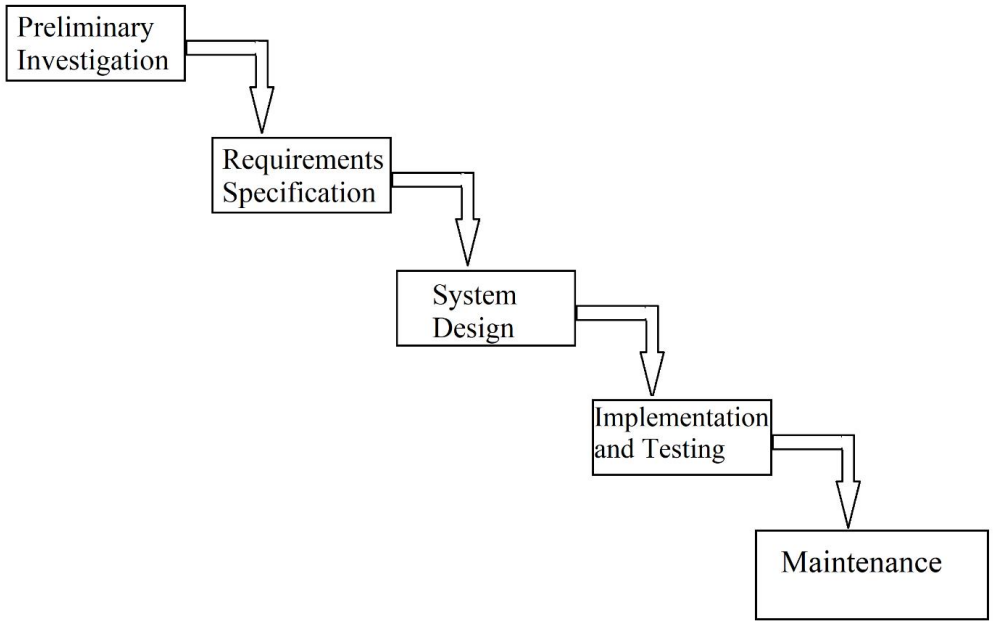

Figure 3.1: System Development Model

The developmental process, as earlier stated began with problem definition, research and reviewing of psychology and pedagogical research to properly identify the problems and the attest to the feasibility of the proposed system; once the problems were properly defined and the feasibility of the system was confirmed. Related literatures were reviewed to find issues in the existing systems and such document issues helped to solidify the requirements of the proposed system. The main functionalities of the system gathered from relevant literatures are: file sharing, text-messaging, audio and video conferencing.

The Audio and Voice conferencing is to be achieved through Web Real-Time Communication (WebRTC) Which had been explained in the previous chapter, but as stated in the previous chapter,

WebRTC was created for Peer-to-Peer connections and since this system is intending on allowing group-communication alone and not one-to-one communications and so a topology will need to be adopted to allow WebRTC to perform group connections; Out of the Three Topologies analyzed in the previous chapter, the topology Selected is the Selected Forwarding Unit (SFU) Topology

3.2 The Selective Forwarding Unit Topology for Web Real-Time Communication of the Proposed System

The SFU topology operates similar to network ring topology in that it allows all the WebRTC clients to send their own media stream to the central media server which received and routes the media stream back to all the other WebRTC Clients; meaning user A, B, C, D will send their own media to a central media server which will send back the media of the other three users back to each user

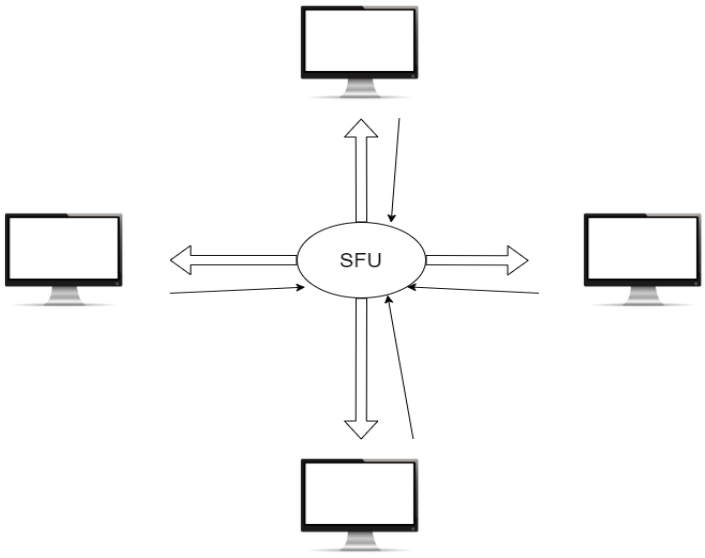

Figure 3.2: Selected Forwarding Unit Topology of the Proposed System

3.3 System Specification of the Proposed System

The System Specification includes the hardware requirement, the software requirements and the non-functional requirements of the system. The hardware requirements describe the requirements needed by the hardware devices, the Software requirements list the necessary requirements for the development of the project and the non-functional requirements are more of qualities that the system should possess after being developed.

Therefore, the minimum requirements for the system are:

3.3.1 Hardware Requirement of the Proposed System

The hardware requirements are:

1. Intel Core™ i5 and above
2. 4GB RAM
3. 64-Bit Operating System
4. Hard Disk of 256GB and above

3.3.2 Software Requirement of the Proposed System

The Software requirements are:

1. Operating System: Microsoft Windows 10
2. Programming Language Framework: ASP.NET MVC 3.1
3. Main Programming Language: C#
4. Front-End Languages: HTML, CSS, JavaScript, BOOTSTRAP, JQUERY
5. Database Language: Microsoft SQL with Entity Framework
6. IDE: Microsoft Visual Studio 2019 and above
7. Signaling Protocol: ASP.NET Signal R

8. Email API: SendGrid Email API
9. Background Processing API: HangFire
10. OpenVidu Media Server which runs on Kurento Media Server for WebRTC Connection
11. Docker CE for running the media server in command line

3.3.3 Basic Functional Requirements of the Proposed System

1. Users should be able to create learning groups and join learning groups
2. Users should be able to send files of any format within their groups
3. Users should be able to start or join audio or video calls within their groups
4. Users should be able to send Text messages to each member of their groups
5. Users should be reminded of their meeting times and roles through the use of emails

3.3.4 Basic Non-Functional Requirement of the Proposed System

The non-functional requirements of the System are:

1. The system should have a beautiful and user-friendly interface
2. High communication speed for the Text-messaging
3. The system should have basic security and authentication
4. The system should be easy to navigate

3.4 System Design of the Proposed System

The requirements and specifications of the system were then studied to develop the system design. The system was then divided into a number of sub-systems based on the functionalities they are intended to provide which include: The Email reminder system, The Audio and Voice communication system, the Text messaging system and the file sharing system.

However; the system is designed for group-learning so it requires the user to currently be in a group before being able to use any of the sub-systems. Once the user logs in, they can create a group or join an existing group to enjoy the fullness of the system.

The gather data was then represented in diagrammatic form through the use of various design tools such as: Architectural Pattern (Design) Diagram, Overall System Block diagram, Use-case diagrams and Flow-chart diagrams

3.4.1 Architectural Pattern Diagram of the Proposed System

Due to the number of services and sub-systems incorporated in the system, an architectural pattern which is relatively easy to modify, scale, and can allow services to be added to was considered and the MVC (Model-View-Controller) Architectural pattern was selected to make this possible to manage the interactions in this web-based system

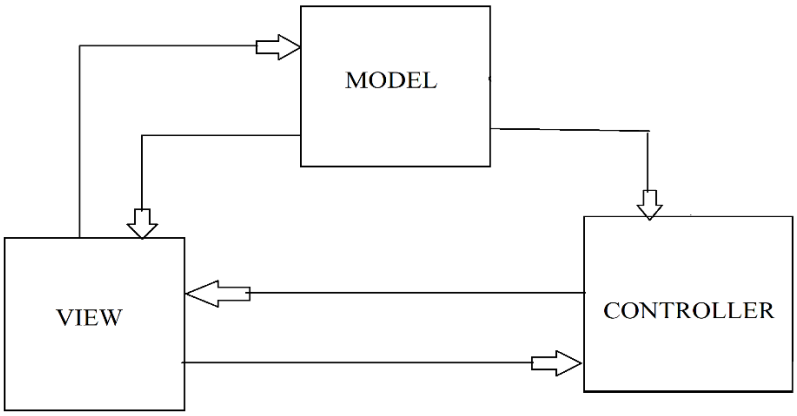

Figure 3.3: System Architectural Pattern Adopted for the Proposed System

Views and Controllers can easily be added and changed in order to accommodate the different functionalities of the system and since the user interface is such a prominent part of the non-

functional requirements of the system; the MVC architecture allows the views and the user-interface to be changed even at run-time.

Although there have been many complaints that the architecture relies on the model component, tight coupling between the view, model and controller can be minimized through the use of 'view models' which serve as intermediaries between the models and the views

3.4.2 Overall System Block Diagram

The block diagram in Figure 3.4 illustrates the design of the overall system. As earlier stated, the system requires user registration or log in, and also for the user to then enter the portal for a particular group, weather one they created or not. After they have accessed a group portal then the users are allowed to interact with the other subsystems within the group

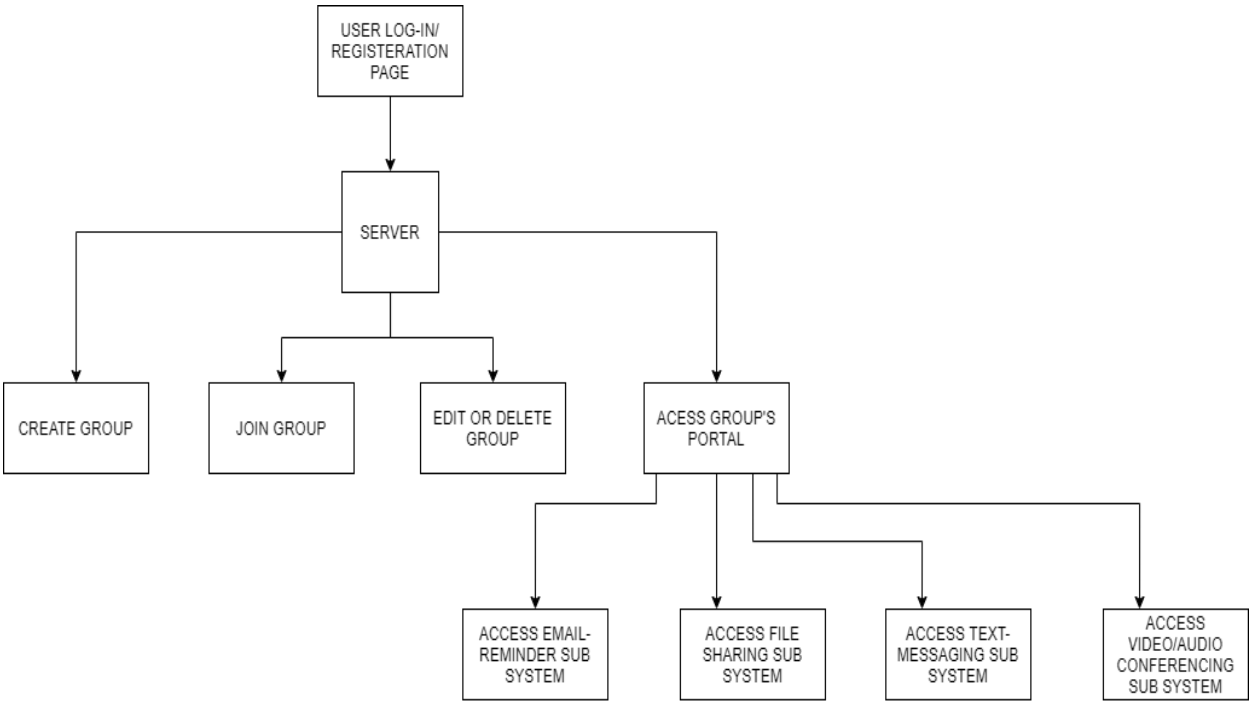

Figure 3.4: Block Diagram of the Proposed System

3.4.3 The Email Reminder Sub-System

The email reminder sub-system main operation is to send email reminders of any activity in a predefined email to the intended user. If the emails were sent immediately after creation, then this sub-system would be unnecessary as that would be the same as sending a simple email to one's self. Instead, the email-reminder system allows the user to create the email and set time limit for the reminder and then sends at the date and within the time frame it has been set for. In order for this to occur, the system makes use of background processing, which is a way of performing pre-set operation in the system without having to cause an event at the specific time. The system makes use of HangFire API for its background processing

As shown in Figure 3.5; Each time a user creates an email reminder and sets it to a particular date and time, it is saved to the database. A HangFire recurring event is called created in the background and it recursively checks through the list of reminders in the database until the date and time set for a particular reminder is set and then it sends it using an Email Sending API; SendGrid Email API is employed by the system for sending of emails to the specified user; it allows for emails to be sent to their destination without requiring the development and maintenance of a personal SMTP server for the system. Once the Email has been sent; the reminder is then marked as 'sent' and joins the rest of the other emails in the database who have been sent and do not need to ever be sent again

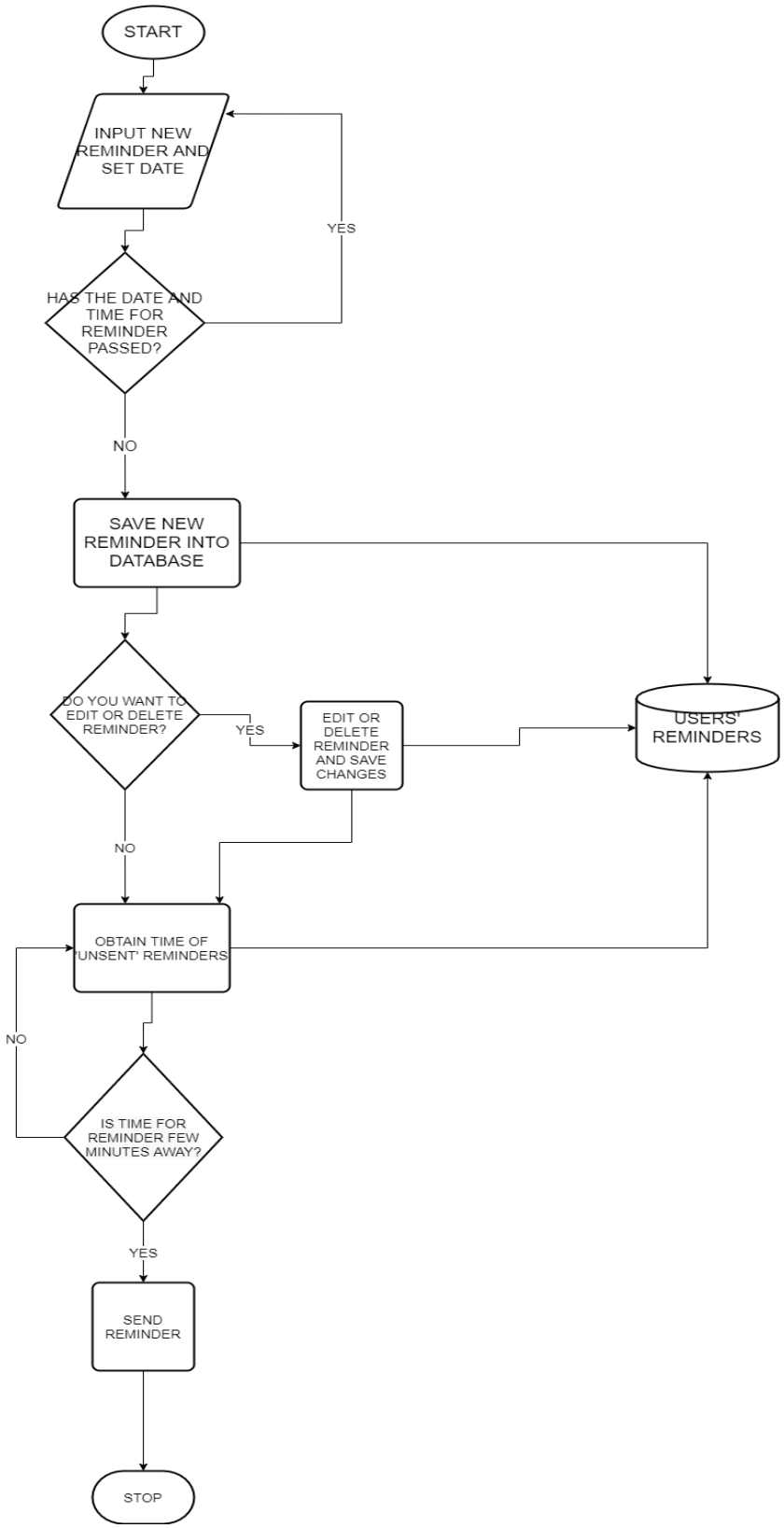

Figure 3.5: Flow Chart of Email-Reminder Sub-System

3.4.4 Use-Case and Sequence Diagram for Email Reminder Sub-System

The use-case diagram in Figure 3.6 is a simple diagrammatic representation of the user's interaction with the system. It shows the operations that each user can perform on the system. Each user can create reminders for themselves, can view, edit and delete the reminders made for themselves while the group administrator can create a broadcasted reminder for everyone in the group, this is especially useful for reminding group members of an upcoming video conference meeting

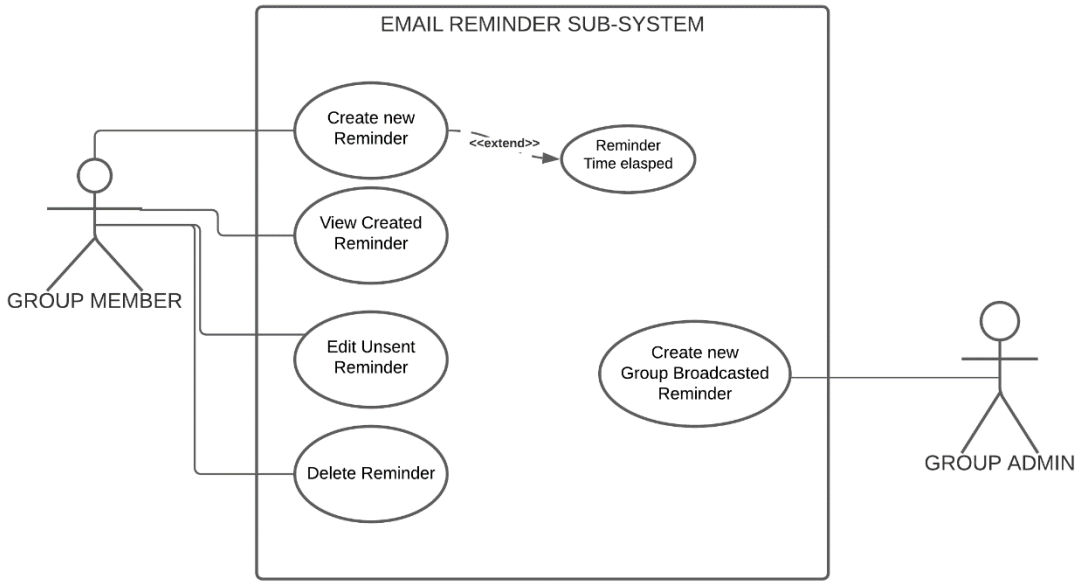

Figure 3.6: Use-Case Diagram of Email Reminder Sub-System

The Sequence diagrams in Figure 3.7 and Figure 3.8 is a simple diagrammatic representation of the various interactions in the email reminder sub-system and how operations are carried out. The user interacts with the Reminder sub-system which interacts with the database and the SMTP server in other to send the emails to the required sender. Figure 3.7 represents the interactions a

regular user may perform when making personal reminders and Figure 3.8 represents how a group administrator user would interact with the system when making group reminders

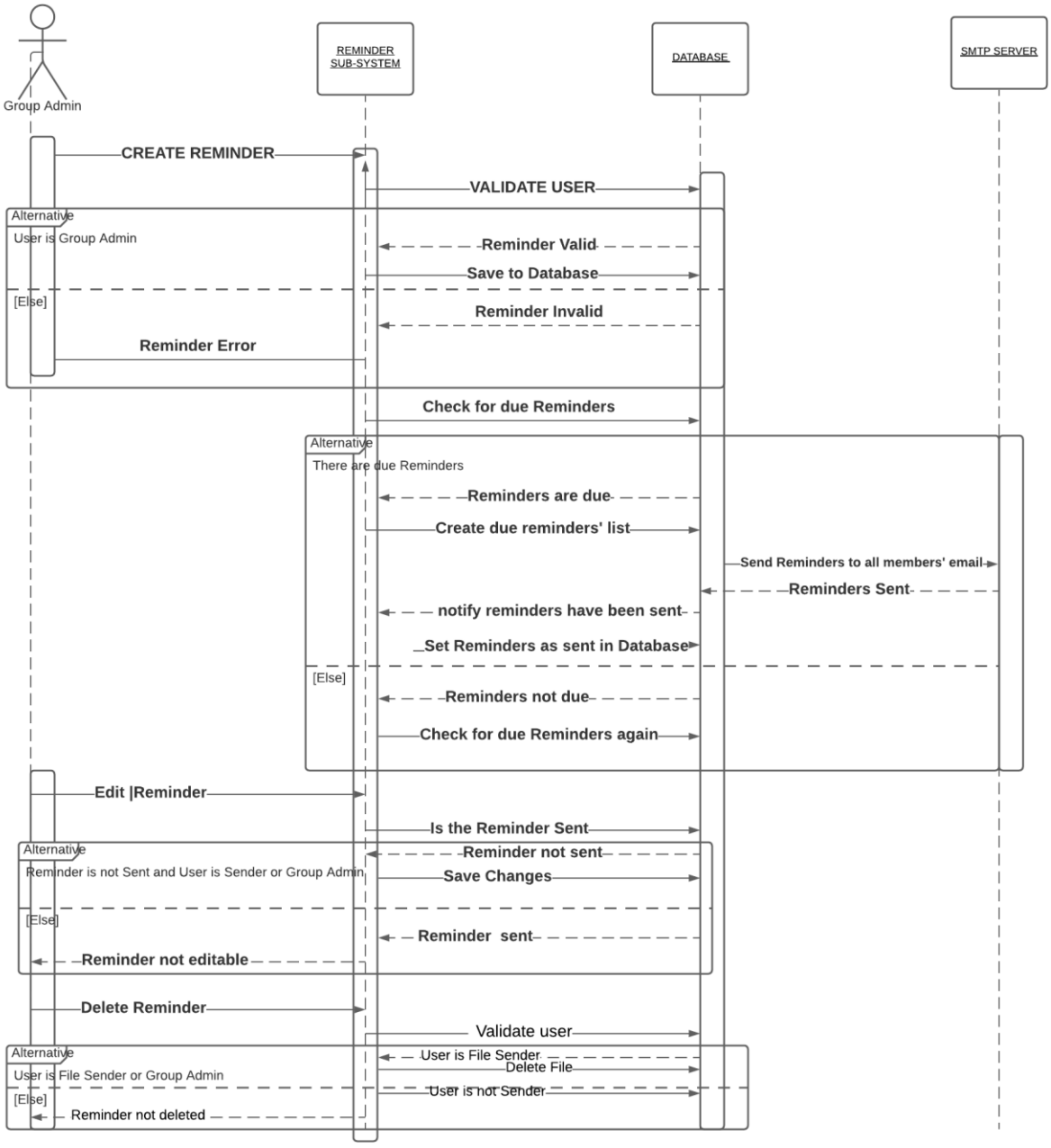

Figure 3. 7: Sequence Diagram of Email Reminder Sub-System (Admin)

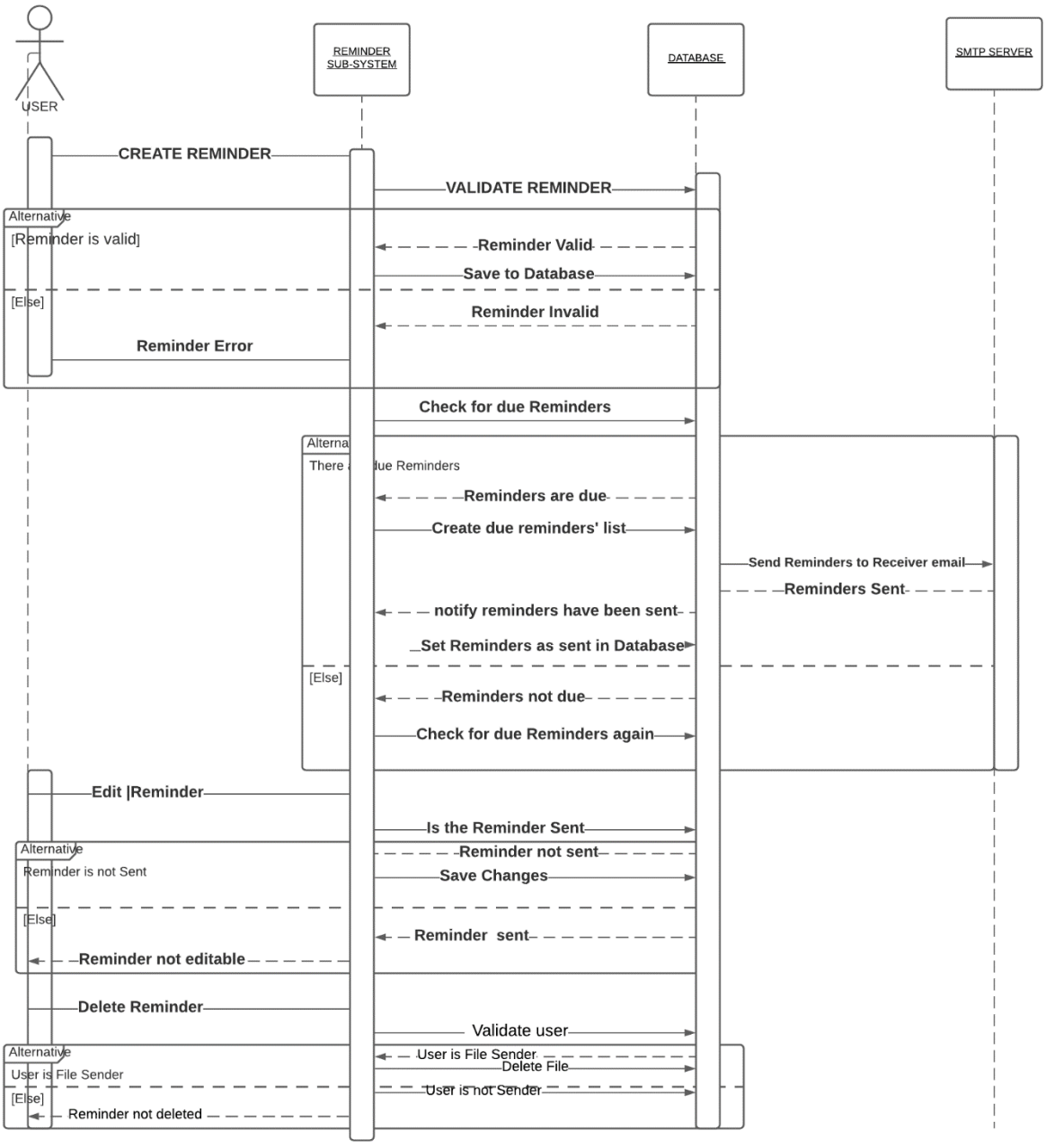

Figure 3.8: Sequence Diagram of Email Reminder Sub-System

3.4.5 The File Sharing Sub-System

The file sharing sub-system main function is to allow the users to send files of any type and format to their group. As shown in the flow-chart Figure 3.9; Each file sent to the group is stored in the database as an equivalent byte file along with some other details to uniquely identify each file that has been sent. The file can then be accessed by every member of the group who can view or download the file.

