SMART SOLUTION FOR LABOR ACQUISITION USING BIM

FINAL YEAR PROJECT UG – 2020

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CERTIFICATION

This is to certify that the

Final Year Project Titled

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has been accepted towards the requirements.

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in

BACHELOR OF ENGINEERING IN CIVIL ENGINEERING

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ABSTRACT

In the construction industry, a multitude of challenges continually plague the field, from breakdowns in communication and design issues to workplace accidents and labor shortages. However, our extensive research has led to the development of an innovative solution that leverages the power of digital technologies and machine learning to address these challenges and bridge the gap between construction companies and the workforce. Our groundbreaking approach involves the creation of two distinct modules designed to directly confront and mitigate these pervasive obstacles. Module One serves as a comprehensive platform that facilitates seamless communication between clients and workers, enabling the provision of remote job opportunities, efficient bid management, streamlined employee selection, and real-time interaction. This module essentially acts as a unified hub for all communication and operational needs within the construction ecosystem. Meanwhile, Module Two functions as a sophisticated plug-in, harnessing the immense capabilities of REVIT in harmony with machine learning algorithms to optimize labor allocation and enhance workforce management. By leveraging data and advanced analytics, this module can significantly improve resource allocation and task assignment, leading to enhanced operational efficiency and resource utilization. The impact of our solution has been profound, with tangible improvements evident in all facets of construction project management. This includes notable enhancements in task scheduling efficiency, substantial reductions in project delays, and cost savings. Most significantly, the seamless integration of machine learning has revolutionized and streamlined critical processes, leading to a substantial boost in overall operational efficiency, thus establishing our solution as a transformative force in the construction industry.

ACKNOWLEDGEMENT

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LIST OF ABBREVIATIONS

BIM   Building Information Modeling

API   Application Program Interface

GUI   Graphical User Interface

ICT   Information and Communication Technologies

RII   Relative Importance Index

CHAPTER 1
INTRODUCTION

1.1 Brief description

The problem of finding and retaining skilled labor in the construction industry becomes a serious problem, increasing risks of jump in costs, deadlines, and sometimes even project cancellations. Based on various surveys conducted, 90% of the construction contractors find they have a specialized labor shortage (NAHB, 2019); this figure has turned over by 18% annually (ORACLE NetSuite, 2022). Also, 70% of companies face the problems of a poor number of qualified workers and 76% of companies face a shortage of available workforce which is unskilled (AGC, 2017). Similarly, staff deficiencies are the most blamed concern of project managers (Jones, 2016). Furthermore, communication problems used to be added fuel to the flames of the evolving conflict on the job site (Patel & Wang, 2017). The skilled labor shortages, jobs, communication issues, etc cause huge losses to the industry.

For instance, construction firms face 37% more projects not completed on time, and 58% wrestle with extra costs and delays because of the shortage of skilled labor (AGC, 2022). The foregoing challenges indicate that labor factors play a great role in the construction landscape and make the sector heavily lose money. Hence, the issues are becoming crucial and need to be highlighted. To resolve this issue, addressing these questions like How can workers be introduced and eased into the labor market in the construction sector? Besides this, how will contractors' limited contact networks effectively address the skilled workers' employment shortage? are deemed necessary. Therefore, this study aims to develop a linkup platform to minimize the communication between construction entities and laborers.

Our method has two components which are discussed below, and they address all the queries. Module

One seeks to open the doors to laborers to get them jobs. On the other hand, Module Two takes a step further to facilitate contractor staffing in the face of limited contacts. Through leveraging the power of digital technology, the platform that our solution utilizes prompts an easy connection between construction companies and both skillful and unskilled workers. The central notion of streamlined communication and teamwork features planned for our platform is to accelerate work and minimize delays on construction sites. The platform aims to facilitate easy reach to a diverse crowd of highly skilled experts, thus relieving the companies of the necessity to source and retain these employees, thereby lowering the costs of projects and reducing cancelations of projects.

1.2 Existing research

Numerous studies have been conducted to enhance the process of scheduling and labor acquisition in construction projects using Building Information Modeling (BIM). The construction sector persists in searching for different methodologies to improve performance, provide solutions, support operation processes, and help in overcoming inherent obstacles. An analysis of the last number of years' publications exemplifies the issues that are generally agreed upon as important, among them are the prevention through design (PtD/P), building information modeling (BIM), labor productivity, and the labor market dynamics in the construction sector.

In the study by Johansen, Schultz, and Teizer (Johansen et al., 2024), they went in-depth on the issue of PtD/P strategies implementation the author emphasizes the significance of automation in performance assessment on construction projects. They emphasized the reactive character of active management and its good performance regarding risks when it comes to the safety of the project.

Meanwhile, Zhang et al. (Zhang et al., 2023) shifted their focus to building information modeling (BIM) and AEC digital transformation investigations, linking to the concept of Construction 4.0 on the rise [2]. Their two-sided relation underlines the BIM potential of making the design workflow much more coordinated, collaborative, and prepared which in turn enables the effective utilization of resources.

Chaturvedi, Thakkar, and Shankar (Chaturvedi et al., 2018), focused on detailed matters concerning labor productivity within the construction industry. Their study is multi-dimensional in the sense that it explores both technology and non-technical issues that can affect the speed and productivity of the workforce such as organizational strategies and workforce demographics and culture.

Raza et al. (Raza et al., 2023) for the so-called BIM are listed out by them. The task is for the application project management within the construction project. Their research unveils how BIM and project management methods can collaboratively ensure the success of projects. Such insights can be utilized to develop ideal practical settings.

Gamayunova (Gamayunova, 2015) demonstrates the labor market market structure in the construction business through the investigation. Emphasizing the importance of workforce development policies has been a constant threat throughout the research, and this threat contributes to addressing skill gaps, enhancement of productivity, and achieving sustainable growth within the sector

The fact that this industry is at a crossroads, between facing change with the help of an introduction of digital technology, advanced techniques, and strategic human resource management approaches or abdications. Through the utilization of the abundant knowledge and experience attained from these academic arenas, stakeholders can overcome arising challenges and stimulate innovative ideas for future construction initiatives, consequently propelling progress and sustainable prosperity.

1.3 Research gap.

For this study, the research gap was analyzed extensively through a literature review. Table 1 shows the aspects of project management being addressed in relevant research papers published before.

Table 1 Gap analysis

Research paper	Year of research	Automation using BIM	Labor acquisition system
(Johansen et al., 2024)	2024	Yes	No
(Raza et al., 2023)	2023	Yes	No
(Zhang et al., 2023)	2023	Yes	Yes
(Chaturvedi et al., 2018)	2018	No	Yes
(Gamayunova, 2015)	2023	No	Yes
(Associated General Contractors of America, 2021)	2021	No	Yes
This Study	2024	Yes	Yes

1.4 Research objectives.

The objectives set forth hence are:

1. To Launch a centralized platform for construction Labor acquisition.

2. To transform the global construction job market with BIM Automation.

3. To establish a central hub for Laborers.

1.5 Significance of study

The importance of this research lies in its approach to tackling the problems in the construction industry specifically the lack of skilled workers and communication obstacles. By analyzing data from surveys and reports the study emphasizes the seriousness of these challenges and how they negatively impact project schedules, expenses and overall effectiveness. The proposed connection platform presents a solution by combining two modules designed to simplify labor market entry for workers and improve contractor staffing despite limited connections. Using technology, the platform aims to streamline communication and encourage cooperation between construction companies and workers ultimately resulting in cost savings, project efficiency increased accessibility and long-term sustainability, in the industry.