When the file is to be viewed or downloaded; the system converts the file from the byte format back to its original format and the file is then viewed or downloaded for the intending viewer; Each file sent to the group is protected from external influence from other group members, as only the group-leader and the member who sent the file are allowed to delete the file once it has been saved into the database

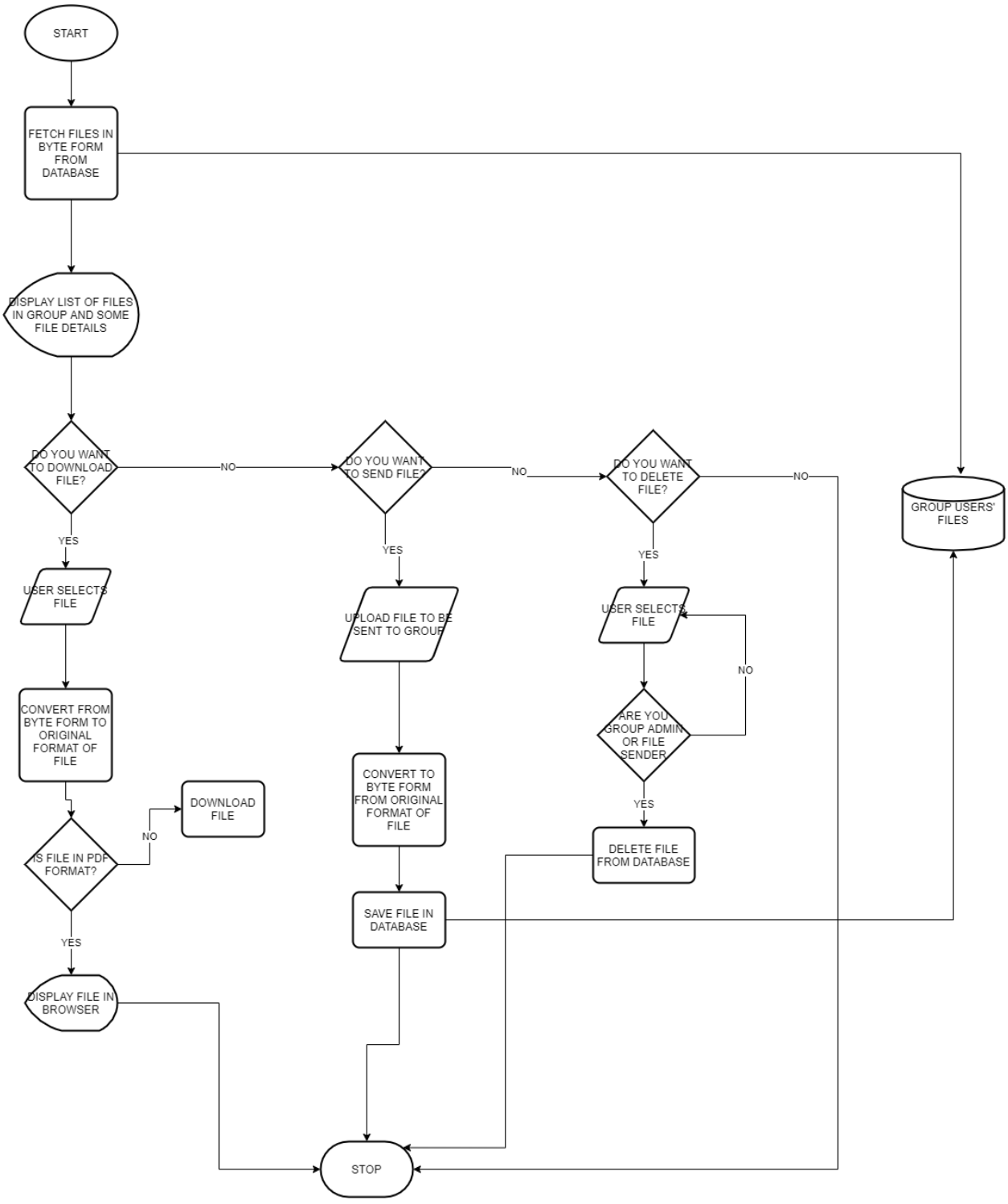

Figure 3.9: Flow Chart Diagram of File-Sharing Sub-System

3.4.6 Use-Case and Sequence Diagram for File Sharing Sub-System

The use-case digram in Figure 3.10 shows the diagrammatic representation of the group members and group admin's interaction with the system by showing operations that each kind of user can perform. Every user can send and download any file within their group but can only delete the files that they themselves sent. Each group admin is also a user and can also perform every operation a user can perform but with added privilegde of being able to indiscriminately delete any file of their choice

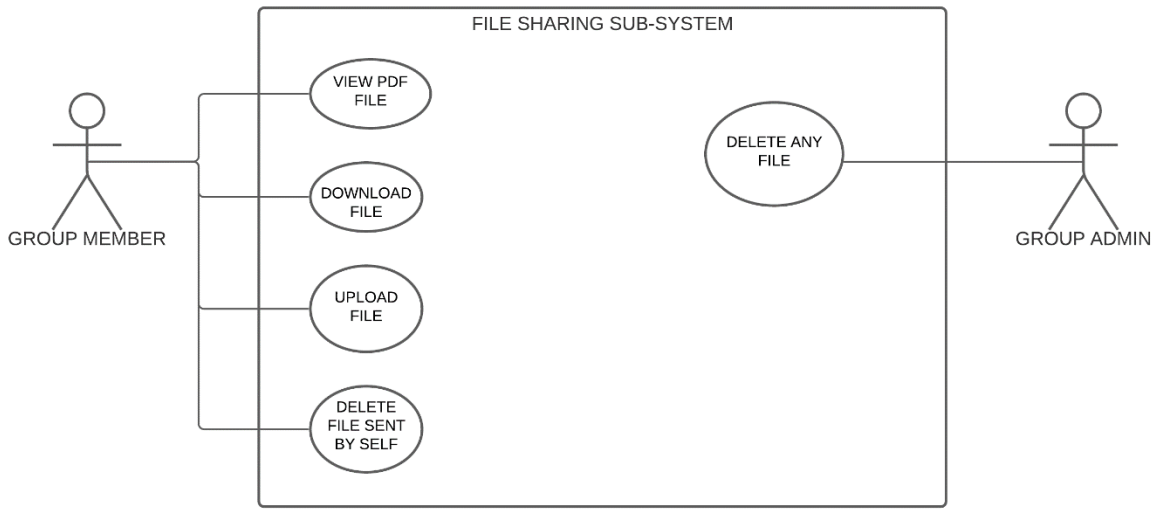

Figure 3.10: Use-Case Diagram of File-Sharing Sub-System

The Sequence diagrams in Figure 3.11 is a simple diagrammatic representation of the various interactions in the file-sharing sub-system and how operations are carried out. The group user interacts with the sub-system which interacts with the database to save, edit, retrieve files for download and also delete the files. Special interactions exist between file senders or group administrators and files

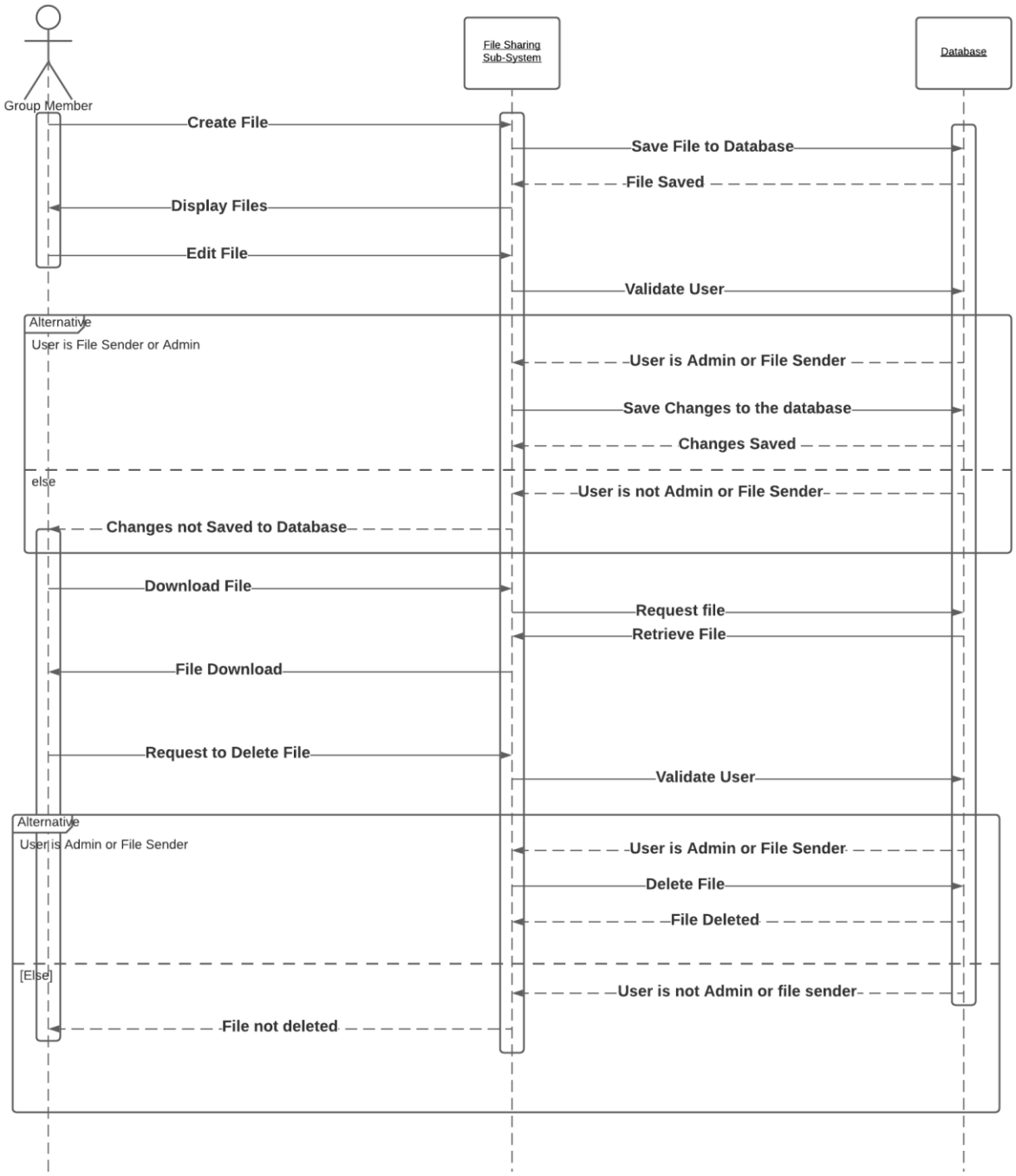

Figure 3.11: Sequence Diagram of File-Sharing Sub-System

3.4.7 The Text Messaging Sub-System

The main function of this sub-system is to enable text communication among group members. This system makes use of Real-time Web Communication Protocol to enable easy communication amongst group members, in that, every message sent from one member to another doesn't need to be refreshed before it can be accessed. The Real-time web communication protocol enables communication between server and client without the client having to make a call to the server. In this system, the Real-Time Communication Protocol will be implemented through a signaling service known as Signal R.

Signal R connects the client and the server side of the application and allows the text published by a group member to be automatically viewed by all other members unlike the push model which still requires the client to make the initial request. Signal R uses WebSockets, Server-sent events and long pulling to help the client and server communicate; It selects the best path for the communication and chooses that to enable the communication

The flow chart in Figure 3.12 shows that: each time a group member sends a text, it is automatically saved to the database and then sent to all the members of the group so members who were not present at that time can easily scroll up ahead and view what was discussed in their absence

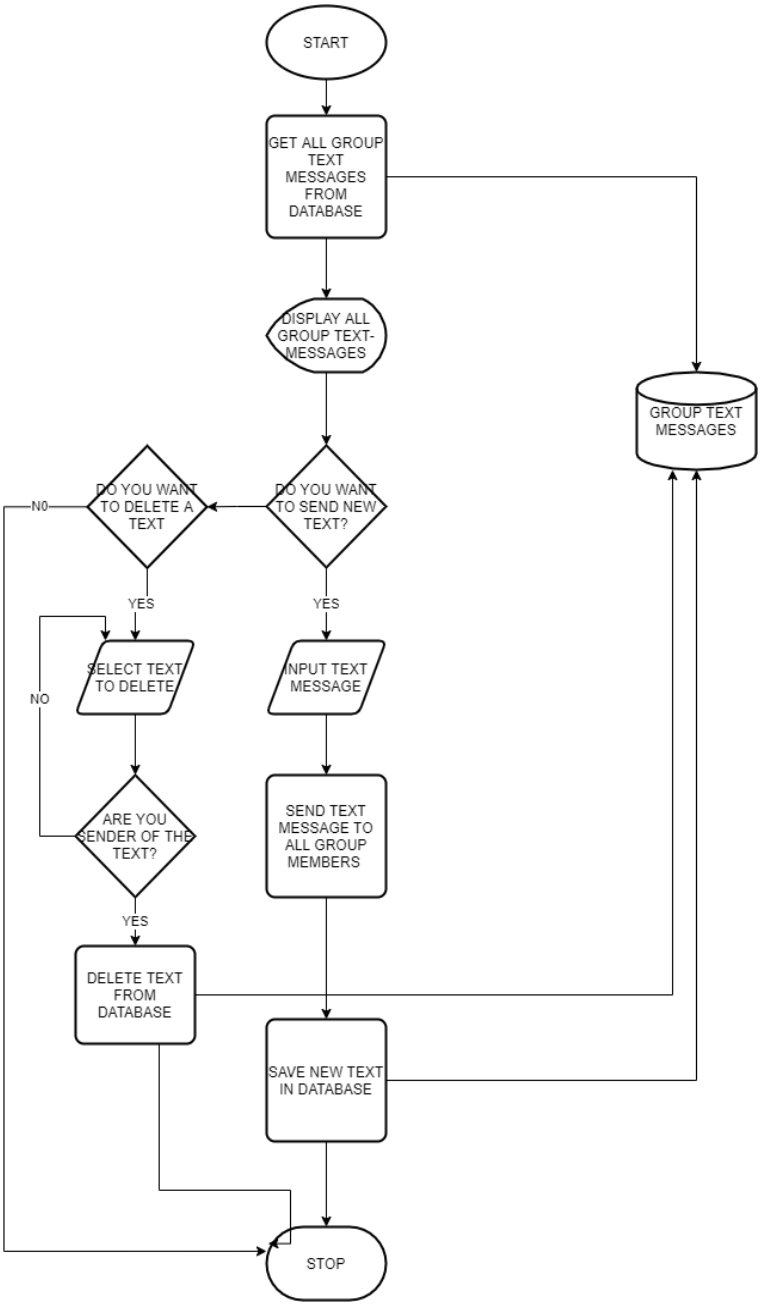

Figure 3.12: Flow Chart Diagram of Text-Messaging Sub-System

3.4.8 Use-Case and Sequence Diagram for Text-messaging Sub-System

The figure 3.13 represents the users of the sub-system and the operations that can be carried out by every type of user. Unlike other sub-systems where the Group Admin has special privileges, the text-messaging sub-system doesn't give such. The admin is like every other user; capable of

sending texts, viewing their text messages and the messages sent by other group members and deleting their own texts

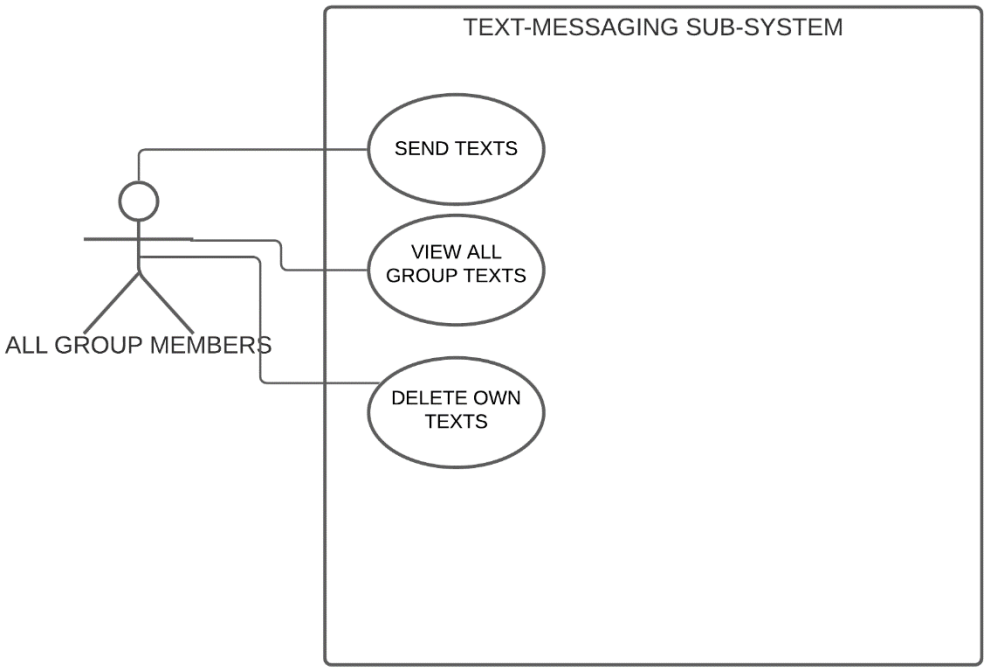

Figure 3.13: Use-Case diagram for Text-Messaging Sub-System

The Sequence diagrams in Figure 3.14 is a simple diagrammatic representation of the various interactions in the text-messaging sub-system and how operations are carried out. The group user interacts with the system which interacts with the database. Users of all categories within the group can sent valid text messages and view all text messages previously sent as well

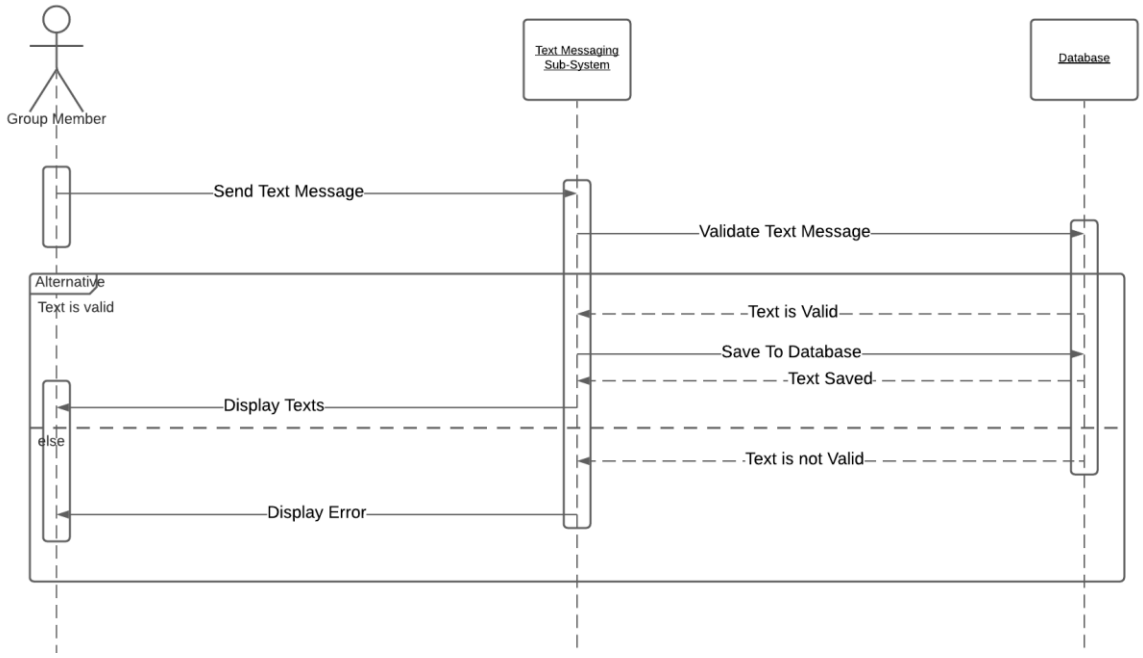

Figure 3.14: Use-Case diagram for Text-Messaging Sub-System

3.4.9 The Audio and Voice Conferencing Sub-System

The Audio and Voice communication sub-system's function is to allow group audio and voice calling and communication between the group members of created groups using SFU topology of WebRTC

As shown by the flowchart in Figure 3.15; Any one of the members of the group can start an audio or video call and all members who are currently online are free to either join or leave the call. However, once an Audio conference has been started, a video conference cannot take place and vice versa. When all the members of the group leave a call then the call is ended, also the group leader has the privilege of ending any Audio or Voice call even when members are still on the call

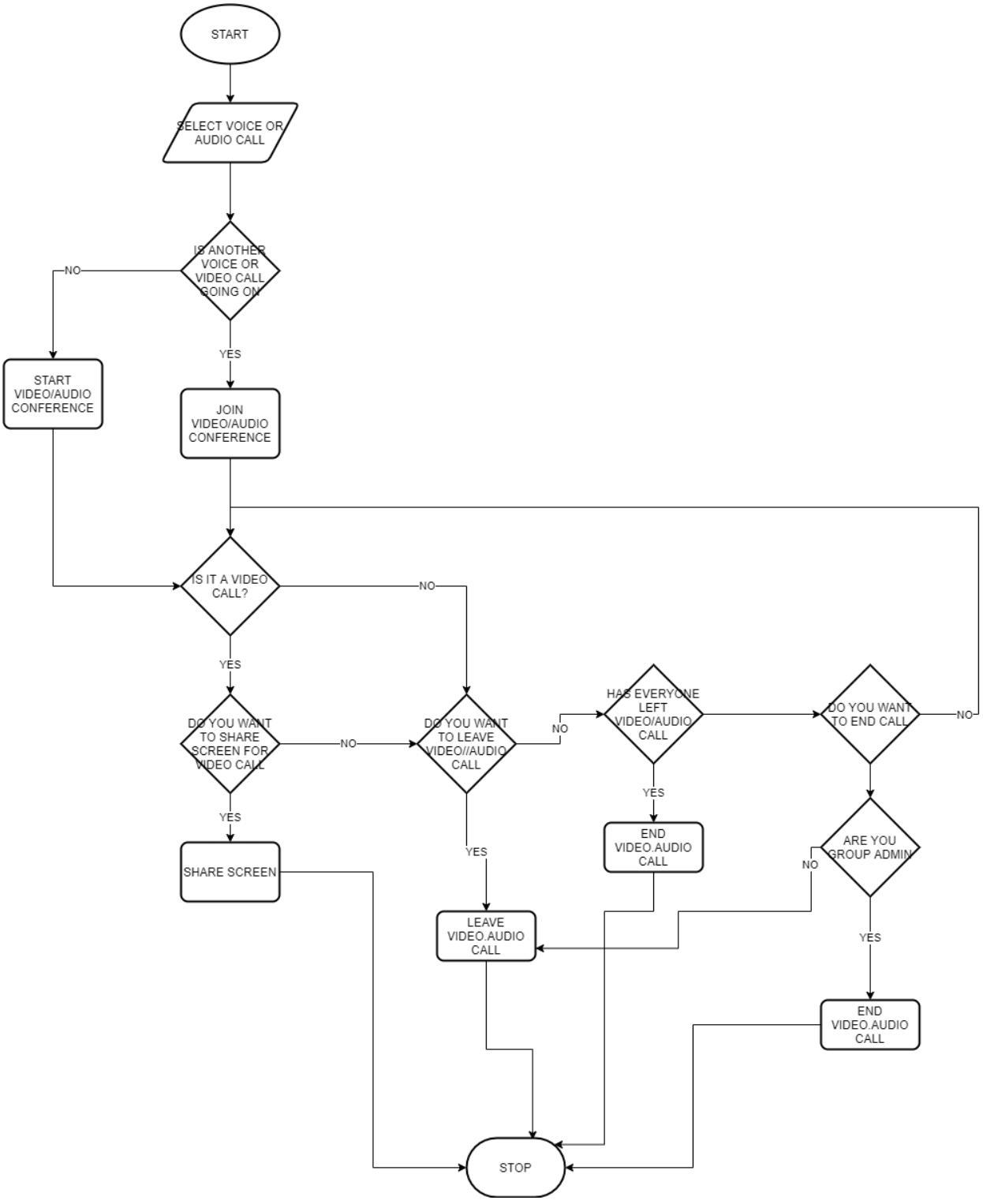

Figure 3.15: Flow-Chart diagram for Audio and Video Calling Sub -System

3.4.10 Use-Case and Sequence Diagram for Video and Audio-Conferencing sub-system

The use-case diagram in Figure 3.16 diagrammatically represents the operations that all group members and the group-admin can perform in the audio and video sub-system. While observing that the group-admin's only special privilege is to end the call even with other group members still in it; it is also important to remember that the group-admin is a group member as well and can perform all the operations a group member can such as: Starting a video or audio call, joining a video or audio call, sharing their screen and leaving the call.