1.6 Relevance to national needs

Within the construction sector of Pakistan, several stakeholders are beginning to realize the importance of digitization of the sector and hence are demanding a digital platform that addresses their needs. The new connection platform has an impact, on priorities especially in terms of boosting the economy and reducing poverty. By automating scheduling and hiring processes in the construction sector this platform is set to save time, money and resources. These efficiencies lead to advantages by cutting project costs improving completion rates and

enhancing industry productivity. Moreover, by streamlining operations and reducing project expenses the platform makes construction projects more accessible and cost effective potentially boosting infrastructure development on a scale. This surge in construction activity creates job opportunities that help tackle unemployment and poverty issues. Additionally, the platforms emphasis on providing access to construction jobs for both unskilled workers can empower marginalized communities, with employment options contributing to poverty alleviation efforts and promoting inclusive economic growth.

1.7 Market Value

The solution for the Pakistani construction industry introduces two new systems to address la bor acquisition and schedule management, the common problems in the industry.

1.7.1 Mobile Application

Module One is a mobile application which has user interface user-interface and Urdu language support thus enabling many users such as laborers up to project managers to access it without struggling. The Labour Management module eases communication between customers and employees; hence it comes with features like posting job opportunities, choosing off-site staff and interacting in real time. In this way, the company can get an efficient acquisition of labor and its management. It enables clients to place jobs and allows workers to bid on these jobs which ensures that the hiring process is transparent and competitive. Furthermore, it provides direct employment opportunities for unskilled workers thus curbing unemployment which has been a big problem in the country due to the recent economic recession. Because there are no similar platforms in Pakistan, demand for this service will be high. Real-time communication helps to minimize miscommunications and delays during the project implementation process.

1.7.2 BIM Plugin

The second module is BIM plugin for Schedule optimization , quantity extraction automated resource calculation using REVIT. This plugin is optimized by explicit programing to automate scheduling processes, quantity extraction, resource calculation. These things are required both during initial stage for Bid preparation , and also during execution stage for different activities execution and also work program (baseline schedule)to be submitted by contractor as per FIDIC 2017 clause,8.3.The aforementioned tasks are not only tedious but also quiet time taking and prone to errors, but using our designed system these tasks can be accomplished in few minutes , all the user need is just a BIM model .The plug-in not only creates optimized schedules but also generates detailed reports like Resource Calculations and Quantity Extractions. These reports are vital for project planning and management because they help people understand better what resources must be spent on individual projects or how much material will be used in each stage respectively. Furthermore, these reports are available through mobile phones, making it convenient for contractors to access necessary information even when they are in transit. With this kind of collaboration, all those involved have current data which enhances better decision-making as well as implementation of projects.

These collaborations not only solve the pressing issues facing the Pakistani construction industry, but also increase efficiency and sustainability through the use of technology andlocal integration. Our solutions increase the overall efficiency and effectiveness of construction projects by improving communication, improving the division of labor, and providing rapid access to information based on the importance of the project. These two methods provide control over personnel and planning, resulting in delays, cost reductions, and project improvements.

1.8 Area of application

The study aims to make construction processes an easy-to-understand concept for every stakeholder involved, specifically the laborer and the client. Our pioneering solution transforms the construction sector through the following two modular facets. Module One: an advanced integrated operational and communications platform that optimizes seamless client–worker communications, remote job opportunities, resourceful bid management, and efficacious employee selection, thereby enhancing transparency and operational productivity. Module Two: an advanced REVIT plug-in powered by machine learning for optimal labor deployment, effective workforce management, and enhanced resource utilization. The integration realizes enhanced efficiency of task scheduling, leading to massive reductions in the delay of projects and related expenses. In general, this system streamlines construction project management, increases operational efficiency, decreases costs, and ensures that projects are completed in good time. Additionally, the construction projects will be safer and in line with compliance requirements.