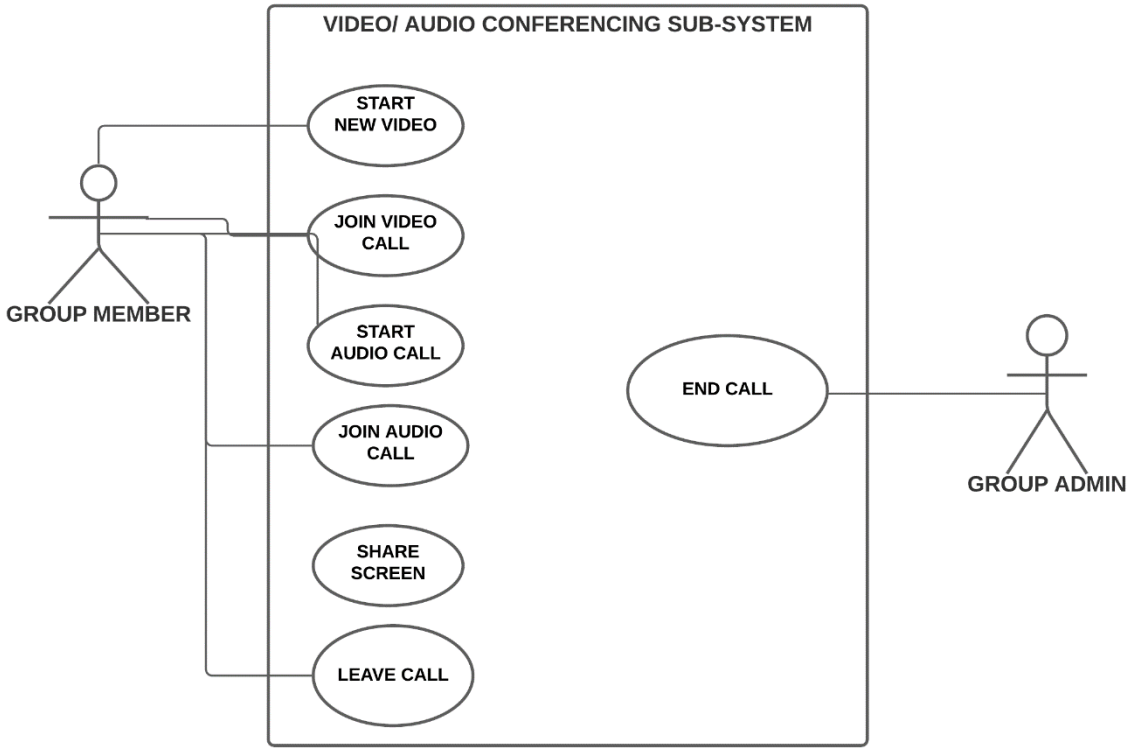

Figure 3.16: Use-Case Diagram of Audio and Video Calling Sub-System

The Sequence diagrams in Figure 3.17 and Figure 3.18 is a simple diagrammatic representation of the various interactions in the audio and video calling sub-system and how operations are carried out. Figure 3.17 represents the sequence of events for the audio calling sub-system, where users can start, join, mute or leave calls; and Figure 3.18 represent the sequence of events for video calling sub-system where users can start, join, mute, stop camera, screen share or leave calls. For both aspects of the sub-system the group administrator has a special interaction that allows them to end the call for all users connected

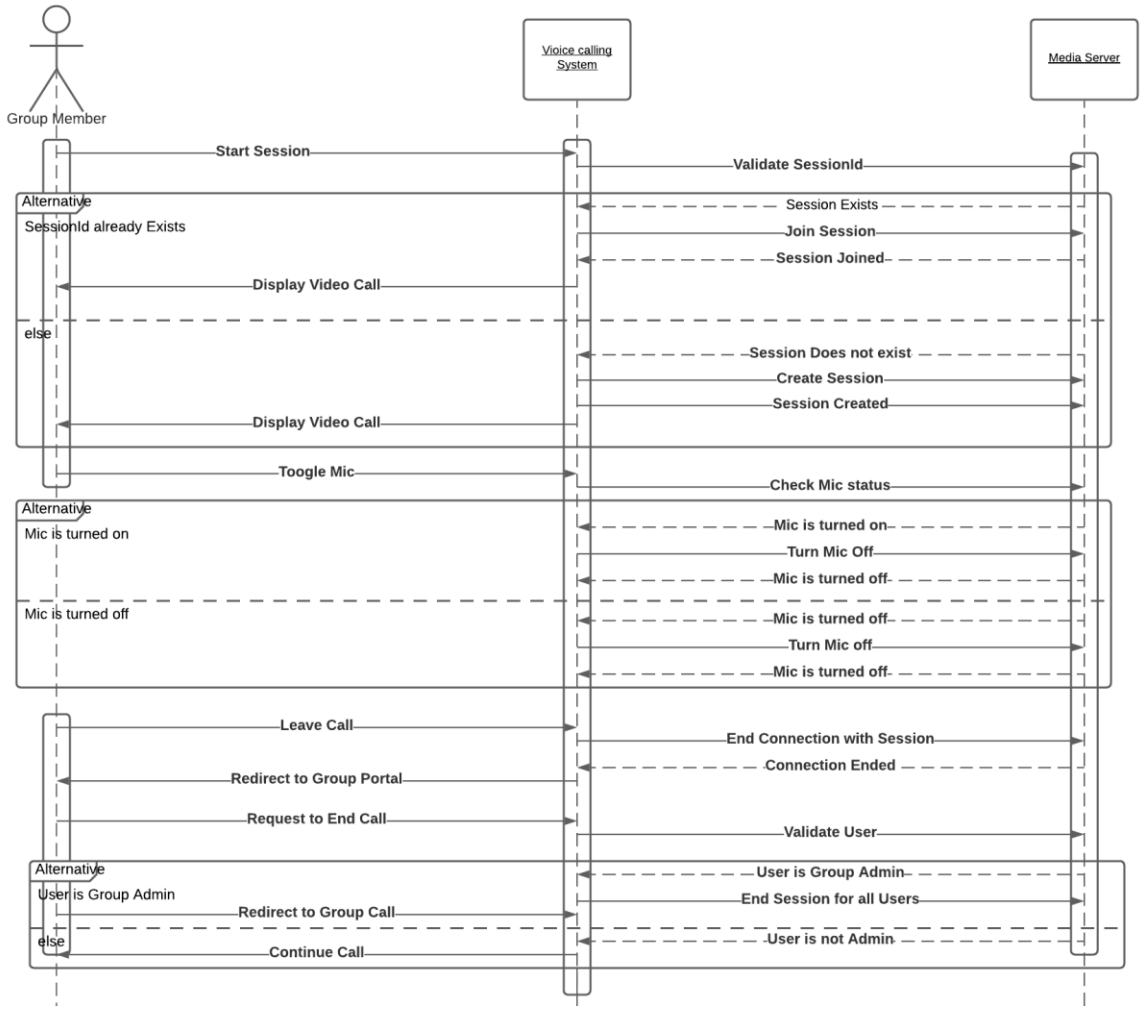

Figure 3.17: Sequence Diagram of Audio Calling Sub-System

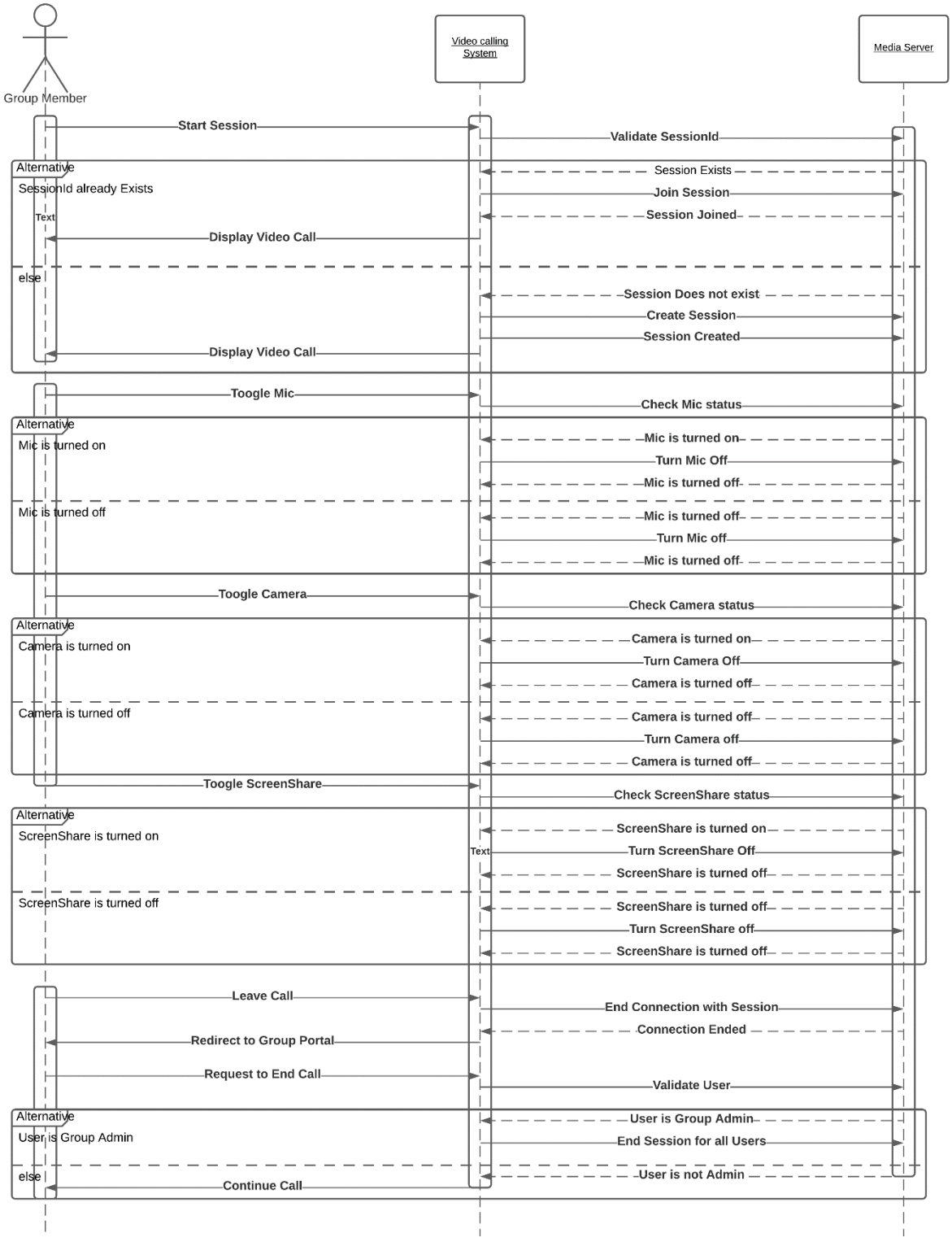

Figure 3.18: Sequence Diagram of Video Calling Sub-System

3.4.11 Overall System Use-Case Diagram

Taking into consideration all the different operations shown in the use-cases of each sub-system; the Use-case diagram in Figure 3.19 shows the operations of the users and Group admin in the system. It diagrammatically represents all the privileges a group Admin has above a regular user but also highlights the functions that users can carry out in the system. It is also important to remember that in this system, a group admin is also a user and can perform all the operations a regular user can

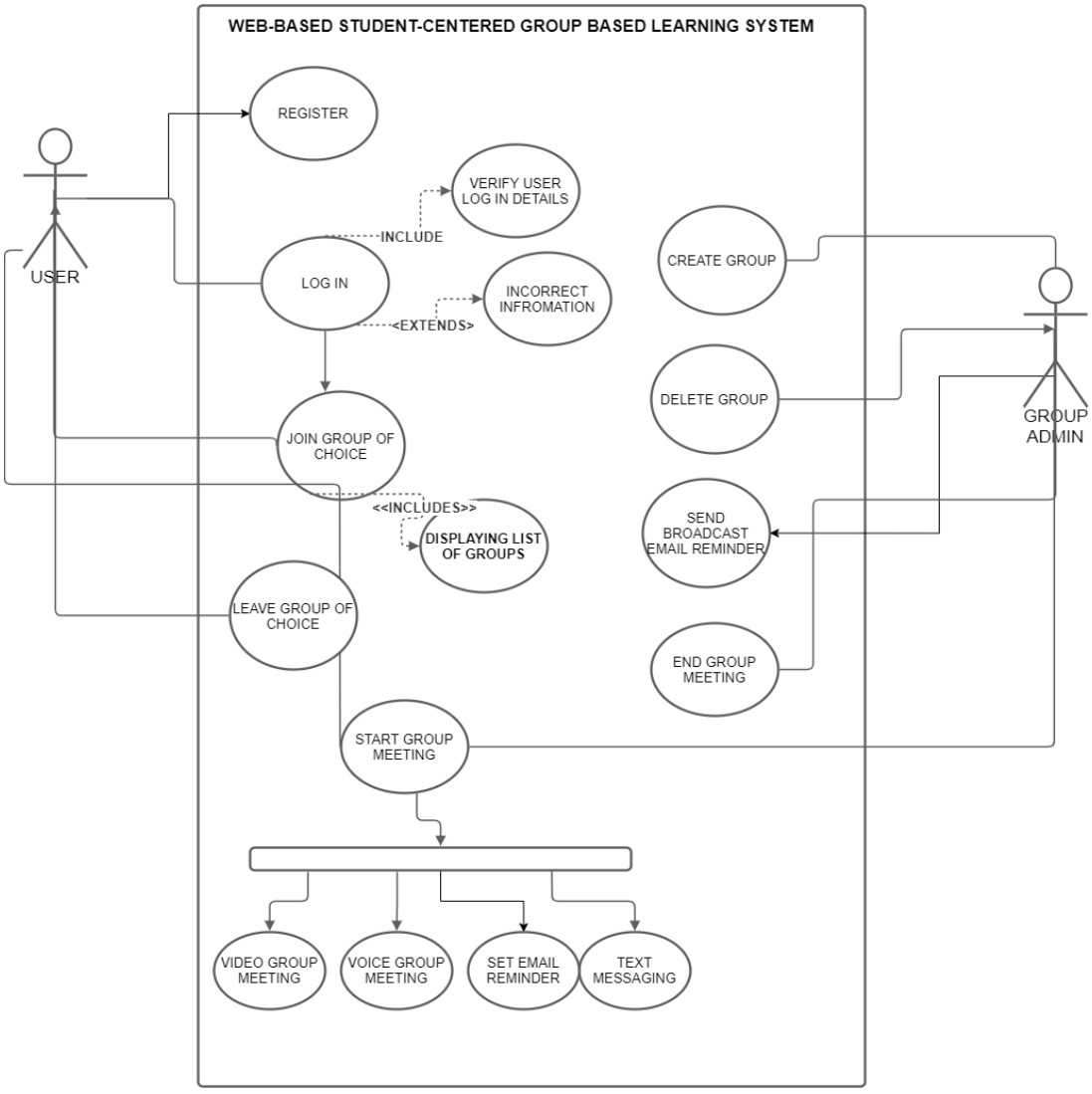

Figure 3.19: Use-case Diagram of the Entire system

3.4.12 Overall System Class Diagram

The Figure 3.20 is the class diagram for the overall system. Since the system makes use of the MVC architectural pattern. This diagram structures represents the model-like structure of different aspects of the systems in terms of classes and their relationships between each other. From the Figure 3.20, a user can have zero or more groups, and reminders as well; a group can also have one or many reminders, blocked user relation, documents and texts, but only one video call and only one voice call.

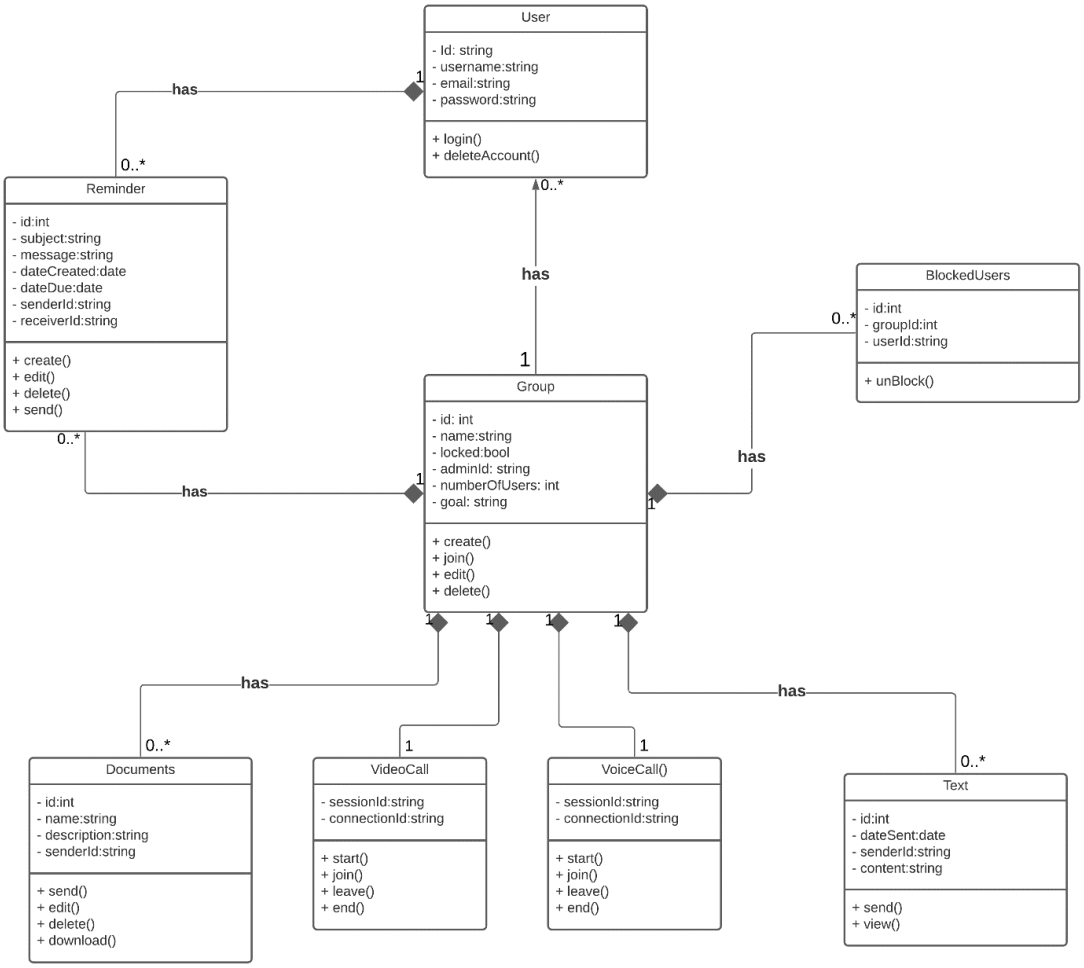

Figure 3.20: Class Diagram of the Entire system

3.5 Overall System Architectural Context Diagram

Now that the system and sub-systems' designs have been thoroughly explained. The Architectural Context Diagram in Figure 3.21 puts the overall system in terms of entities that interact with the software and the nature of interaction

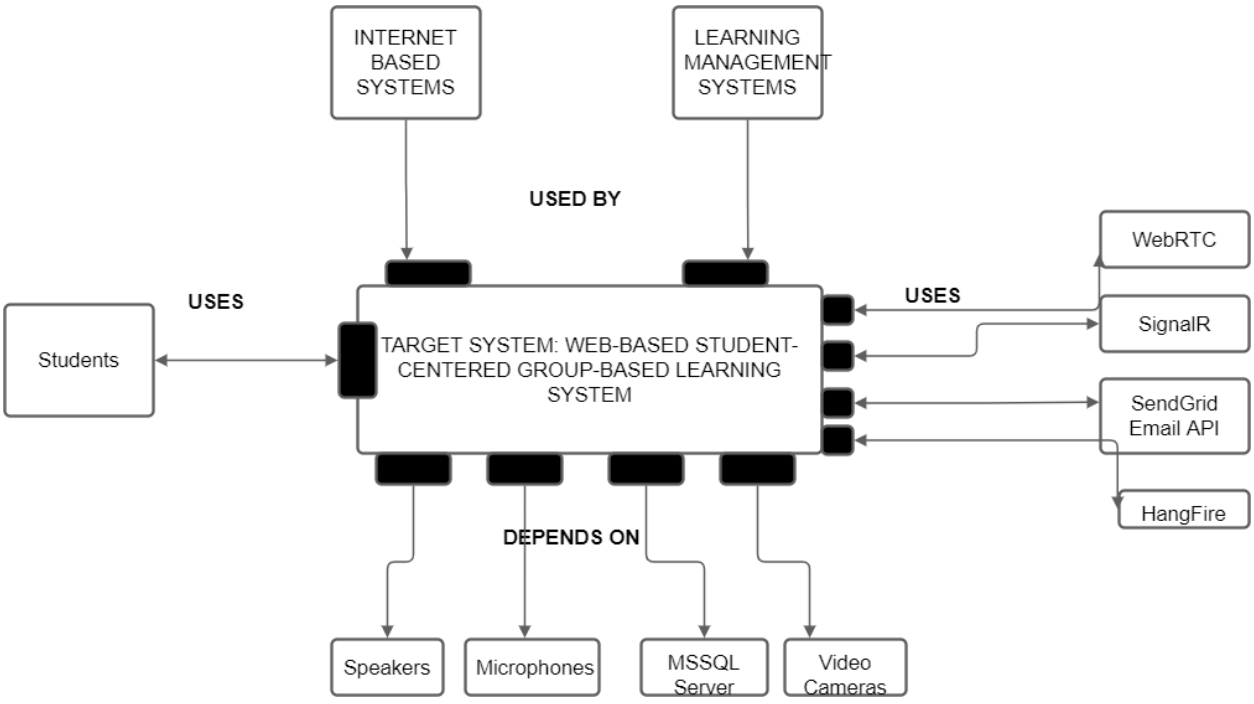

Figure 3.21: Architectural Context Diagram of the entire System

3.5.1 Superordinate Systems:

a) Internet-Based Systems: The Proposed system design is of a web-based system and can therefore be used by other Internet Based Systems specifically internet-based collaboration systems

b) Learning Management System**:** The Proposed system can be adapted into the learning management system of an educational institution to allow easy group learning amongst the students of that particular institution

3.5.2 Subordinate Systems:

a) Speakers: The proposed system design describes a video and audio calling sub-system and will therefore require the need of a properly working speaker for the system to work to its full potential

b) Microphones: In order for the Audio and Video calling sub-systems to properly function, the system requires microphones for the transmission of audio data across the members of a group currently engaging in a call

c) MSSQL Server: The proposed system makes use of a database and therefore depends on a database management system to effectively structure and manage all the data and information shared between groups

d) Video Cameras**:** The proposed system depends on properly functioning video cameras to transmit the video stream of users when using the video calling sub-system

3.5.3 Peers:

a) WebRTC: The proposed system uses WebRTC for real time web communication in the audio and video calling sub-systems. It allows the transmission of data between users that are connected to each other

b) SignalR: The proposed system uses SignalR as the signaling server for the text-messaging sub-system. This allows the users to instantly receive messages without the need to constantly refresh the sub-system

c) SendGrid Email API: The proposed system uses the SendGrid email API in the email reminder system to send automated emails from the system's database

d) HangFire: The proposed system uses HangFire for background processing to recursively check the database for unsent emails and send them at the appropriate times using the email API

3.5.4 Actors:

a) Students**:** Students are the primary end users and thus interact with the proposed system by registering, creating and joining groups, creating reminders, documents and joining audio and video calls

CHAPTER FOUR

SYSTEM IMPLEMENTATION

Introduction

This chapter presents the implementation of the Student-Centered Group-Based Learning System and describes in detail, the functionalities of the sub-systems and system as a whole

4.1 Software Implementation

The system design was implemented into this system which structures and allows for effective management of studying and project groups amongst students. The design was implemented using C# in the ASP.NET CORE MVC 3.1 frame work; HTML, CSS, BOTSTRAP, Vanilla JavaScript and other forms of JavaScript libraries were used to provide a user-friendly interface at the front end while Microsoft SQL Server served as the database management tool for backend of the system. Other tools and frameworks used for the backend of the system include OpenVidu Media Server, HangFire, SignalR and SendGrid Email API.

The system requires user registration, and email confirmation before a user can access any functionalities. The system has one interface for all classes of users; however, for users who take on the roles of group Admins. They are given administration privileges that only they can access and control within the group they have administration over. The system also consists of four sub systems which manifest as functionalities for users in the overall system, they include: An Email Reminder Sub-System, A File-Sharing Sub-System, Text-Messaging Sub-System, Video and Voice Calling Sub-System.

Once a user registers and logs onto the system, they can change their user information, edit their emails, create personal reminders, groups and join groups. It is within groups that users can then access the other three functionalities as well as set reminders for every member of the group.

4.2 The Log-In Page and Register Page

4.2.1 The Log-In Page

The Log-in page of the system presented in Figure 4.1 is the first page displayed to the users when the system is launched; It possess a small slide show showing various functionalities of the system and a user form to allow users log into the system; buttons are also placed for situations in which users forget their passwords or for intending users to be directed to the home page. Even if users try to access any other web page of the web application without logging into their account, they are automatically redirected to the log in page before they can access any other functionalities

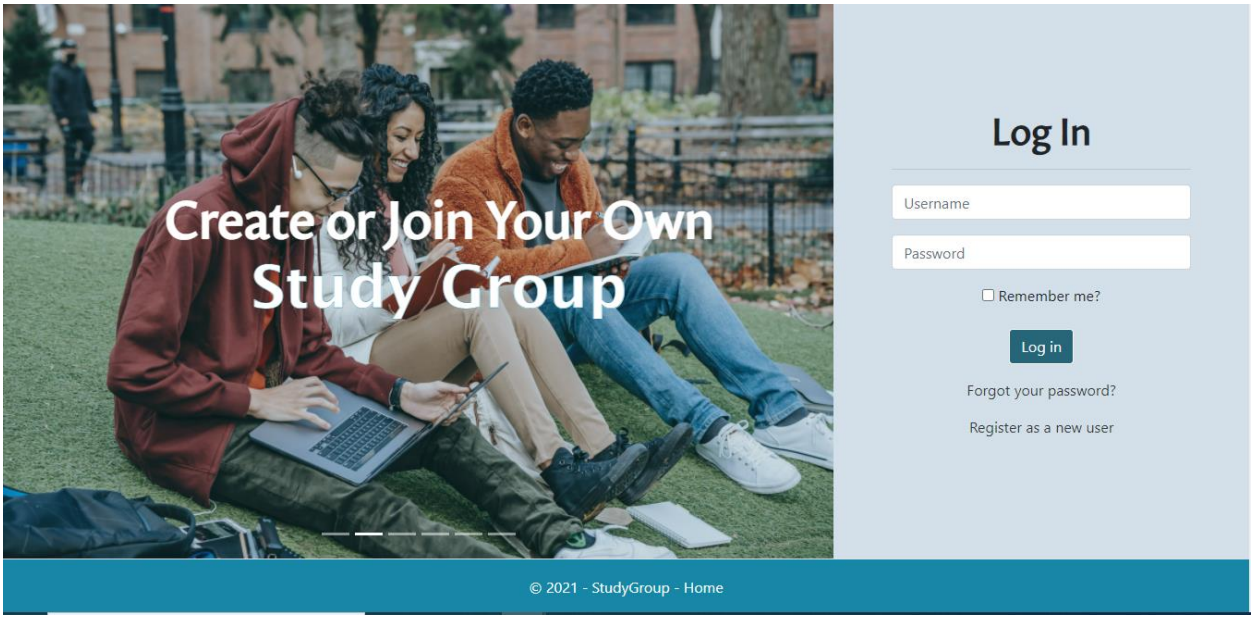

Figure 4.1: Login Page

4.2.2 The Registration Page

For users who do not have an account with the system, they are redirected to the Registration page from the log in page. The registration page shown in the Figure 4.2 also displays a slide show that showcases the system's functionalities and a form to let users either register a new account, or to redirect users back to the log in page.

No two users are allowed to have the same username or email as shown in Figure 4.3. Once a user has been registered successfully with appropriate information, a verification email, as shown in Figure 4.4 and Figure 4.5, is sent to the user's email address along with the verification link which redirects them back to the confirmation page where they can finally click the button to log into the system as shown in Figure 4.6

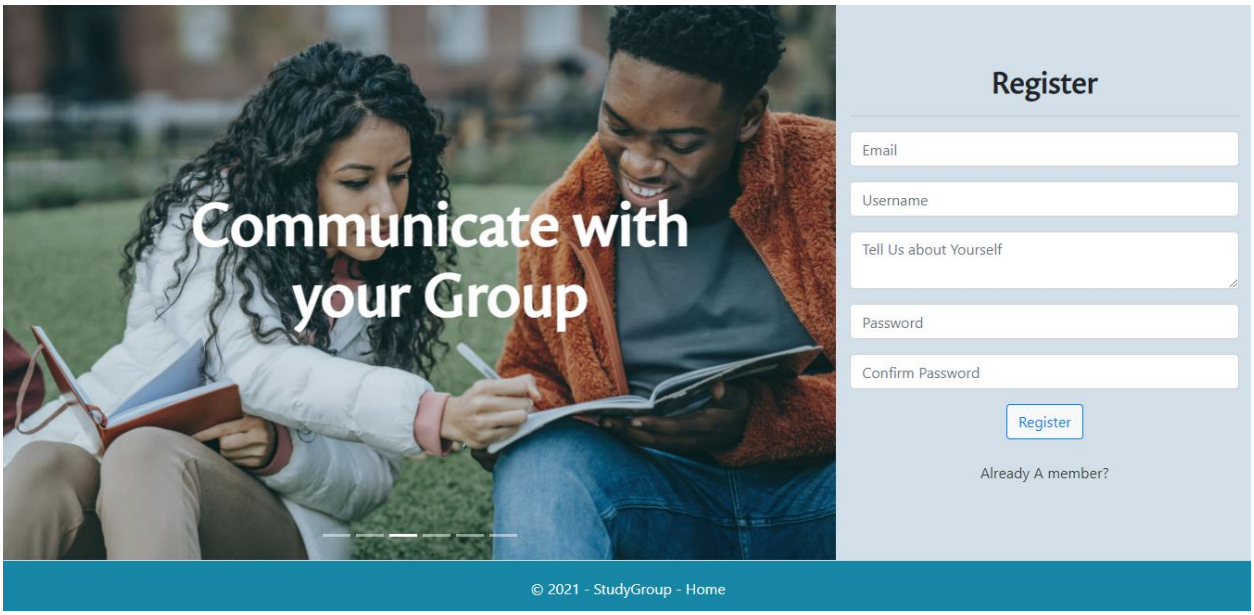

Figure 4.2: Register Page

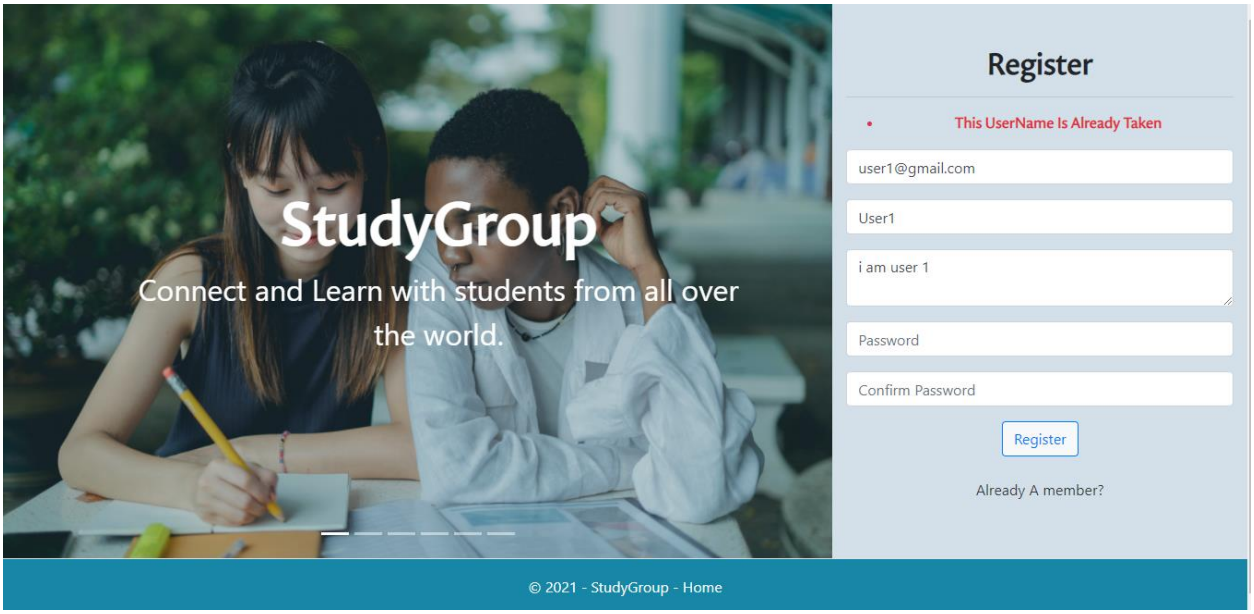

Figure 4. 3: Register Page with Incorrect Values

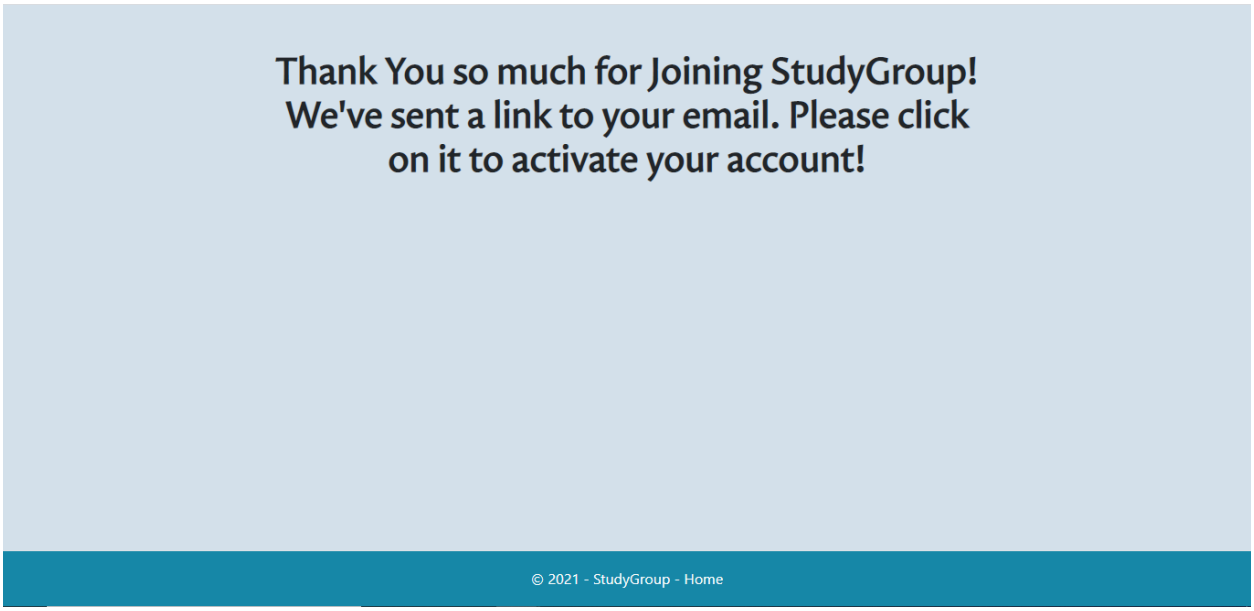

Figure 4.4: Confirmation Link Sent

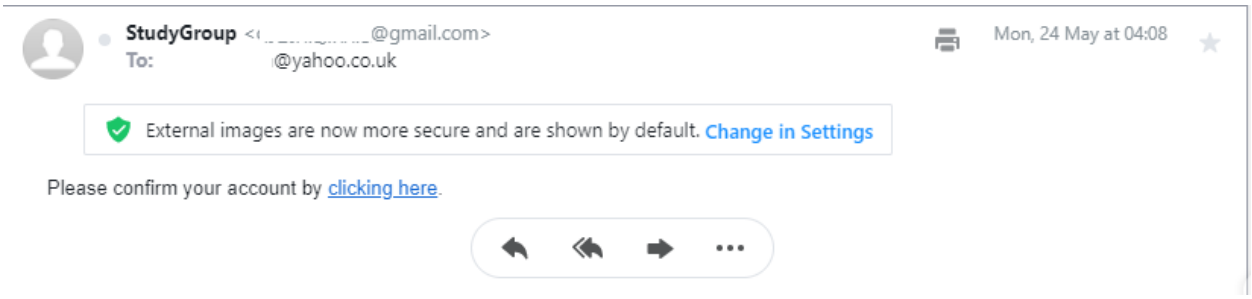

Figure 4.5: Confirmation Link in Email

4.3 The Home Page

The default home page of the system, shown in Figure 4.7, is the user's profile page which displays their username, bio information and a button that redirects them to the manage profile page where they can make changes to their account. The home page also displays all the personal reminders for the user, as well as all the groups that the user belongs to and allows them to enter the group portal from here.

This page also has buttons for creating new groups, as shown in Figure 4.10, a button that redirects users to browse available groups created by other users. It also has buttons to allow users create personal email reminders, edit and even delete these personal reminders as shown in Figure 4.8 and Figure 4.9. It is default page and can be accessed from clicking the user's name on the navigation bar, the 'StudyGroup' navigation bar brand-sign or the home link on the footer

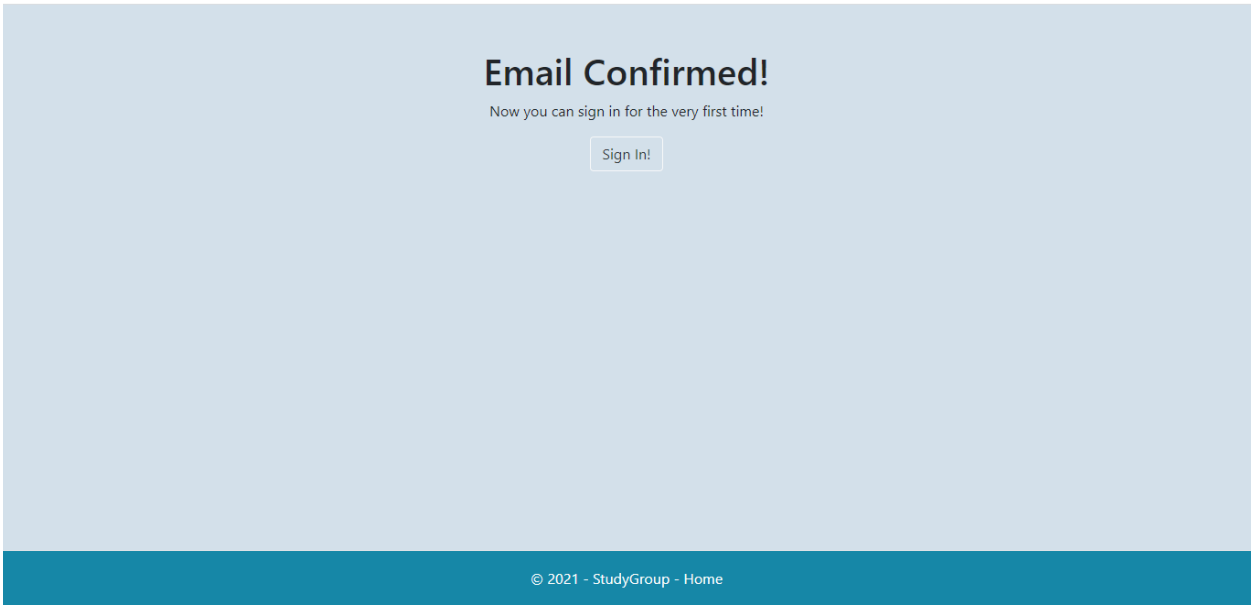

Figure 4.6: Register Page after Email Confirmation

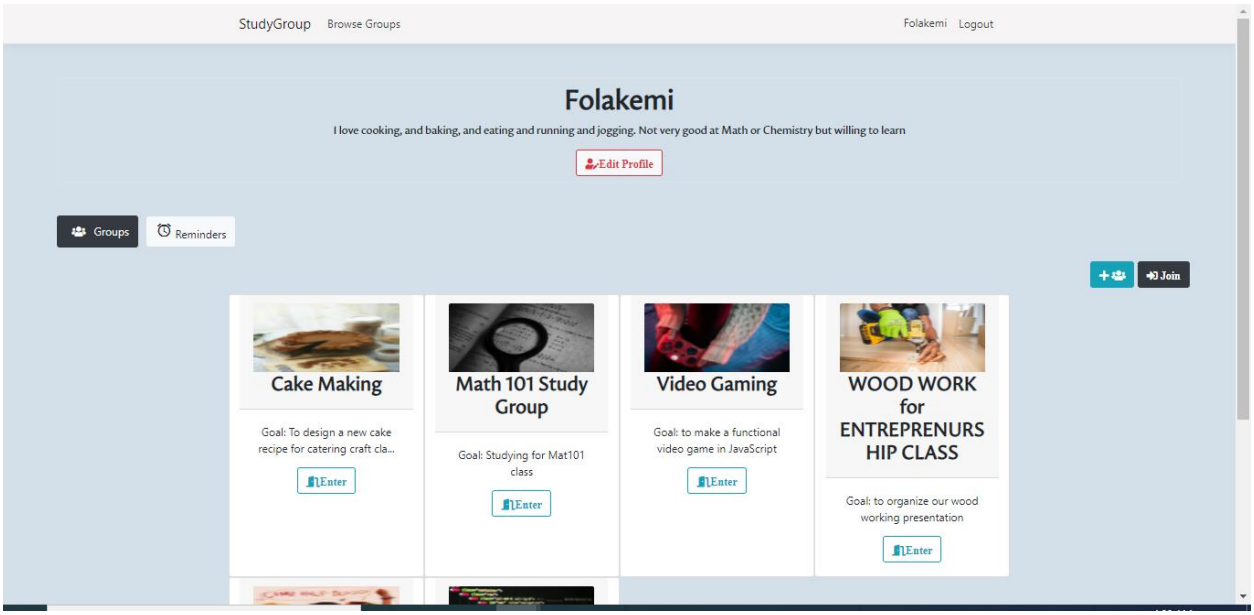

Figure 4.7: Home Page (Group List) For User with Groups

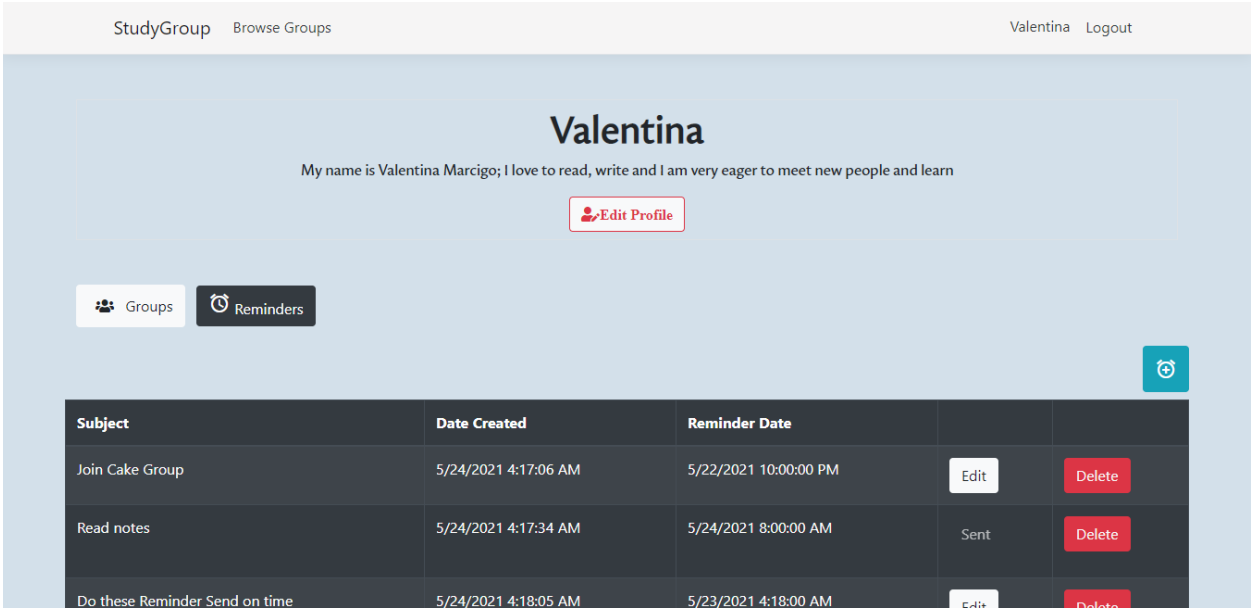

Figure 4.8: Home Page (Reminder List) For User with Reminders

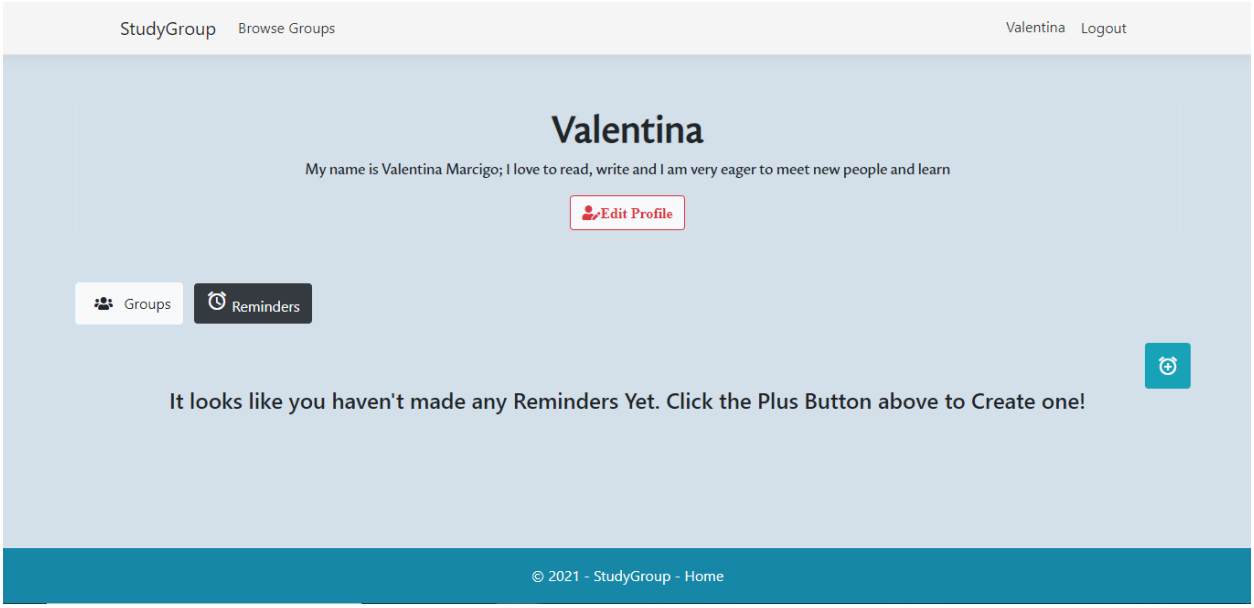

Figure 4.9: Home Page (Reminder List) For User without Reminders

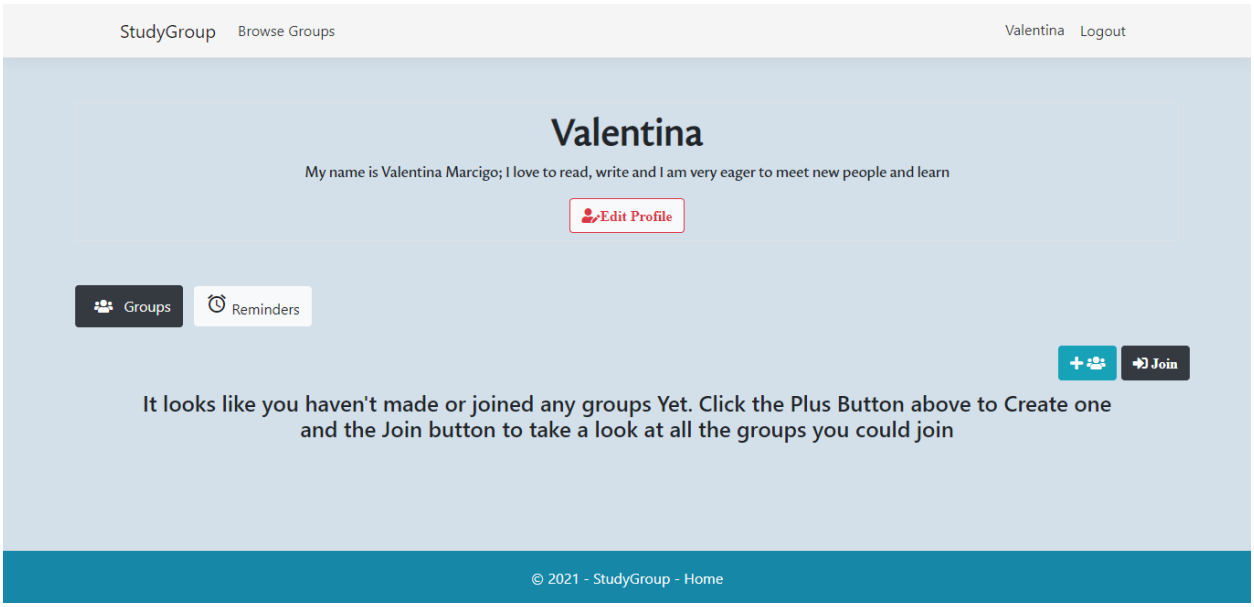

Figure 4.10: Home Page (Group List) For User without Groups

4.3.1 The Manage User-Profile pages

These are a series of interconnected web pages with a special navigation bar that allows users to edit their username and Bio, as well as their Email and even to delete their account. The Figures: 4.11, 4.12, 4.13 and 4.14 show these different pages

4.3.2 The Group-Creation Page

As show in Figure 4.15, this page allows users to create their own groups, define the group's goal, description and even an image for group identification can be created

4.3.3 The Personal-Reminder Creation Page

As show in Figure 4.16, this page allows users to create their own reminders, define the reminder's subject, message and time