LITERATURE REVIEW

2.1 Construction industry

The construction industry has been facing immense backlash due to its reluctance to adapt to the technological advancements being made. Therefore, the industry needs to bring a shift in its policies regarding quality, productivity, and sustainability (Rajesh & Haraprasad, 2022). The construction industry is a highly collaborative industry involving many stakeholders such as suppliers, designers, owners, contractors, and consultants. The construction industry is different from others owing to these unique characteristics (Azhar, 2008). The major success of a construction project relies upon the effectiveness of its schedule, scope management and the availability of the skilled labors.

2.1.1 Research conducted in BIM automation and Labor management

The construction sector persists in searching for different methodologies to improve performance, provide solutions, support operation processes, and help in overcoming inherent obstacles. An analysis of the last number of years' publications exemplifies the issues that are generally agreed upon as important, among them are the prevention through design (PtD/P), building information modeling (BIM), labor productivity, and the labor market dynamics in the construction sector.

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The fact that this industry is at a crossroads, between facing change with the help of an introduction of digital technology, advanced techniques, and strategic human resource management approaches or abdications. Through the utilization of the abundant knowledge and experience attained from these academic arenas, stakeholders can overcome arising challenges and stimulate innovative ideas for future construction initiatives, consequently propelling progress and sustainable prosperity.

2.2 Building information modelling (BIM)

BIM gives the advantage of handling digital data with comparative ease. BIM is not software but rather a process that works with other software. It helps facilitate the design, execution, and operational information in a project (Popov, 2010). BIM promises to yield the desired improvements in the construction industry.

The capabilities of BIM extend in many directions:

1. 3D models containing information such as length, width, and height.

2. 4D Scheduling i.e.,3D Models connected to the project schedule with task sequencing.

3. 5D Cost Estimation; Cost information added to a 4D Model.

4. 6D Model-based analysis for the early and accurate decision-making process

5. 7D Models for Operation and Maintenance

6. 8D Modelling for Risk Assessment (Winberg & Dahlqvist, 2010).

BIM facilitates the integration and sharing of relevant information throughout the project lifecycle, improving coordination, cooperation, and decision-making. The ability to visualize the project reduces cost, improves efficiency, and minimizes the project duration (Deng, 2019). BIM also helps identify and analyze issues before actual construction, resolves coordination issues and automates material quantity identification. BIM has been successfully applied in various areas of construction project management and has proven to be an effective tool in resolving issues in the construction industry (Darko, 2020).

2.2.1 Role of BIM in Schedule Management

In the study by Johansen, Schultz, and Teizer (Johansen et al., 2024), they went in-depth on the issue of PtD/P strategies implementation the author emphasizes the significance of automation in performance assessment on construction projects. They emphasized the reactive character of

active management and its good performance regarding risks when it comes to the safety of the project.

The focus, on automation fits well with the shift towards digitalization in the construction industry especially seen in the implementation of Building Information Modeling (BIM). When BIM is incorporated into scheduling and management procedures construction crews can enjoy operations, better teamwork and efficient resource allocation. This differs from approaches like utilizing software such, as P6 which can be both pricier and take up time.

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2.3 Construction Schedule

In the construction industry a schedule acts as a guide outlining the order of tasks, activities and key points needed to finish a project within a set timeframe. It plays a role, in managing time allocating resources, coordinating efforts fostering communication handling risks and controlling expenses. By offering a roadmap for action schedules assist project teams in staying well organized tracking progress preparing for obstacles and ensuring smooth and efficient workflow.

Ultimately schedules are essential, in driving the success of projects by aiding in completing construction tasks while keeping costs managing risks effectively.

2.4 Schedule management on a construction project

The economy of a nation relies significantly on its construction industry and the success of a construction project lies in its measures: within time, on budget and upon the satisfactory completion of the project.