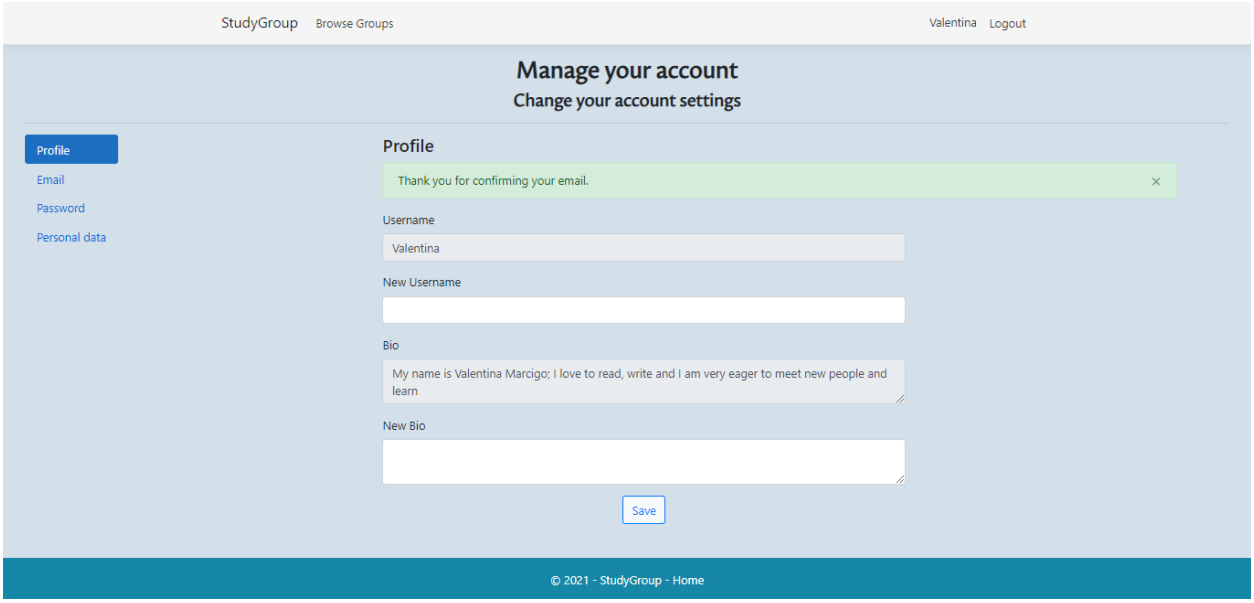

Figure 4.11: Manage Account Page (Username and Bio)

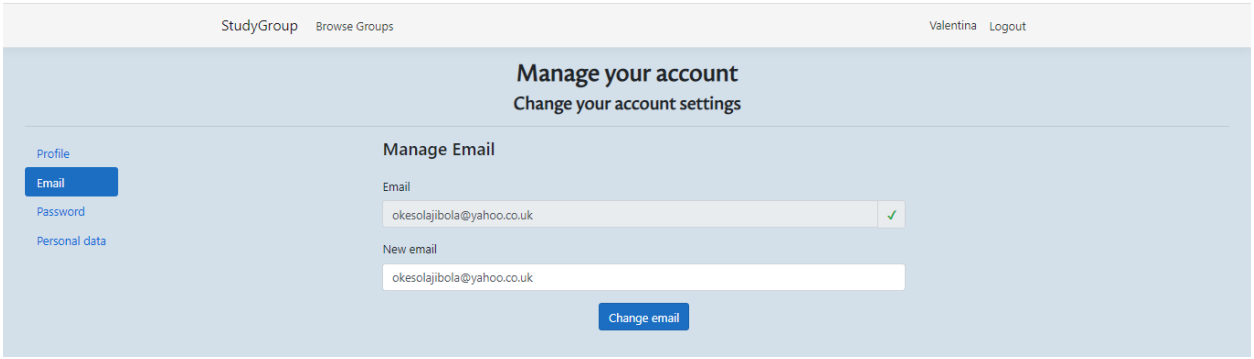

Figure 4.12: Manage Account Page (Email)

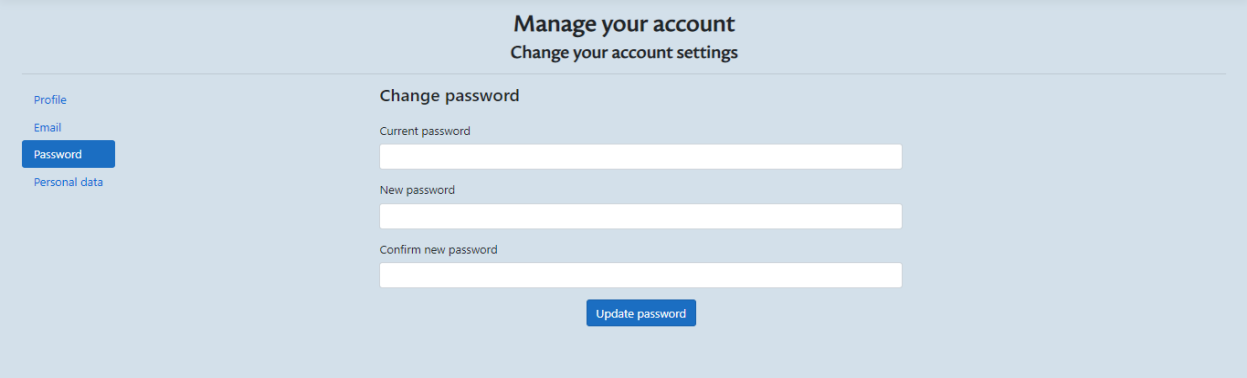

Figure 4.13: Manage Account Page (Password)

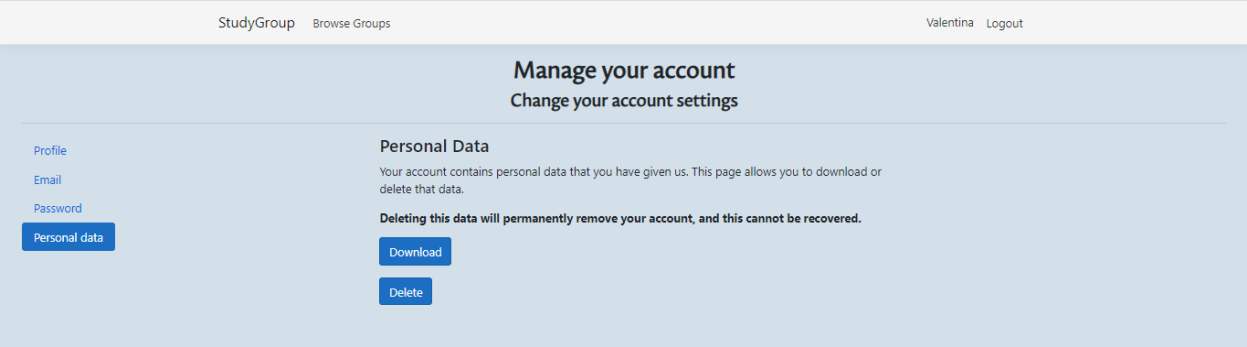

Figure 4.14: Manage Account Page (Delete Account)

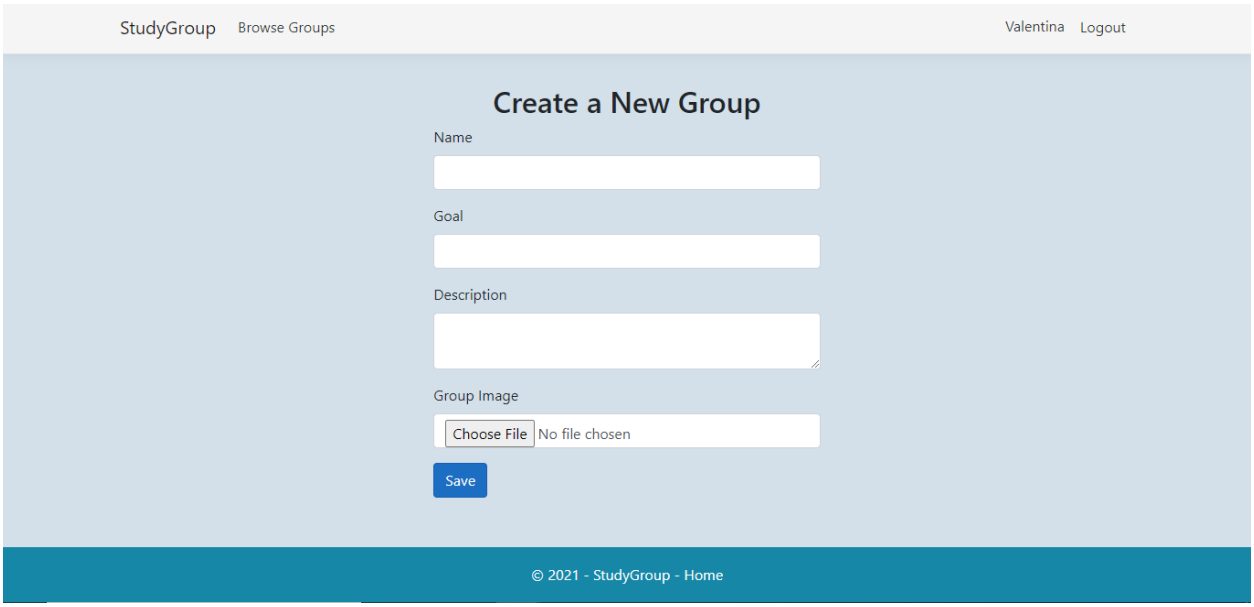

Figure 4.15: Group Creation Page

4.3.4 The Browse-Group Page

This page, shown in Figure 4.17 can be accessed from both the home page and the nav-bar link 'browse-groups'. It shows a list of all the groups that the user does not currently belong to and allows the user to view the group's image goal and description before joining the group as shown in Figure 4.18. If a group is open to new users or the current user is not blocked from the group, the user will be automatically allowed into the group portal and that group will be added to the user's home page. However, if the user has been blocked from that group or the group no longer accepts members, the user will be promptly notified and redirected back to browse for other groups to join as shown in Figure 4.19

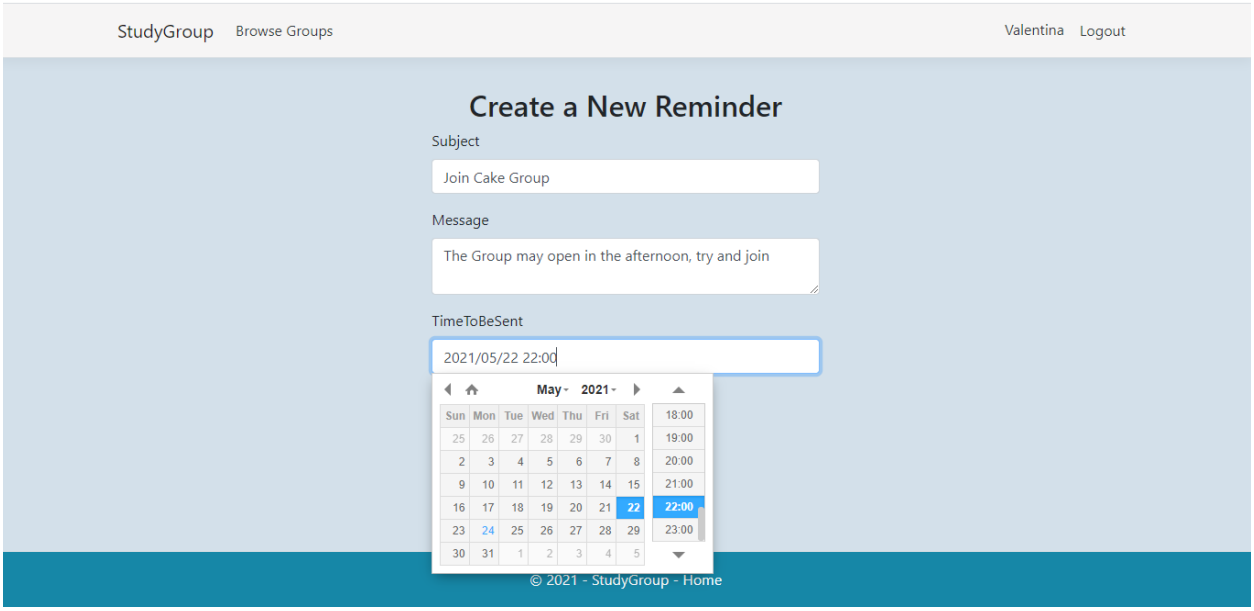

Figure 4.16: Personal Reminder Creation Page

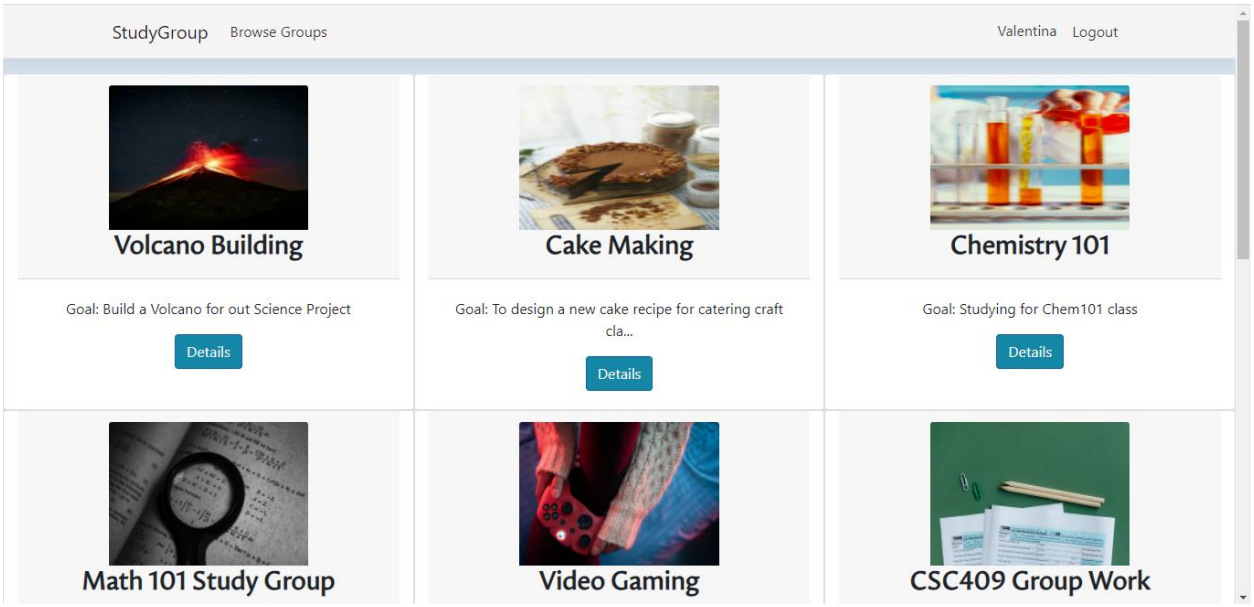

Figure 4.17: Browse Group Page

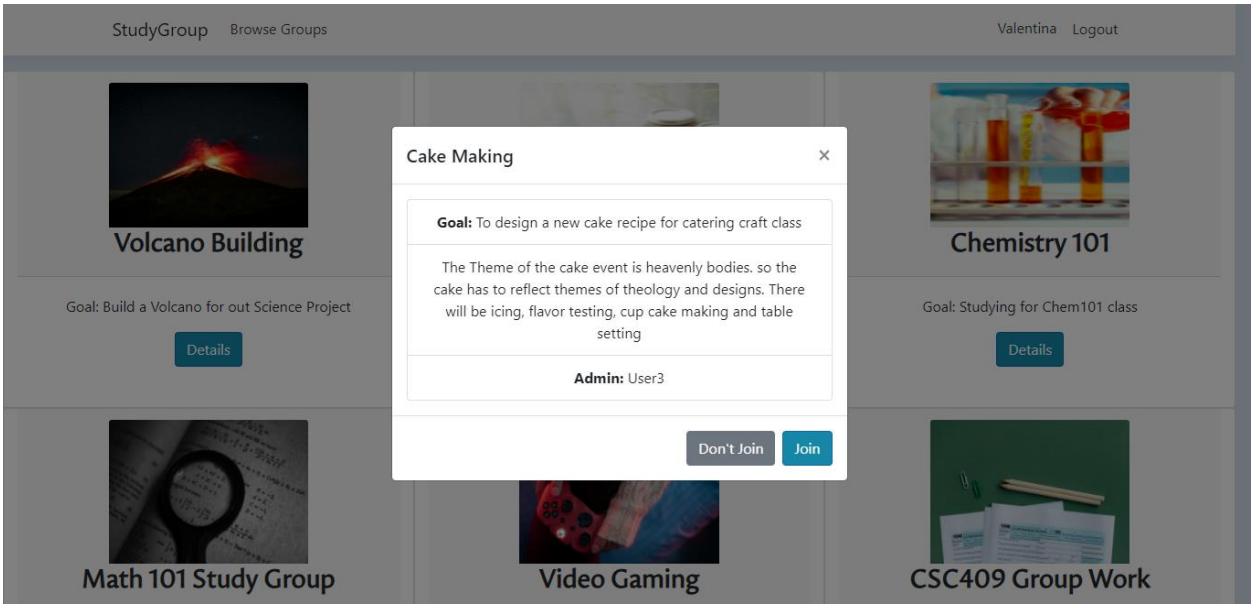

Figure 4.18: Browse Group Page When User Clicks a Group

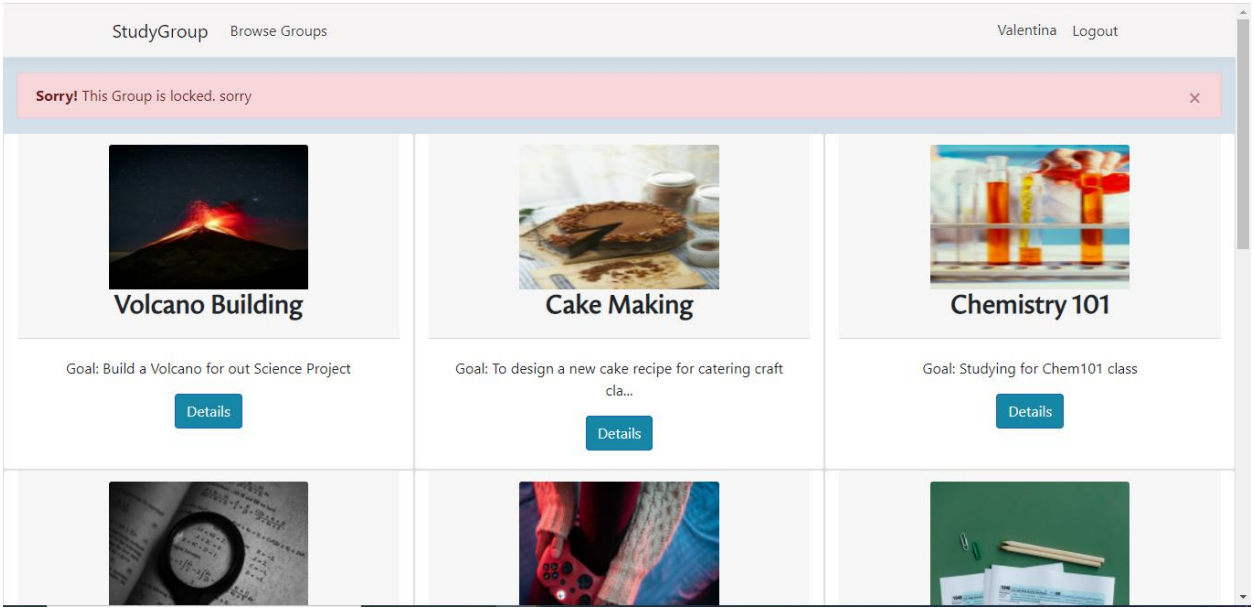

Figure 4.19: Browse Group Page When Group Selected is Locked

4.4 The Group Portal

Once a user clicks the ‘enter’ button for a group in their home page, shown in Figure 4.20 and Figure 4.21. They are immediately taken to the group portal where they harness the full extent of the system. The Group’s Home page displays the Group’s image, all the group members, all the members who are blocked from the users, and a side navigation bar which allows the users to access the functions of the groups.

The side navigation bar has functionalities for text-messaging, group video and audio calling, sending of documents; however, the group administrator can access functionalities to edit the group and the group-reminder functionalities from the side navigation bar

The Home page also has a ‘Leave’ button for group members who want to leave the group; however, for group administrators, they have the privileged of blocking any user who has joined the group, of locking the group from new users or delete the group which will immediately remove all users from the group and delete all the group’s files, reminders and information.

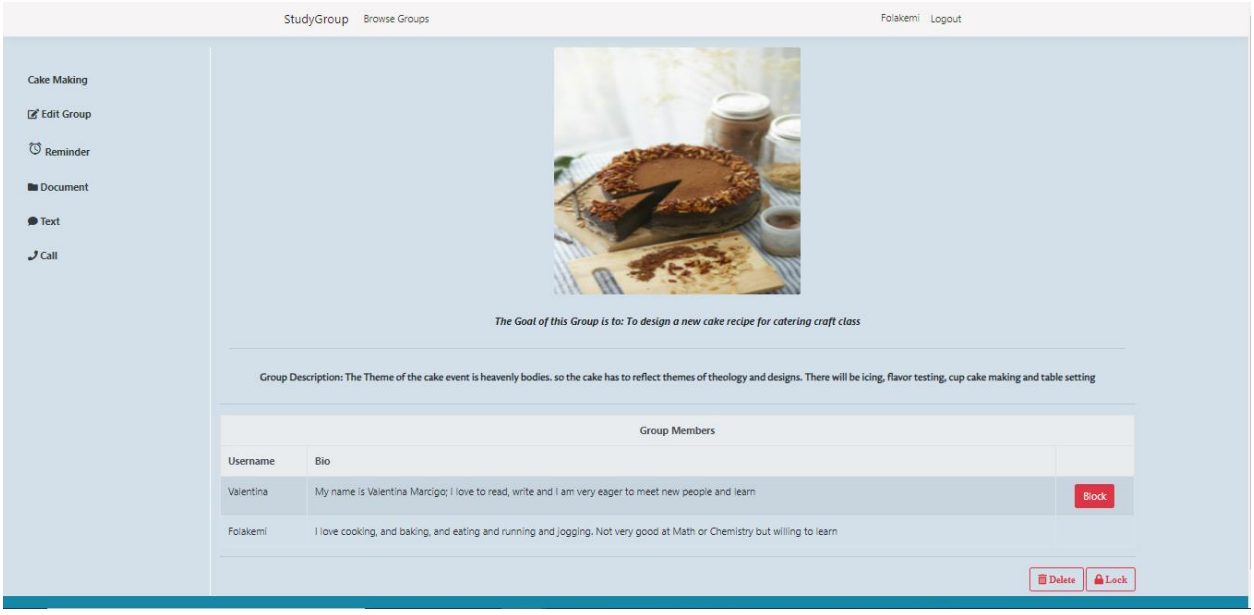

Figure 4.20: Group Portal (Group Admin View)

4.4.1 The Group-Editing Page

Group administrators are given access to this page, shown in Figure 4.22 and can change the name, goal, description and even the group image easily; however, if no changes are made, the system will prompt the administrator to make changes before moving forward. The group administrator can easily navigate back to the group's home page by clicking the group's name on the side navigation bar

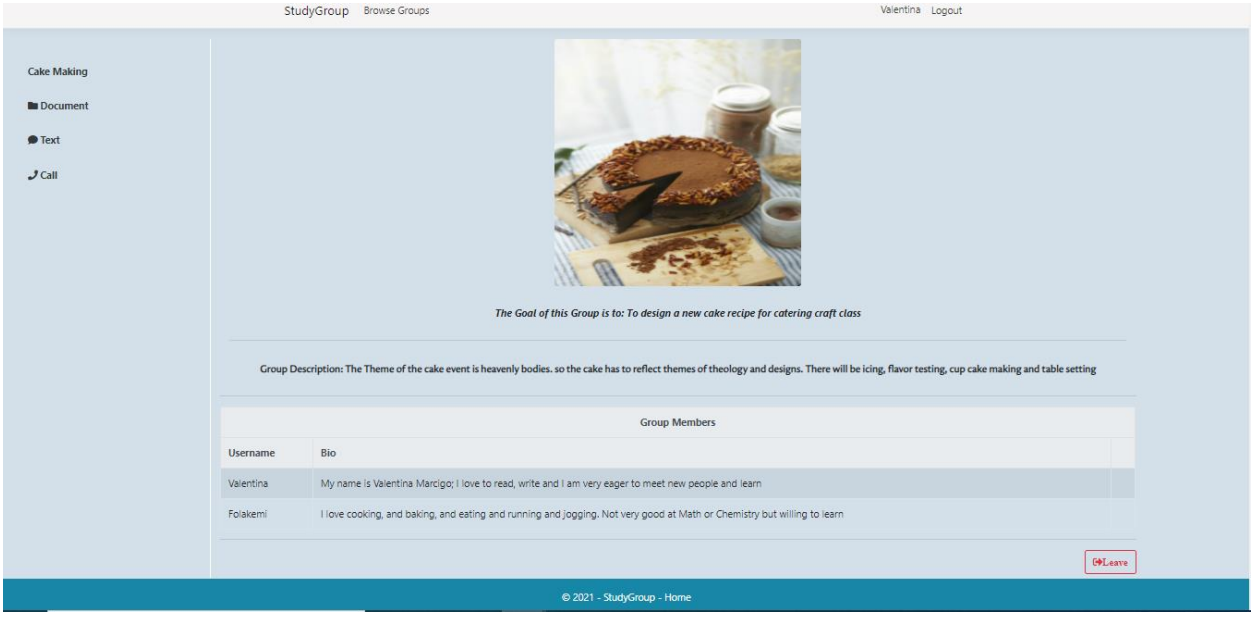

Figure 4.21:Group Portal (Member View)

4.4.2 The Group Reminder Pages

From the side navigation bar in the group portal, the group administrator can access two pages for the group reminders. The Create page or the View All page.

The Create page as shown in Figure 4.23, allows the group admin to enter a subject for the email reminder, a message and a time for the reminder to be sent to the group members.

The View all page, in Figure 4.24 and Figure 4.25, shows a table of all the reminders ever created for the group and allows the administrator to either edit the reminders or delete the reminders. If the administrator chooses to edit the reminders, they shall be redirected to the edit page to make changes to the reminders;

However, only reminders that have not been sent, i.e., reminders whose dates and times have not elapsed can be edited. Otherwise, the page will display that the reminder has been sent and give the admin the option to delete them from the group's list as shown in Figure 4.26

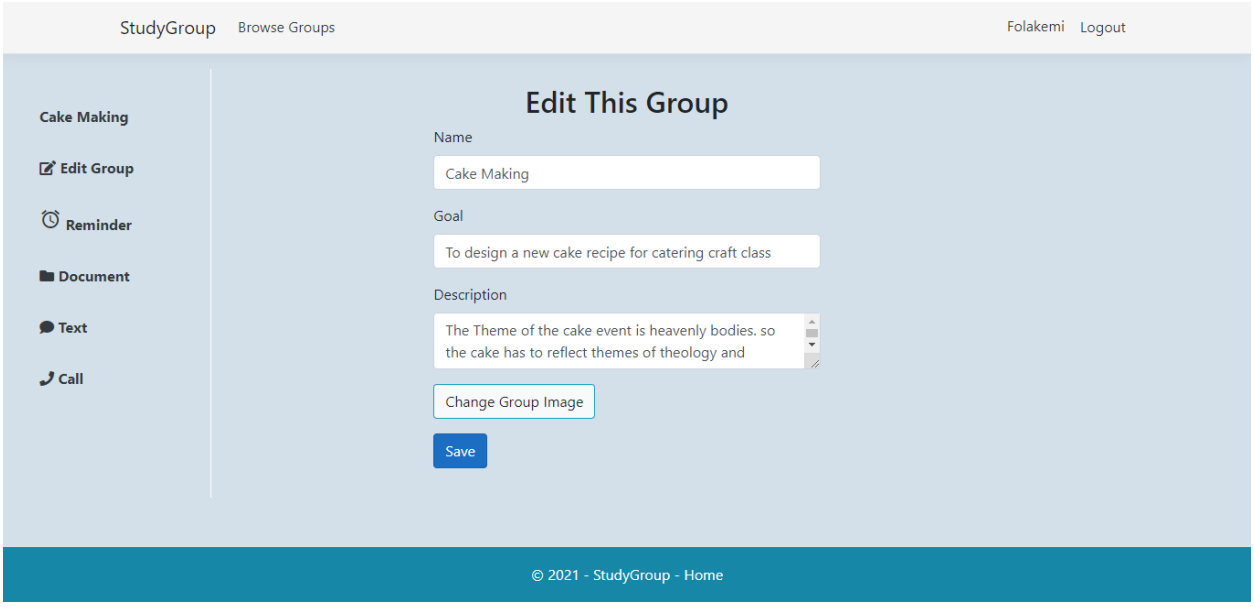

Figure 4.22: Group Editing page

4.4.3 The Group Document Pages

The side navigation bar in the group portal allows all group members to access two pages for the group's documents. The Create page or the View All page

The Create page, shown in Figure 4.27, allows the user to enter a name and description for the document before uploading the file and sending it to the rest of the group.

The View all page, in Figure 4.28, Figure 4.29 and Figure 4.30, shows a table of all the documents sent to the group; all group members can access the download the documents from here. However, all the group administrator or group sender can edit or delete the document sent to the group members as shown in Figure 4.31

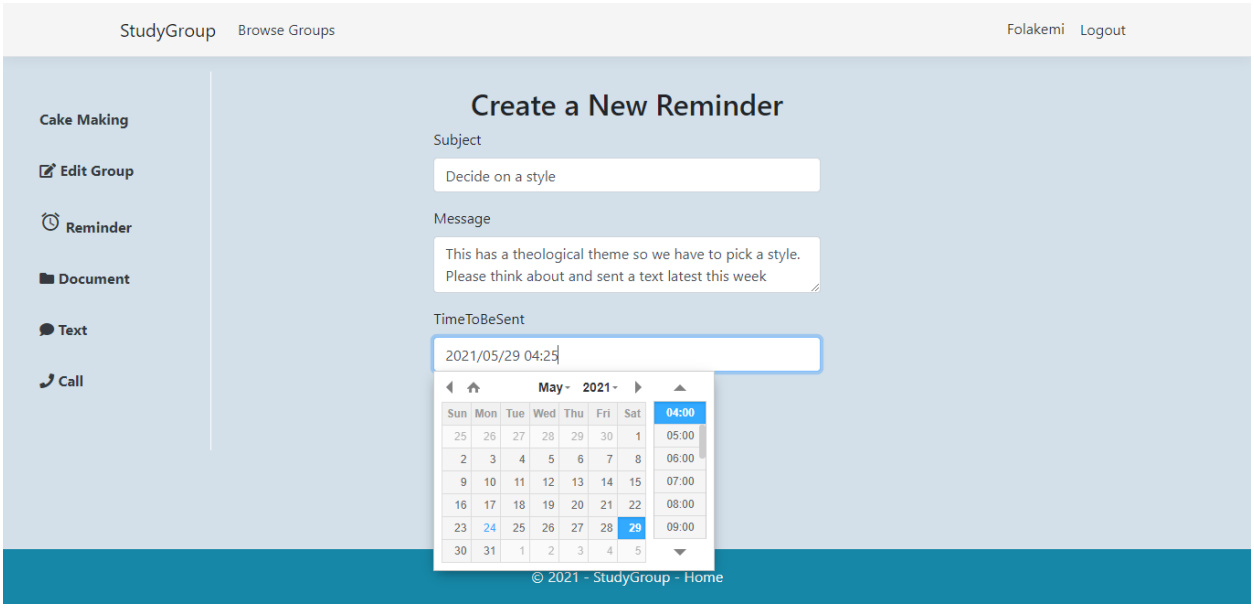

Figure 4.23: Create New Group Reminder

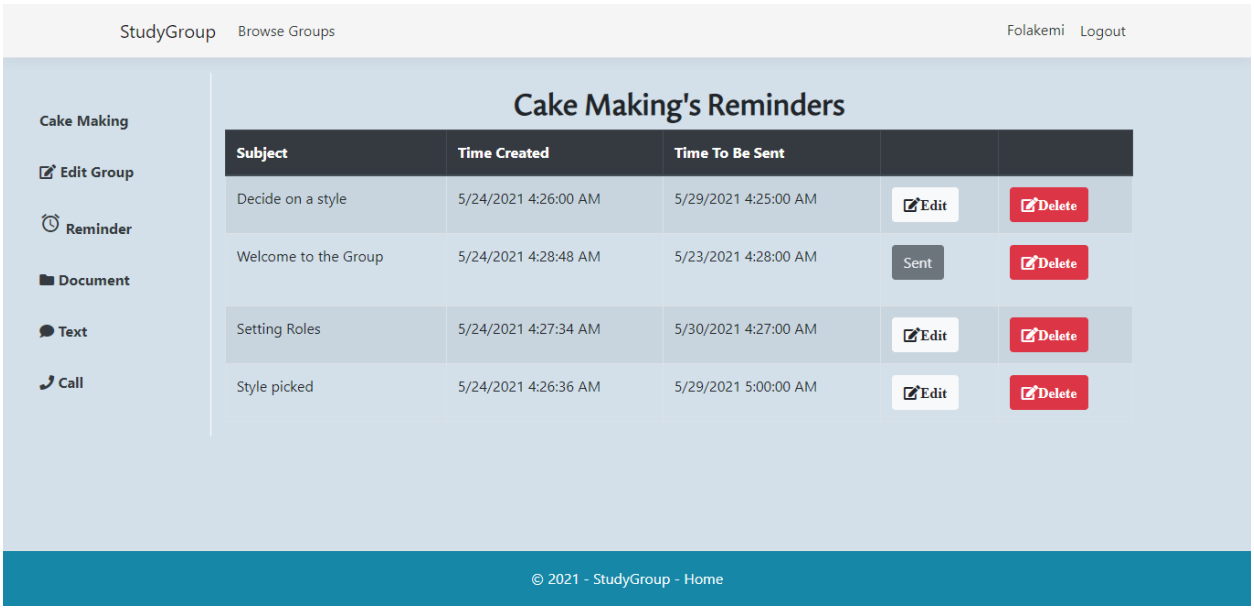

Figure 4.24: Group Reminder Table

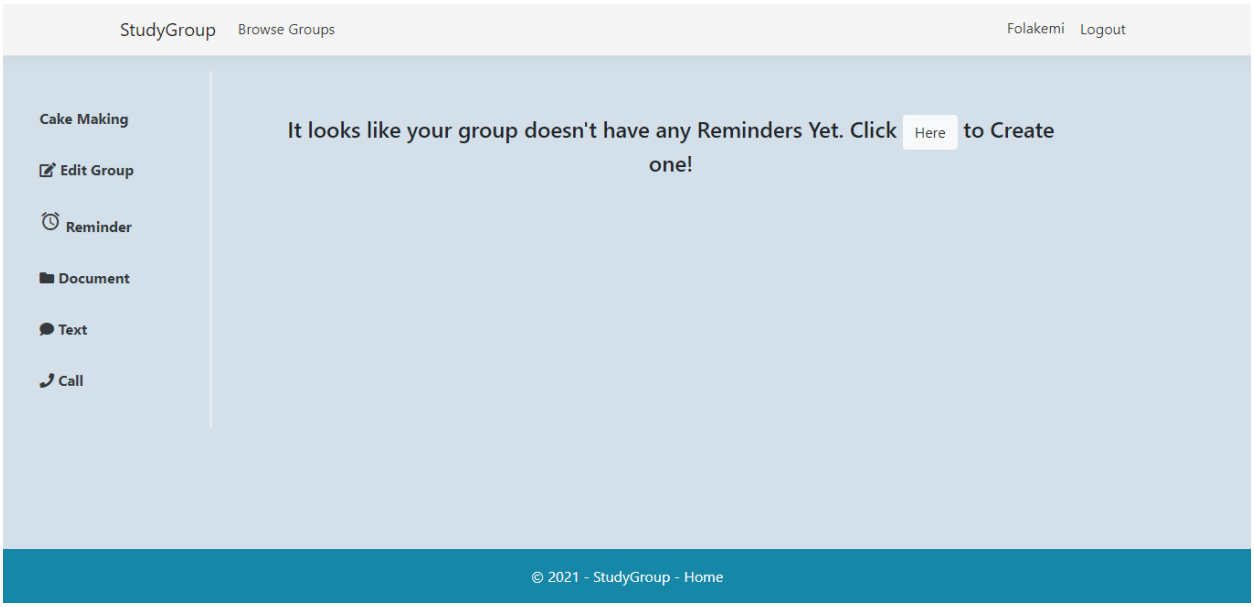

Figure 4.25: Group Reminder Table when empty

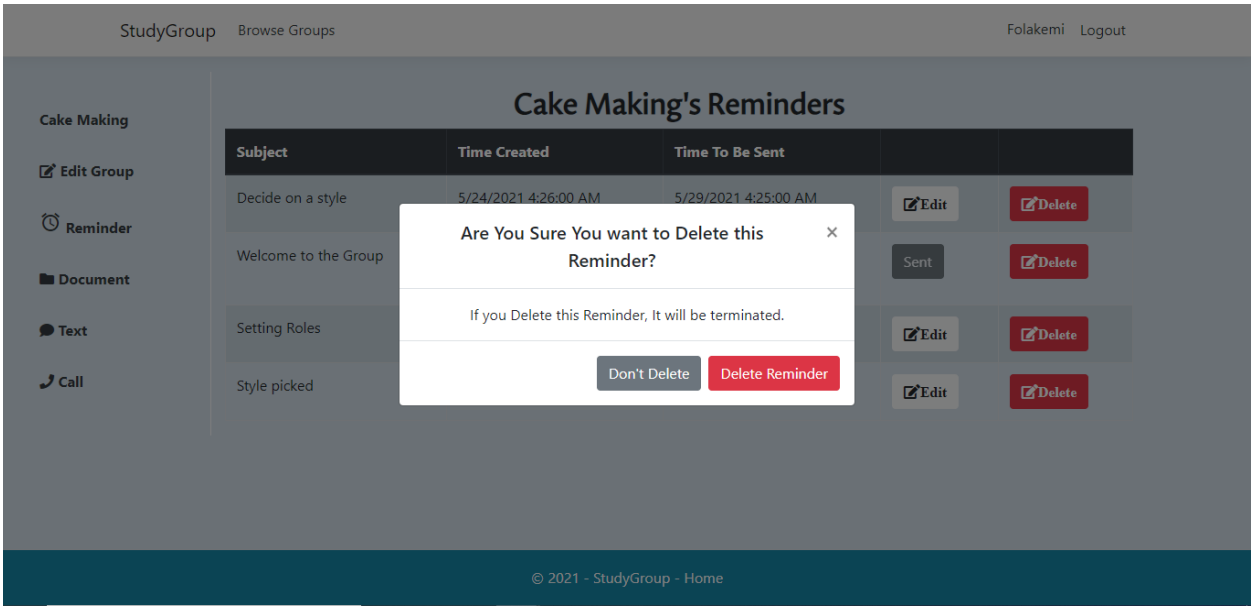

Figure 4.26: Group Reminder Table when Deleting Record

4.4.4 The Group Text-Messaging Page

All group members can freely access The Text messaging page, as shown in Figure 4.32 and 4.33, from the group's side navigation bar. Once in this page, each user can freely send text messages to all other group members. The message sent from one member are automatically saved to the database and seen by all members without the need to refresh the page using real-time communication

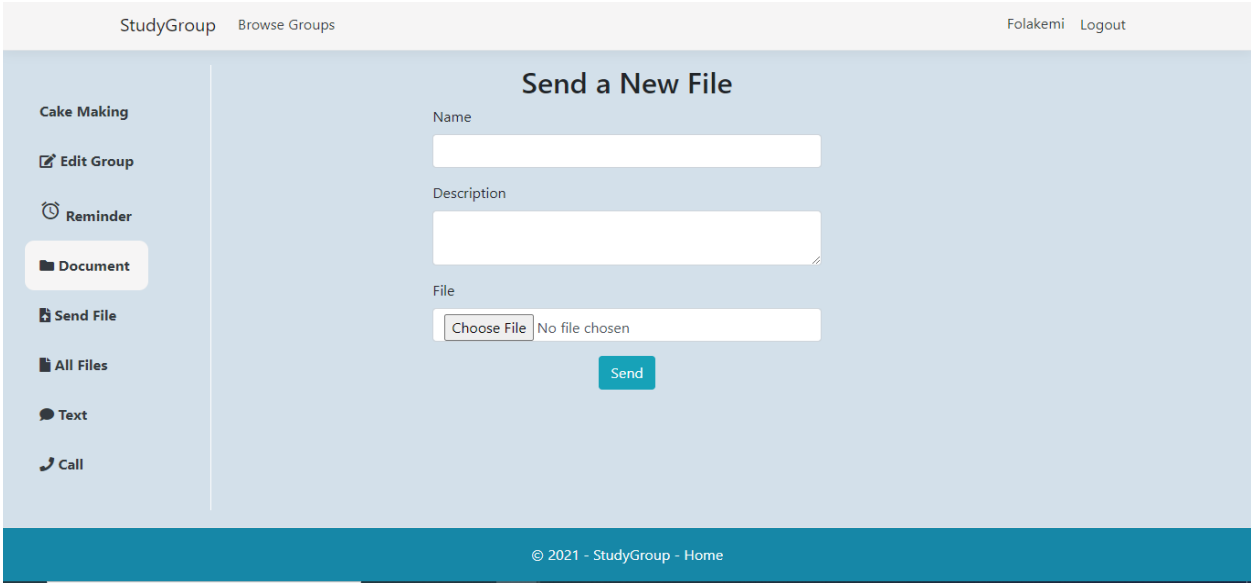

Figure 4.27: Sending a new Group File

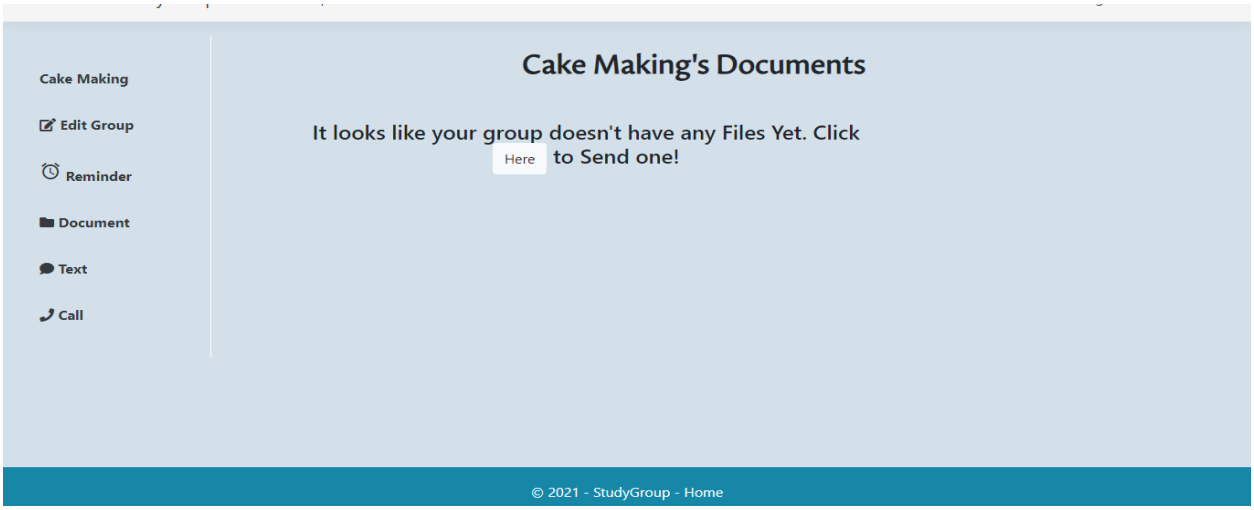

Figure 4.28: Group Documents Table when empty

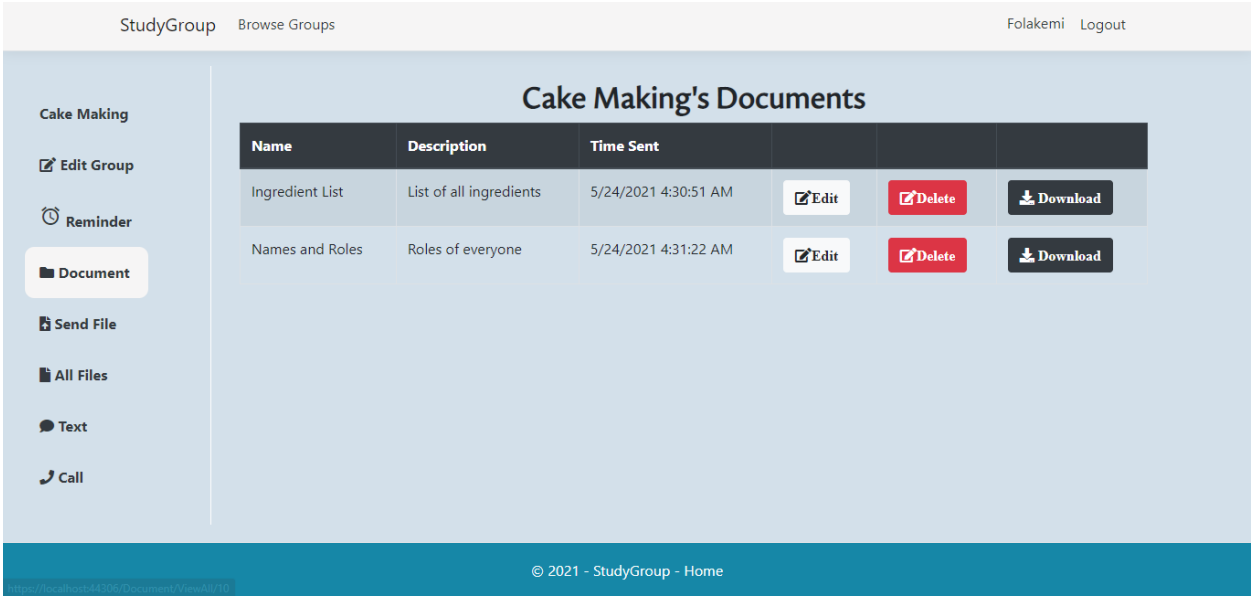

Figure 4.29: Group Documents Table (Group Admin View)

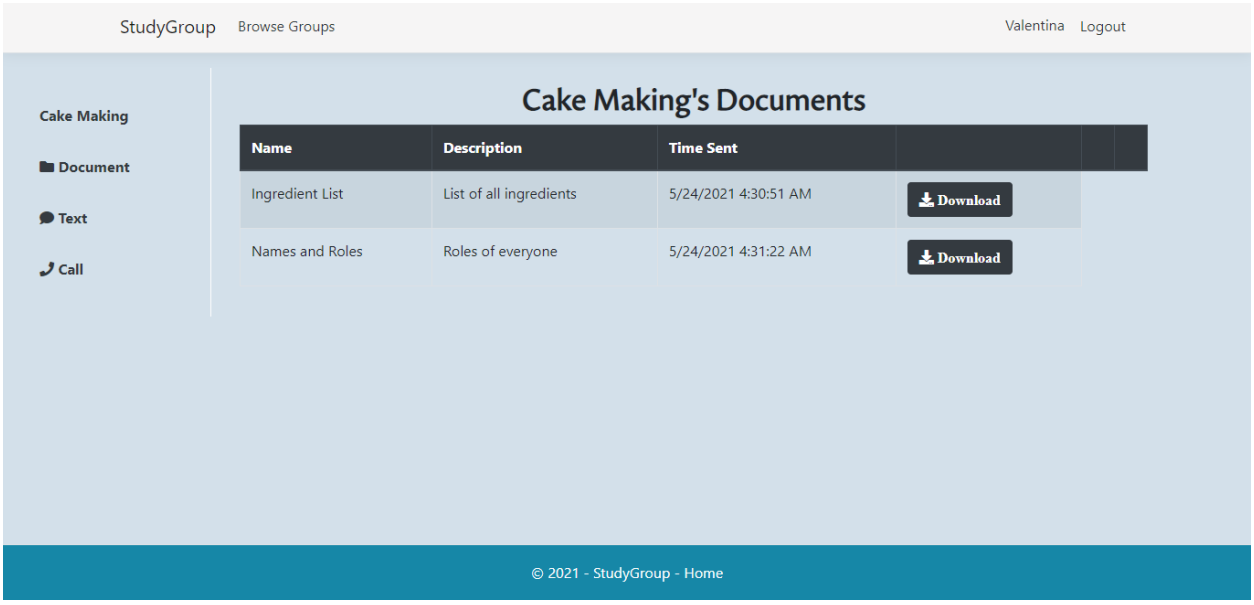

Figure 4.30: Group Documents Table (Member View)

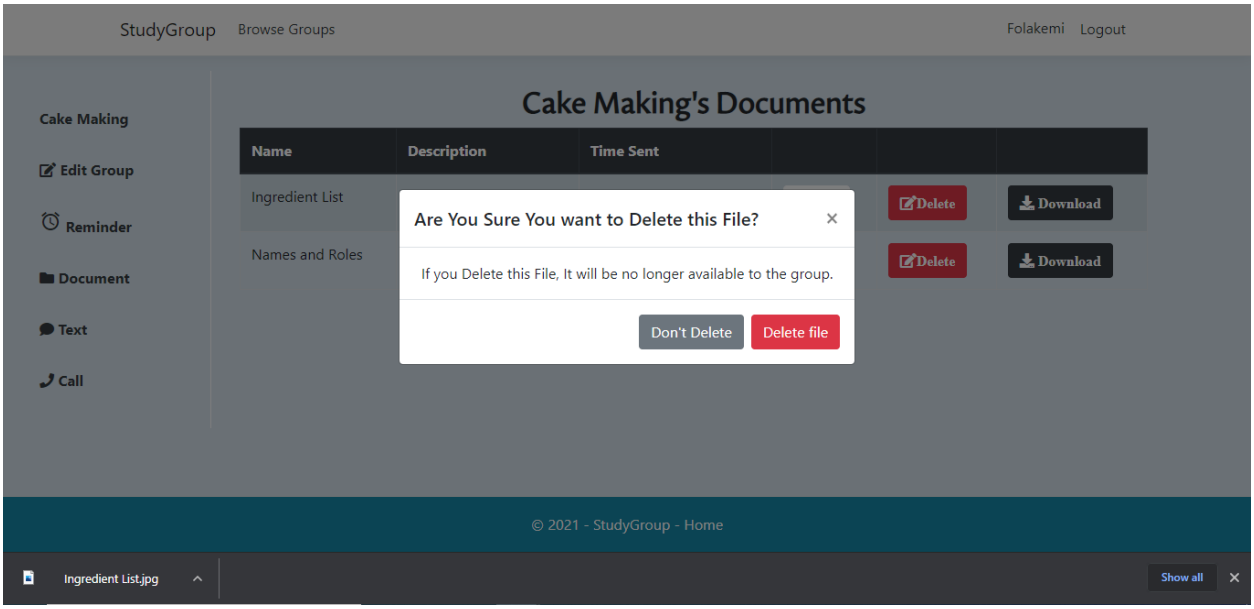

Figure 4.31: Group Documents Table When Deleting a File

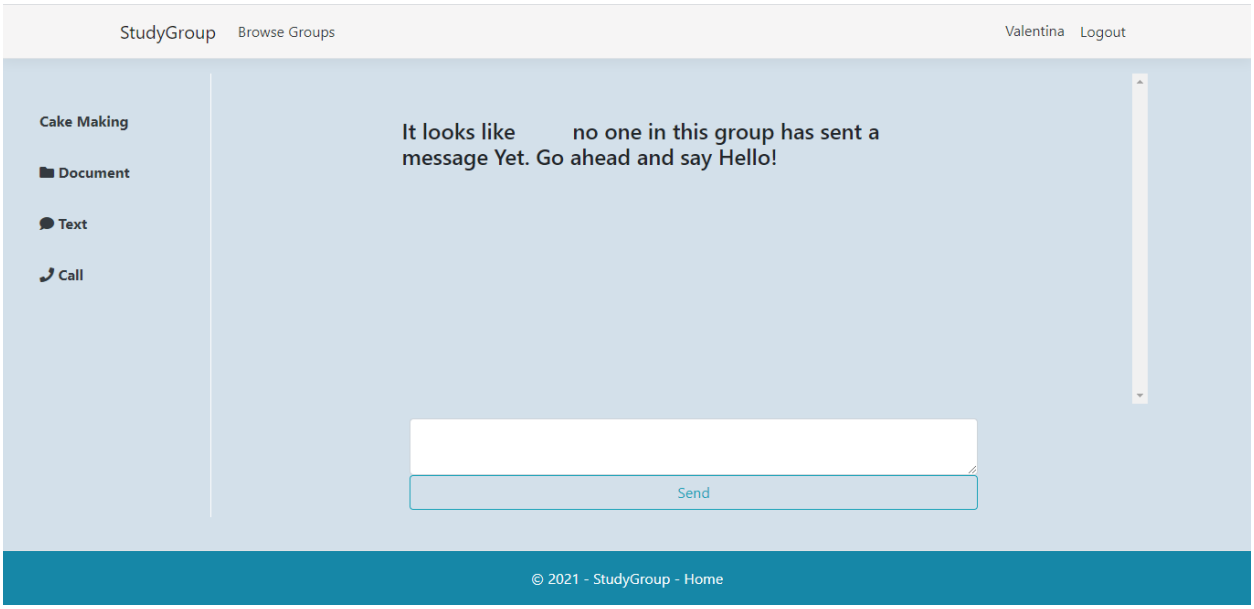

Figure 4.32: Group Text Page When Empty

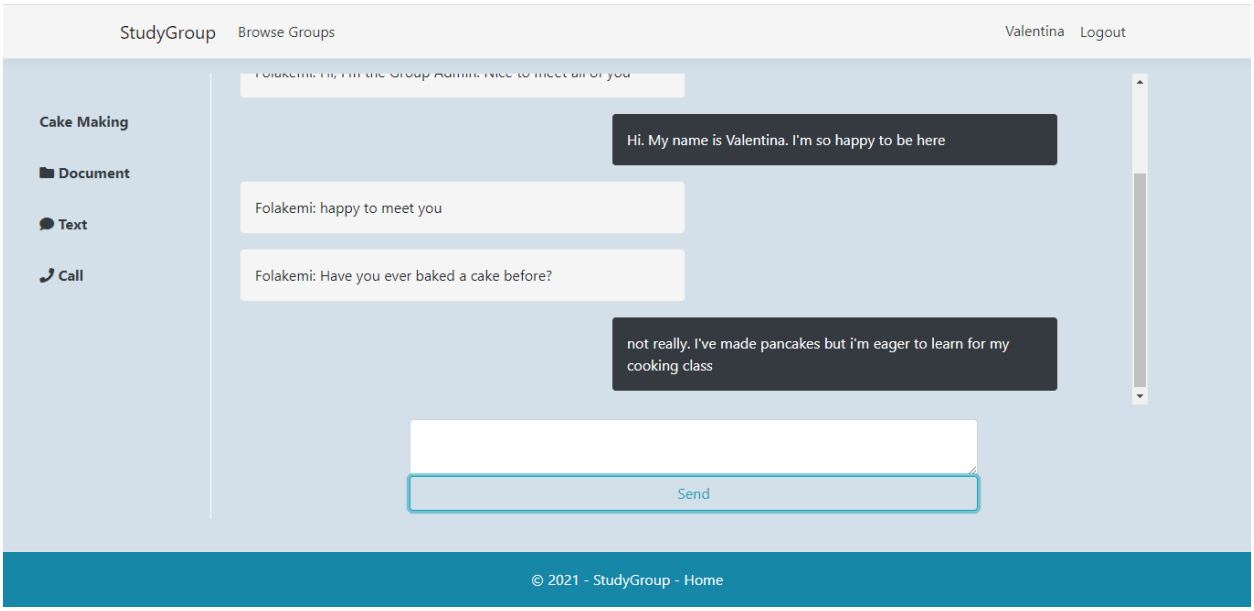

Figure 4.33: Group Text Page When Populated

4.4.5 The Group Calling Pages

The group's side navigation bar gives the option of either video calling or voice calling

A) Video Calling Page

When a user accesses the Video calling page, the default application navbars and footers are removed to allow a full screen access to the video call. Instead at the footer, several buttons are displayed to allow the user pick from the following functions represented by popular icons: *Turn off Mic*, this stops the system from transmitting the sound of that user's microphone to rest of the group and then displays a small muted icon by the user's video to notify everyone that user is not speaking.

The *Turn off Video* icon stops the system from transmitting the user' video to the others in the video call and instead replaces the video with an off-camera image and The *Screen Share* icon allows users to share their screen.

All of the three buttons also reverse their functionalities when clicked again. However, the last few buttons do not; The *Leave call* allows users to leave the call back to the group portal home page.

Group Administrators have access to a special button, The *End Call* allows the group administrator to end the call for all users which in turn prompts the users that the call has been ended and redirects them back to the group portal

The Page, shown in Figure: 4.34, 4.35, 4.36, 4.37, 4.38 and 4.39, also features the current user in a special main video box right before the footer and the rest of the connected users on a horizontally scrollable video grid. If a user clicks on another user's video. Their positions shall be switched, with the clicked user's video being placed in the main video box and vice versa

B) Voice Calling Page

The default navigation bars and footers have also been removed for the voice call, as shown in Figure 4.40, Figure 4.41 and Figure 4.42. All users get a blank image with their names on it. A footer with several buttons also exists to allow the user access the following functions through the buttons with icons: The *Turn off Mic* stops the system from transmitting the user's sound to all other users in the voice call and replaces the blank image with the icon of the microphone being turned off. The effects of this button are reversed by clicking it again

The *Leave Call* allows the users to leave the voice call and redirects them back to the group portal's home page; However, group administrators have access to a special button, The *End Call* allows the group administrator to end the call for all users which in turn prompts the users that the call has been ended and redirects them back to the group portal

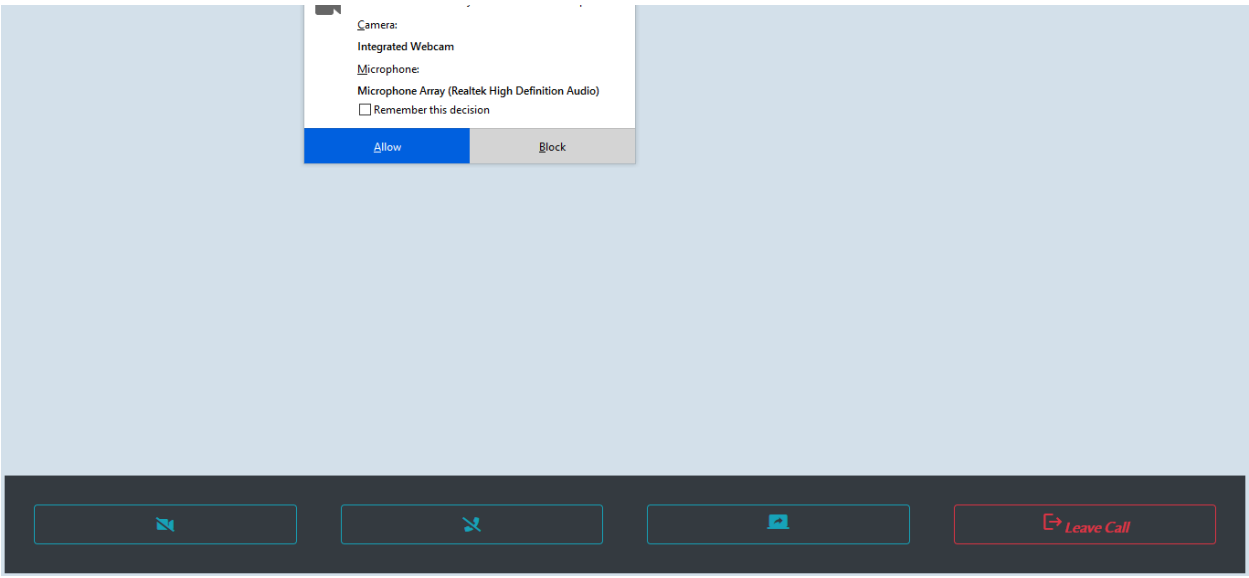

Figure 4.34: Group Video Call Page on Load (Member View)

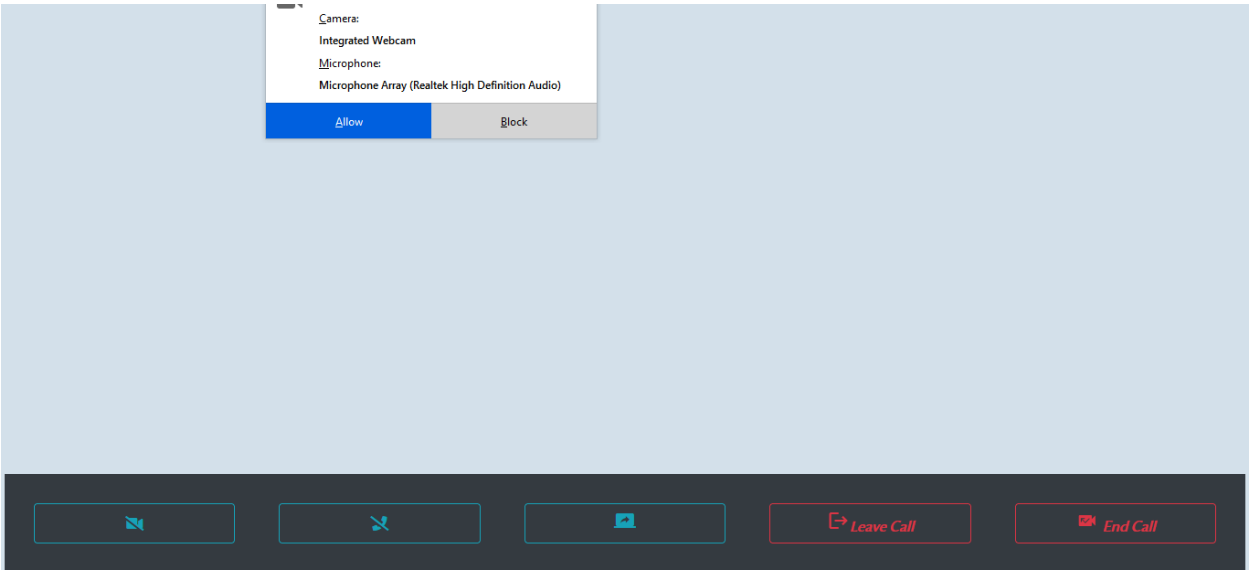

Figure 4.35: Group Video Call Page on Load (Group Admin View)

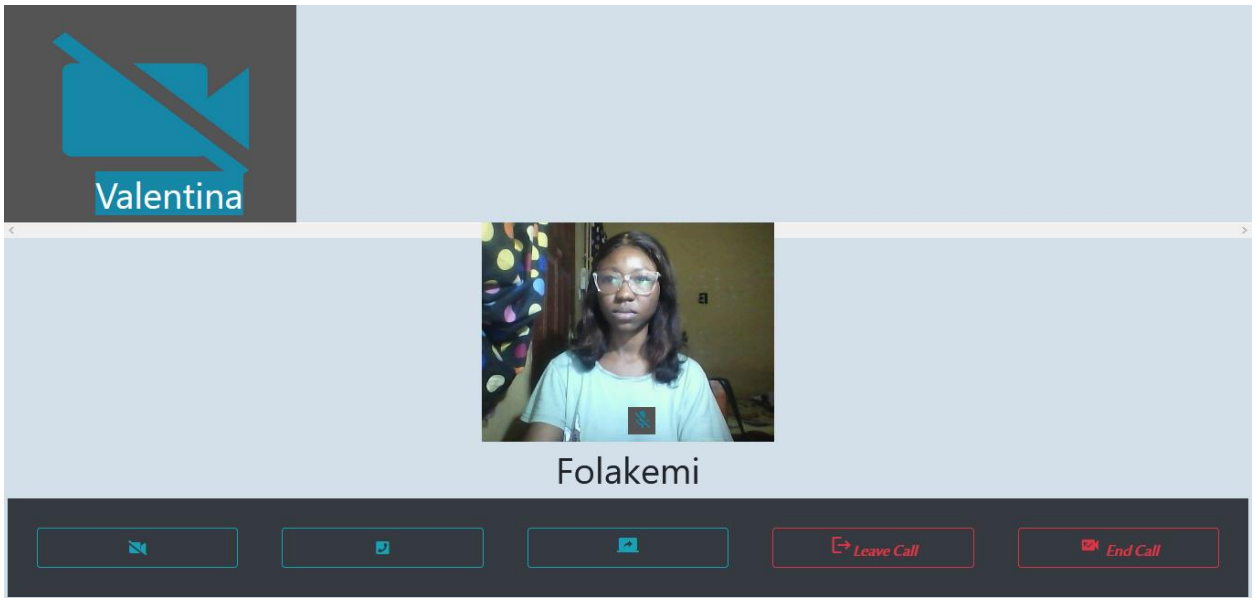

Figure 4.36: Group Video Call Page with two Users (One Muted, The Other Camera Off)

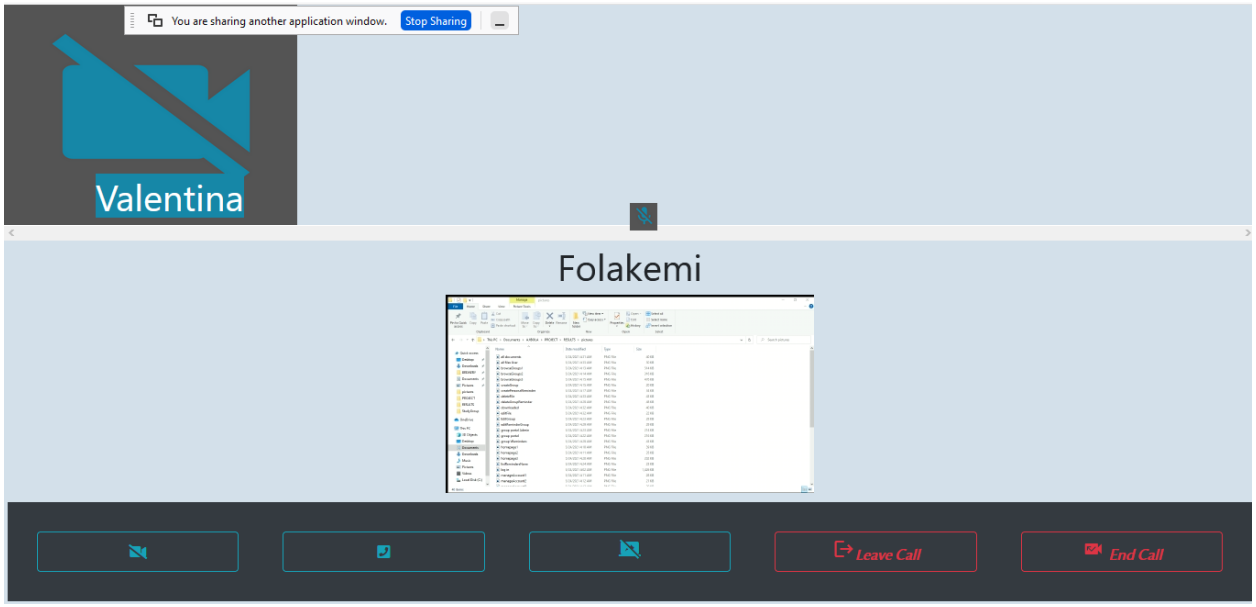

Figure 4.37: Group Video Call Page during Screen Sharing

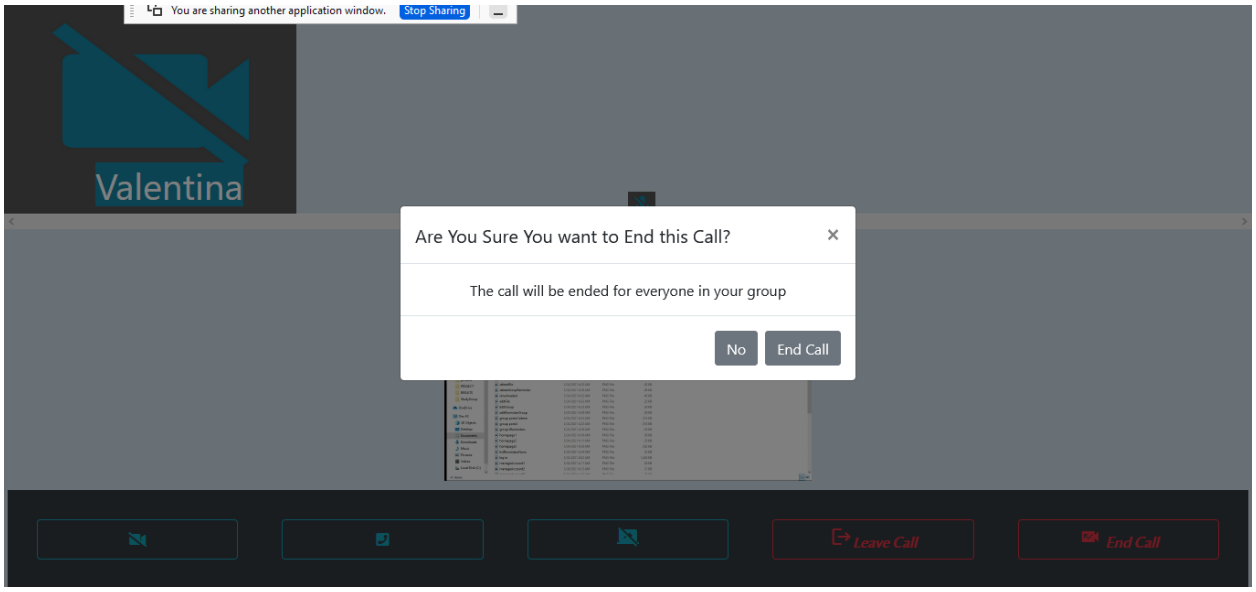

Figure 4.38: Group Video Call Page When Group Admin is Ending Call

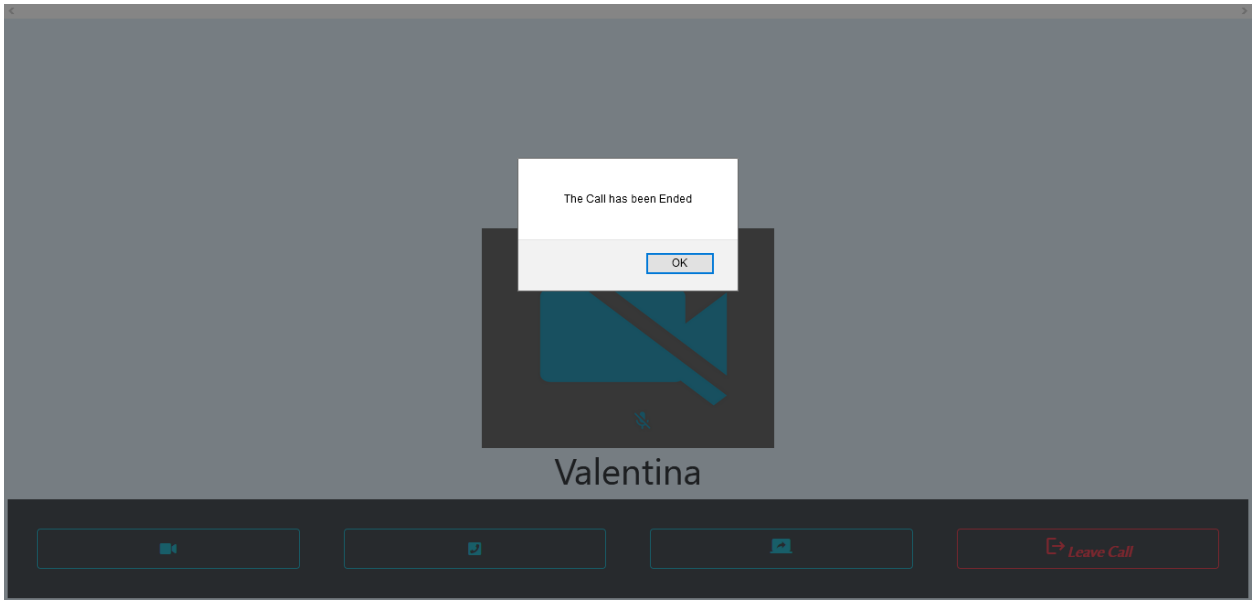

Figure 4. 39: Group Video Call Page When Call Has Ended

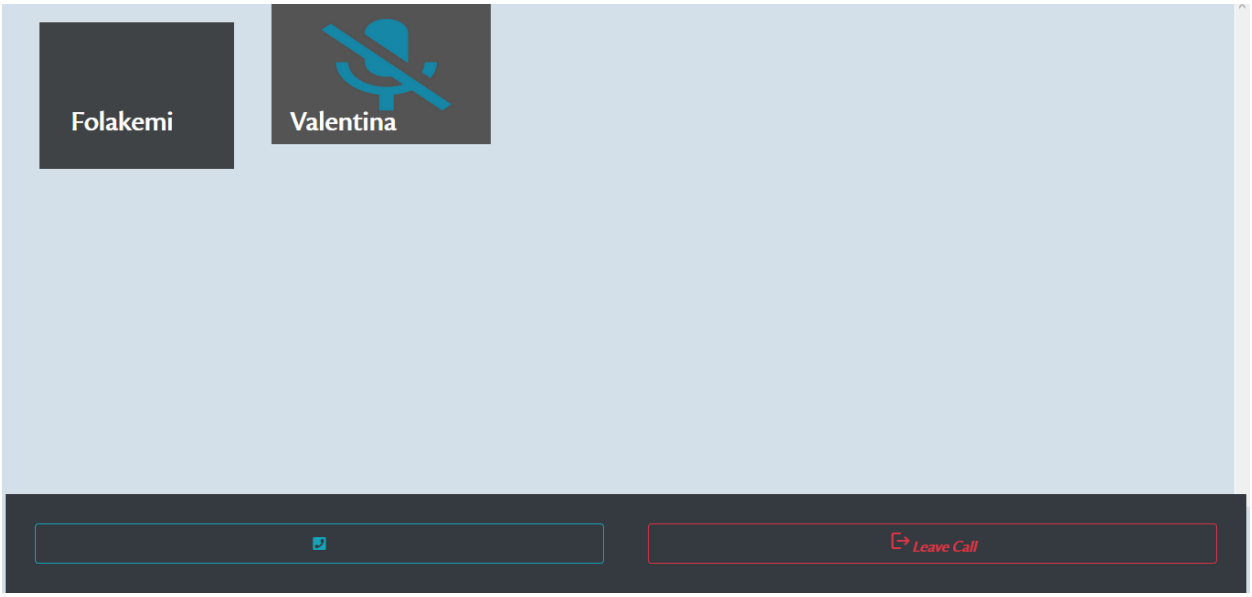

Figure 4.40: Group Voice Call Page with two Users (One Muted) – Member View

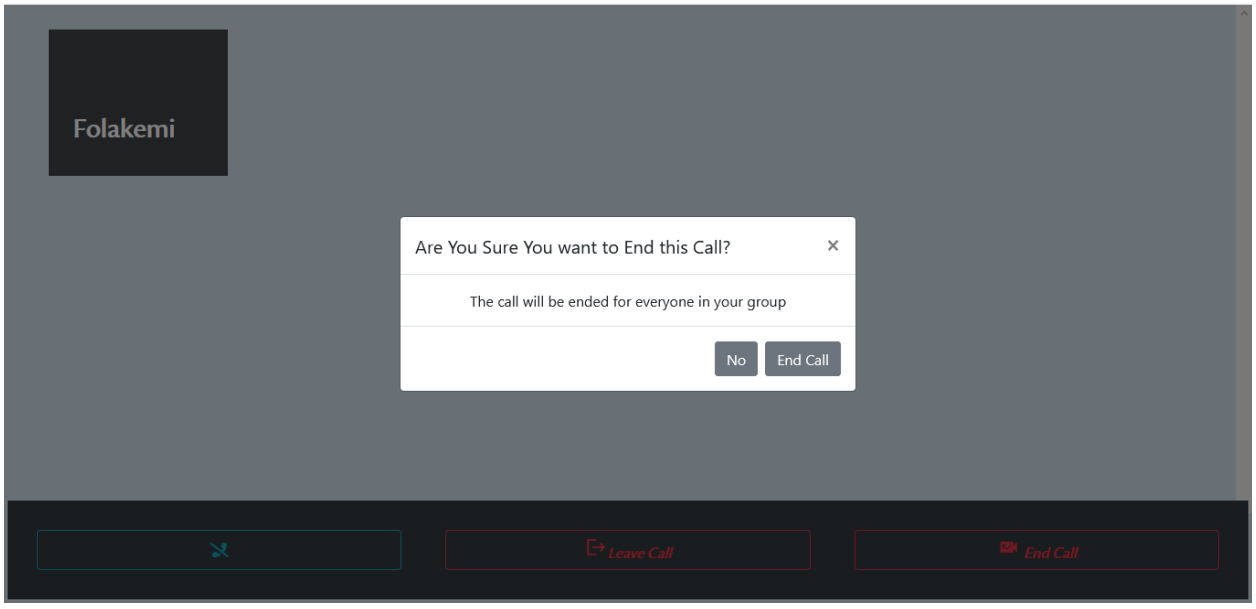

Figure 4.41: Group Voice Call Page When Group Admin is Ending Call

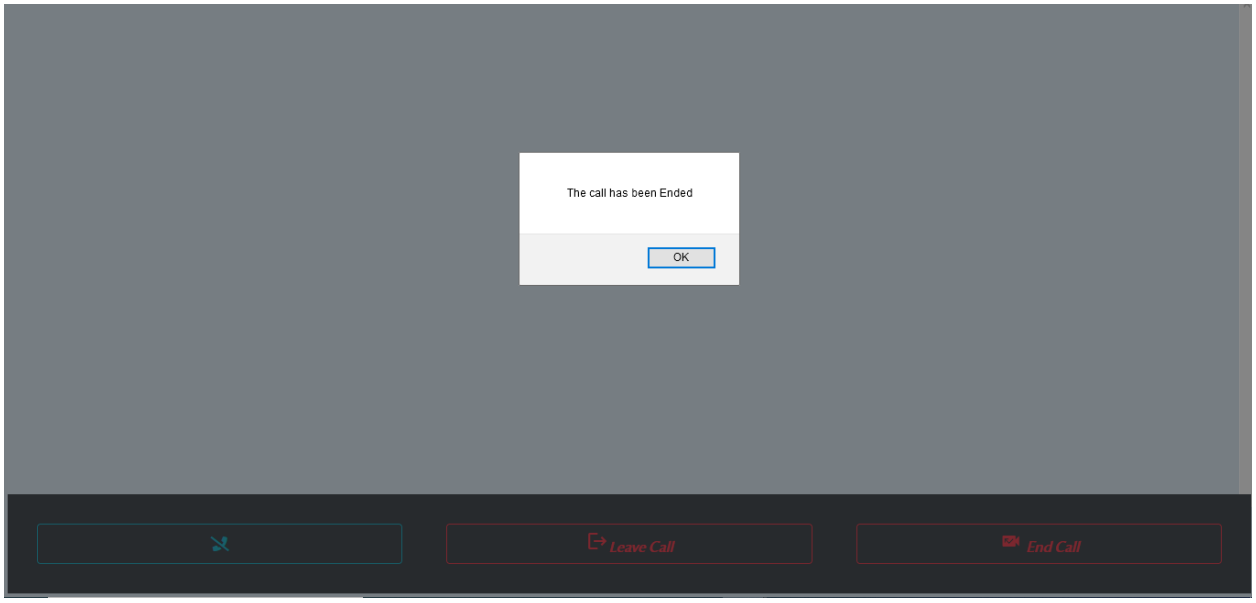

Figure 4.42: Group Voice Call Page When Call is Ended

4.5 System Testing

The implemented system was tested using three functional testing techniques with high focus on the system functional requirements defined during system design. Each of the three functional tests performed went through the positive approach and the negative approach

a) Unit Testing: After each of the sub-systems were implemented according to the system design, those sub-systems were individually tested to see if they performed effectively especially in the situation of incorrect input values
b) Regression Testing: After the unit test of each of the sub-systems were performed. The system was tested to see if it would function properly with the implementation of the newly added sub-system. Relationships between sub-systems were analyzed.
c) System Testing: After all the unit tests and regression tests were performed, the system was tested as a whole with both positive and negative values to observe the performance and make necessary corrections to the application logic

4.6 Evaluation of System in Comparison to Related Works

Table 4.1: Comparison to Related Works (Tabular Form)

S/N	TITLE AND AUTHOR	EMAIL REMINDER	TEXT MESSAGING	VOICE CALLING	VIDEO CALLING	FILE SHARING
1	WebRTC Based Remote Collaboration System by (Kandari, 2016)	NO	NO	NO	YES	NO
2	Intranet Video Conferencing System by (Lala, O.J., & Adeyemo, 2014).	NO	YES	NO	YES	NO
3	Virtual Machine Video Conferencing Application by (Adewale, et al., 2014)	NO	NO	NO	YES	YES
4	Video Conference Platform Based on WebRTC by	NO	YES	YES	YES	NO

	(Mahmood & Ercelebe, 2018).					
5	Videoconference System Based on WebRTC With Access to The PSTN by (Rosas & Martínez, 2016).	NO	NO	YES	YES	NO
6	P2P Audio and Video Calling Application Using WebRTC by (Majid, et al., 2016).	NO	YES	YES	YES	YES
7	Virtual Classroom Solution with WebRTC In A Collaborative Context in Mathematics Learning Situation by (Faye, et al., 2018).	NO	YES	NO	YES	YES

8	Real Time Collaborative Platform for Learning and Teaching Foreign Languages by (Osipov, et al., 2015).	NO	YES	NO	YES	YES
9	A Web-Based Learning System Using Project-Based Learning and Imagineering by (Chatwattana & Nilsook, 2017)	YES	YES	NO	NO	NO
10	Development of A Web-Based Active Learning System and Its Application and Evaluation in Faculty Development By (Yoshida, 2019)	NO	YES	YES	NO	YES

11	Design and Implementation of Web Based Collaborative Learning Model for ICT Course of College Student in Bangladesh by (Islam, et al., 2014)	NO	YES	NO	NO	YES
12	**THE IMPLEMENTED SYSTEM OF THIS WORK**	**YES**	**YES**	**YES**	**YES**	**YES**

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

This work identifies the problems associated with student-centered group-based learning and defines the core issue as social loafing. The aim of this work is to design and implement a Student-Centered Group-Based Learning System. Related literatures on pedagogy especially student-centered pedagogy, group-based learning, communication and Web Real Time Communication (WebRTC) were researched, reviewed and analyzed to derive system specifications. A comprehensive analysis and design of the system was undertaken, including the various system requirements. The designed system was then implemented using the appropriate tools, tested and evaluated in comparison to the earlier reviewed related works of the system

5.2 Conclusion

In this work, the issue of social loafing was critically looked upon in relation to student-centered group-based learning. The design and implementation of a Student-Centered Group-Based Learning System was then performed, with which students can easily create, and manage their own learning groups to ensure proper communication and participation to reduce the incidence of social loafing in group-works. The system design was achieved using block diagrams, architectural patterns, flow-chart diagrams, use-case diagrams and the architectural context diagram. The system was then implemented and has gone through three different kinds of functional testing which yielded successful result. The designed Student-Centered Group-Based Learning System has therefore been proven to be effective and efficient in providing different forms of communication and structure to group-learning to reduce social loafing

5.3 Recommendations

This system can be recommended for:

1. Tertiary institutions in order to promote student-student relationship on related courses
2. Secondary schools, to allow students share ideas on possible group projects and presentations they have been assigned
3. Libraries and reading clubs which would like members to engage and interact with the literature works better

5.4 Further Areas of Study

During the course of research, design and implementation, several observations were made and as a result, the following are suggested areas for future works:

1. The System's Voice and Video Calling system currently possess many features; however, it does not possess in-application recording of sessions. The application's functionalities can be implemented to support recording of sessions and other user-friendly functions like dynamic backgrounds
2. The System currently allows users to send files and edit files sent, however, this functionality only allows the user to change the file name, description and even the file. This sub-system can be further extended to allow in-house editing of files
3. The system has been implemented as a web-based application but can be further worked upon for a mobile implementation

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APPENDIX

```
@model StudyGroup.ViewModels.RemindersListViewModel


<div class="row">
    <partial name="_GroupNav" />


    @if (Model.Reminders.Count() > 0)
    {
<div class="col-9 mt-3">
    <h2 class="specialHead text-center">@Model.Group.Name's Reminders</h2>


    <table class=" table table-bordered table-striped">
        <thead class="thead-dark">
            <tr>
                <th> Subject </th>
                <th> Time Created</th>
                <th> Time To Be Sent</th>
                @if (Model.CurrentUser == Model.GroupAdminID)
                {
                    <th></th>
                    <th></th>
                }
            </tr>
```

```
</thead>
<tbody>
    @foreach (var reminder in Model.Reminders)
    {
        <tr>
            <td>
                @if (reminder.Subject.Length > 20)
                {
                    @reminder.Subject.Substring(0, 20)<span>...</span>
                }
                else
                {
                    @reminder.Subject
                }
            </td>
            <td>@reminder.DateCreated</td>
            <td>@reminder.TimeToBeSent</td>
            @if (Model.CurrentUser == Model.GroupAdminID)
            {
                @if (reminder.TimeToBeSent >= DateTime.Now)
                {
                    <td>
```

```
                    <a class="btn btn-light" asp-controller="Reminder" asp-action="Edit" asp-
route-id="@reminder.Id"> <i class="fas fa-edit">Edit</i> </a>
                </td>
            }
            else
            {
                <td> <p class="btn btn-dark disabled"> Sent</p></td>
            }
            <td>
                @{
                    string targetId = "Delete" + reminder.Id;
                }
                <button class="btn btn-danger" data-toggle="modal" data-target="#@targetId">
<i class="fas fa-trash-alt">Delete</i> </button>

                <div class="modal fade" id="@targetId" data-backdrop="static" tabindex="-1"
role="dialog">
                    <div class="modal-dialog modal-dialog-centered" role="document">
                        <div class="modal-content text-center">
                            <div class="modal-header">
                                <h5 class="modal-title">Are You Sure You want to Delete this
Reminder?</h5>
```

```
                        <button type="button" class="close" data-dismiss="modal" aria-
label="Close">
                            <span aria-hidden="true">&times;</span>
                        </button>
                    </div>
                    <div class="modal-body">
                        If you Delete this Reminder, It will be terminated.
                    </div>
                    <div class="modal-footer">
                        <button type="button" class="btn btn-secondary" data-
dismiss="modal">Don't Delete</button>
                        <a class="btn btn-danger" asp-route-id="@reminder.Id" asp-
controller="Reminder" asp-action="Delete" > Delete Reminder</a>
                    </div>
                </div>
            </div>
        </td>


    }
</tr>
```

```
            }
        </tbody>
    </table>
</div>

    }
    else
    {
        <div class="col-8 offset-md-2 container m-5 text-center">
            <h4>
                It looks like your group doesn't have any Reminders Yet. Click <a class="btn btn-light"
asp-controller="Reminder" asp-action="Create" asp-route-
name="@Model.Group.Name">Here</a> to Create one!
            </h4>
        </div>
    }




</div>

@model StudyGroup.ViewModels.ReminderDetailsViewModel
```

```
@{
    ViewData["Title"] = "Edit Reminder";
    Layout = "~/Views/Shared/_Layout.cshtml";

    var colVal = "";
}



<div class="row">
    @if (Model.Reminder.GroupId != null && Model.Reminder.GroupId != 0)
    {
        <partial name="_GroupNav" />
        colVal = "offset-3";
    }
    else
    {
        colVal = "offset-4";
    }

    <div class="col-md-4 @colVal">
        <h4 class="text-center"> Edit Reminder</h4>
        <hr />
```

```
@if (Model.ErrorMessage != null)
{
    <p class="text-danger">@Model.ErrorMessage</p>
}
<form asp-action="EditReminder" method="post">
    <div asp-validation-summary="ModelOnly" class="text-danger"></div>
    <div class="form-group">
        <label asp-for="Reminder.Subject" class="control-label"></label>
        <input asp-for="Reminder.Subject" required class="form-control" />
        <span asp-validation-for="Reminder.Subject" class="text-danger"></span>
    </div>
    <div class="form-group">
        <label asp-for="Reminder.Message" class="control-label"></label>
        <textarea asp-for="Reminder.Message" required class="form-control"></textarea>
        <span asp-validation-for="Reminder.Message" class="text-danger"></span>
    </div>

    <a class="btn btn-outline-info btn-light mb-3" data-toggle="collapse" data-
target="#RemTime">Change Reminder Time</a>

    <div class="form-group collapse" id="RemTime">
        <label asp-for="Reminder.TimeToBeSent" class="control-label"></label>
```

```
            <input asp-for="Reminder.TimeToBeSent" id="datetimepicker" class="form-control"
/>
            <span asp-validation-for="Reminder.TimeToBeSent"  class="text-danger"></span>
        </div>
        <input asp-for="Reminder.Id" class="form-control" hidden />

        @if (Model.Reminder.GroupId != 0 || Model.Reminder.GroupId != null)
        {
            <input asp-for="Reminder.GroupId" class="form-control" hidden />
            <input asp-for="Reminder.UniqueTag" class="form-control" hidden />
        }

        <div class="form-group">
            <input type="submit" value="Edit" class="btn btn-primary" />
        </div>
    </form>
  </div>
</div>


@section Scripts{
  <script>
    jQuery('#datetimepicker').datetimepicker();
```

```
    </script>

}

@model StudyGroup.ViewModels.CreateReminderViewModel

@{
    ViewData["Title"] = "Create";
    Layout = "~/Views/Shared/_Layout.cshtml";

    var colVal = "";
}

<div class="row">

    @if (Model.GroupId != 0)
    {
        <partial name="_GroupNav" />

        colVal = "offset-md-2";
    }
    else
```

```
    {
        colVal = "offset-4";
    }
    <div class=" @colVal p-3 col-md-4">
        <h2 class="text-center"> Create a New Reminder </h2>
        <form asp-action="CreateReminder" method="post">
            <div asp-validation-summary="ModelOnly" class="text-danger"></div>
            <div class="form-group">
                <label asp-for="Reminder.Subject" class="control-label"></label>
                <input asp-for="Reminder.Subject" required class="form-control" />
                <span asp-validation-for="Reminder.Subject" class="text-danger"></span>
            </div>
            <div class="form-group">
                <label asp-for="Reminder.Message" class="control-label"></label>
                <textarea asp-for="Reminder.Message" required class="form-control"></textarea>
                <span asp-validation-for="Reminder.Message" class="text-danger"></span>
            </div>
            <div class="form-group">
                <label asp-for="Reminder.TimeToBeSent" class="control-label"></label>
                <input asp-for="Reminder.TimeToBeSent" type="datetime" id="datetimepicker"
class="form-control" />
                <span asp-validation-for="Reminder.TimeToBeSent" class="text-danger"></span>
            </div>
```

```
            <input asp-for="GroupId" class="form-control" hidden />



            <div class="form-group">
                <input type="submit" value="Create" class="btn btn-primary" />
            </div>
        </form>
    </div>
</div>

@section Scripts{
    <script>
      jQuery('#datetimepicker').datetimepicker();
    </script>

}

using Hangfire;

using Microsoft.AspNetCore.Authorization;

using Microsoft.AspNetCore.Identity.UI.Services;

using Microsoft.AspNetCore.Mvc;

using StudyGroup.Data;
```

```
using StudyGroup.Models;
using StudyGroup.ViewModels;
using System;
using System.Collections.Generic;
using System.Linq;
using System.Security.Claims;
using System.Threading.Tasks;

namespace StudyGroup.Controllers
{
    [Authorize]
    public class ReminderController : Controller
    {
        private readonly ApplicationDbContext _context;
        private readonly IEmailSender _emailSender;

        public ReminderController(ApplicationDbContext context, IEmailSender emailSender)
        {
```

```
    _context = context;
    _emailSender = emailSender;
}

[Route("{controller}/{action}/{name?}")]
public IActionResult Create(string name)
{
    if (String.IsNullOrEmpty(name))
    {
        CreateReminderViewModel viewModel = new CreateReminderViewModel
        {
            GroupId = 0
        };
        return View(viewModel);
    }
    else
    {
        var group = _context.Groups.FirstOrDefault(g => g.Name == name);
```

```
        var claimsIdentity = (ClaimsIdentity)User.Identity;
        var claim = claimsIdentity.FindFirst(ClaimTypes.NameIdentifier);
        Group remGroup = new Group
        {
            Id = group.Id,
            Name = group.Name,
            GroupAdmin = group.GroupAdmin,
            GroupImage = group.GroupImage
        };
        CreateReminderViewModel viewModel = new CreateReminderViewModel
        {
            GroupId =group.Id,
            CurrentUser = claim.Value,
            Group = remGroup
        };
        return View(viewModel);
    }
}
```

```
public IActionResult Edit(int id)
{
    var reminder = _context.Reminders.FirstOrDefault(r => r.Id == id);
    var group = _context.Groups.FirstOrDefault(g => g.Id == reminder.GroupId);
    var claimsIdentity = (ClaimsIdentity)User.Identity;
    var claim = claimsIdentity.FindFirst(ClaimTypes.NameIdentifier);
    if(reminder!= null)
    {
        ReminderDetailsViewModel viewModel = new ReminderDetailsViewModel
        {
            Reminder = reminder,
            ErrorMessage = null,
            Group = group,
            CurrentUser = claim.Value
        };
            return View(viewModel);
```

```
    }
    return RedirectToAction("Index", "Users", new { filter = "_Reminders" });
}

[HttpPost]
public async Task<IActionResult> EditReminder(ReminderDetailsViewModel vm)
{
    Reminder EdittedReminder = vm.Reminder;
    var reminder = _context.Reminders.FirstOrDefault(r => r.Id == EdittedReminder.Id);
    var groupR = _context.Groups.FirstOrDefault(g => g.Id == reminder.GroupId);
    var claimsIdentity = (ClaimsIdentity)User.Identity;
    var claim = claimsIdentity.FindFirst(ClaimTypes.NameIdentifier);
    if (reminder.Subject == EdittedReminder.Subject &&
            reminder.Message == EdittedReminder.Message &&
            reminder.TimeToBeSent == EdittedReminder.TimeToBeSent)
    {
        ReminderDetailsViewModel viewModel = new ReminderDetailsViewModel
        {
```

```
        Reminder = EdittedReminder,
        ErrorMessage = "You have made no Changes",
        Group = groupR,
        CurrentUser = claim.Value
    };
    return View(nameof(Edit), viewModel);
}
if(EdittedReminder.TimeToBeSent <= DateTime.Now)
{
    ReminderDetailsViewModel viewModel = new ReminderDetailsViewModel
    {
        Reminder = EdittedReminder,
        ErrorMessage = "Time has passed already",
        Group = groupR,
        CurrentUser = claim.Value
    };
    return View(nameof(Edit), viewModel);
}
```

```
if (reminder!= null && (reminder.TimeToBeSent >= DateTime.Now))
{
   if (reminder.UniqueTag != null && (reminder.GroupId != 0))
   {
      // for a group

      var group = _context.Groups.FirstOrDefault(g => g.Id == reminder.GroupId);
      if (group.GroupAdmin == claim.Value)
      {

         var groupReminders = _context.Reminders.Where(r => r.GroupId == group.Id)
                                    .Where(r => r.UniqueTag == reminder.UniqueTag);
         foreach(var rem in groupReminders)
         {
            rem.Subject = EdittedReminder.Subject;
            rem.Message = EdittedReminder.Message;
            rem.TimeToBeSent = EdittedReminder.TimeToBeSent;
```

```
            };
            await _context.SaveChangesAsync();
            return RedirectToAction(nameof(ViewAll), new { name = group.Name });
        }
        else
        {
            return View(nameof(Edit), reminder.Id);
        }
    }
    else
    {
        reminder.Subject = EdittedReminder.Subject;
        reminder.Message = EdittedReminder.Message;
        reminder.TimeToBeSent = EdittedReminder.TimeToBeSent;
       await _context.SaveChangesAsync();
        return RedirectToAction("Index", "Users", new { filter = "_Reminders" });
    }
}
```

```
        else
        {
            return RedirectToAction(nameof(Edit), EdittedReminder.Id);
        }

    }
    public async Task<IActionResult> Delete(int id)
    {
        var reminder = _context.Reminders.FirstOrDefault(r => r.Id == id);
        if(reminder!= null)
        {
            if(reminder.UniqueTag != null)
            {
                var group = _context.Groups.FirstOrDefault(g => g.Id == reminder.GroupId);
                var reminderList = _context.Reminders.Where(r => r.UniqueTag ==
reminder.UniqueTag);
                _context.Reminders.RemoveRange(reminderList);
                await _context.SaveChangesAsync();
                return RedirectToAction(nameof(ViewAll), new { name = group.Name });
```

```
        }
        else
        {
            _context.Reminders.Remove(reminder);
            await _context.SaveChangesAsync();
            return RedirectToAction("Index", "Users", new { filter = "_Reminders" });
        }
    }
    else
    {
        return NotFound();
    }
}

public IActionResult ViewAll(string name)
{
    var group = _context.Groups.FirstOrDefault(g => g.Name == name);
    if (group != null)
```

```
        {
            var uniqueTags = _context.Reminders.Where(r => r.GroupId == group.Id).Select(r=>
r.UniqueTag).Distinct();
            List<Reminder> rem = new List<Reminder>();
            foreach(var tag in uniqueTags)
            {
               var first = _context.Reminders.Where(r => r.UniqueTag == tag).FirstOrDefault();
               if (first != null)
               {
                  rem.Add(first);
               }
            }

            //var categorizedReminders = uniqueTags.GroupBy(c =>
c.UniqueTag).FirstOrDefault();

            Group remGroup = new Group
            {
               GroupAdmin = group.GroupAdmin,
```

```
            Id = group.Id,
            Name = group.Name,
            GroupImage = group.GroupImage
        };

        var claimsIdentity = (ClaimsIdentity)User.Identity;
        var claim = claimsIdentity.FindFirst(ClaimTypes.NameIdentifier);
        RemindersListViewModel viewModel = new RemindersListViewModel
        {
            GroupAdminID = group.GroupAdmin,
            CurrentUser = claim.Value,
            Reminders = rem,
            Group = remGroup
        };
        return View(viewModel);

    }
    return RedirectToAction("ViewGroup", "Group", new { name = name });
```

```
    }

    [HttpPost]
    public async Task<IActionResult> CreateReminder(CreateReminderViewModel
Createdreminder)
    {
        var reminder = Createdreminder.Reminder;
        reminder.GroupId = Createdreminder.GroupId;
        if (reminder.GroupId == 0)
        {
            var claimsidentity = (ClaimsIdentity)User.Identity;
            var claim = claimsidentity.FindFirst(ClaimTypes.NameIdentifier);

            reminder.SenderId = claim.Value;
            reminder.ReceiverId = claim.Value;
            reminder.IsSent = false;
            reminder.DateCreated = DateTime.Now;
            reminder.GroupId = null;
            _context.Reminders.Add(reminder);
```

```
            await _context.SaveChangesAsync();
            return RedirectToAction("Index", "Users", new { filter = "_Reminders"});
        }
        else
        {
            var group = _context.Groups.FirstOrDefault(g => g.Id == Createdreminder.GroupId);
            var groupName = _context.Groups.FirstOrDefault(g => g.Id == Createdreminder.GroupId).Name;

                var GroupsUsers = _context.UserXGroups.Where(u => u.GroupId == Createdreminder.GroupId);
                var GroupMembers = _context.AppUsers.Where(a => GroupsUsers.Any(users => users.UserId == a.Id));
                List<Reminder> reminders = new List<Reminder>();
            string uniqueTag = Guid.NewGuid().ToString() + DateTime.Now.ToString();
                //var uniqueTag = Createdreminder.UniqueTag + DateTime.Now.ToString()+ group.GroupAdmin;
                foreach (var member in GroupMembers)
                {
```

```
    var reminderEach = new Reminder();
    reminderEach.Subject = Createdreminder.Reminder.Subject;
    reminderEach.Message = Createdreminder.Reminder.Message;
    reminderEach.TimeToBeSent = Createdreminder.Reminder.TimeToBeSent;
    reminderEach.GroupId = Createdreminder.GroupId;
    reminderEach.DateCreated = DateTime.Now;
    reminderEach.SenderId = group.GroupAdmin;
    reminderEach.ReceiverId = member.Id;
    reminderEach.IsSent = false;
    reminderEach.Receiver = member;
    reminderEach.UniqueTag = uniqueTag;
    reminders.Add(reminderEach);
}

foreach (var rem in reminders)
{
    _context.Reminders.Add(rem);
}
```

```
            await _context.SaveChangesAsync();



            return RedirectToAction("ViewAll", "Reminder", new { name = groupName });


        }


}


//Trigger only once oh!


//[Route("[Action]")]

//public IActionResult SendEmails()

//{

//    RecurringJob.AddOrUpdate(() => SendEmailEvery2Minutes(), "*/2 * * * * ");

//    return Ok("SendEmails Triggered");

//}
```

```
public async Task<IActionResult> SendEmailEvery2Minutes()
{
    var unsentReminders = _context.Reminders.Where(r => r.IsSent == false);
    List<Reminder> lessThan2MinuteReminders = new List<Reminder>();
    foreach(var reminder in unsentReminders)
    {
        if((reminder.TimeToBeSent - DateTime.Now)<= TimeSpan.FromMinutes(2))
        {
            lessThan2MinuteReminders.Add(reminder);
        }
    }
    foreach(var reminder in lessThan2MinuteReminders)
    {
        if(reminder != null)
        {
            reminder.Receiver = _context.AppUsers.FirstOrDefault(a => a.Id ==
reminder.ReceiverId);
            if(reminder.Subject == null)
            {
```

```
                reminder.Subject = " ";
            }
            await _emailSender.SendEmailAsync(reminder.Receiver.Email, reminder.Subject,
reminder.Message);
            reminder.IsSent = true;
            await _context.SaveChangesAsync();
        }
    }
    return Ok();
  }
 }
}
```