2.4.1 Objectives and goals of schedule management

The objectives of schedule management in construction involve ensuring projects are completed on time optimizing resource use, managing risks promoting communication and coordination controlling expenses and upholding quality standards. Successful schedule management includes setting timelines monitoring progress and making adjustments as necessary to prevent delays. It also requires coordinating resources to boost productivity and minimize waste. By identifying paths and potential obstacles schedule management helps reduce risks that could affect project deadlines and create plans for unexpected challenges. Clear and precise schedules aid in communication and coordination among project participants to ensure everyone knows their roles. Following the schedule also helps manage project expenses by avoiding costs associated with delays. Ultimately effective schedule management supports maintaining quality standards by allowing time, for planning, execution and inspection of work.

METHODOLOGY

3.1 Introduction

The research methodology covers systematic stages and approaches. Initially, a study literature review was carried out to uncover present solutions in the field and assay the fallouts that remain. Subsequently, a solution with two modules was developed: The first module will be based on the Flutter framework written in DART with the second module to include a plug-in, a supervised, and a reinforced learning. The scope of these modules is to help fill the found gaps in the construction domain. The flow diagram attached shows the methodology framework to achieve the project objectives.
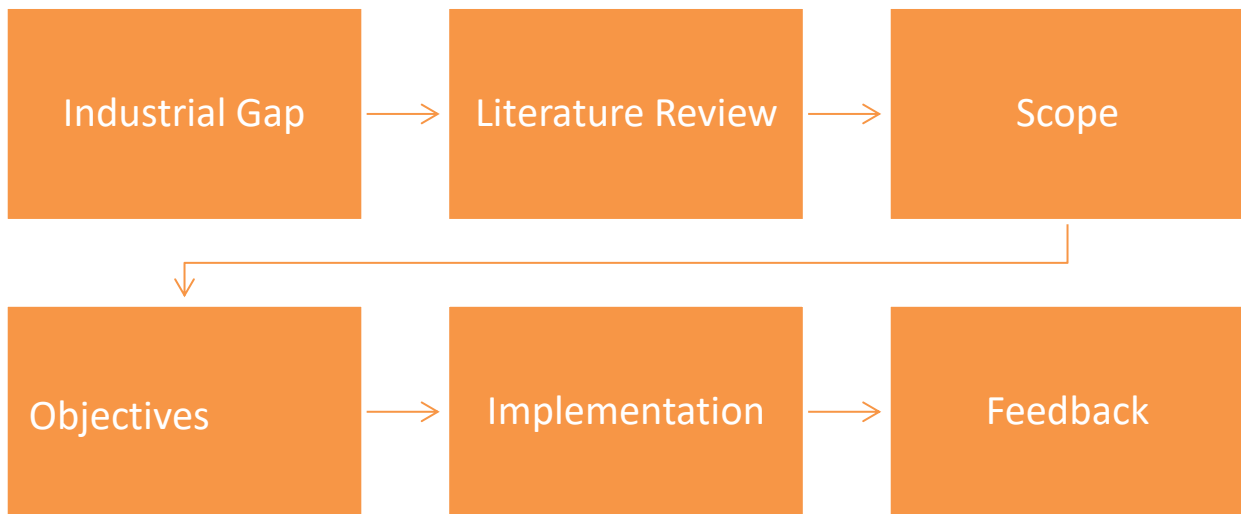
Figure 1: Research Methodology

So, upon examination of all the possible opportunities for the implementation of our plans, we came up with a solution that consists of two modules. Module One is comprised of the Flutter framework with DART language underlining the same. We found Flutter to be best suited for us as it's cross-platform which means that we won't have to code for each operating system

separately. Our main purpose here was to empower Flutter in such a way that will make the interface of our solution responsive and user-friendly, thus improving its availability and usability among various devices and operating systems. Module two is a creation of plug-in, supervised, and reinforced learning. C Sharp is the chosen language for the development of these plugins as any other language like Python would have asked for additional downloads before the plug-in was fully operational. Also, it would have slowed the overall efficiency of the process. However, Python was used for machine learning operation as it is simple and flexible. With the aid of such technologies merger, we aimed at developing a system that will be powerful enough and effective enough in solving problems discussed in the research.

3.2 Identification of inefficiencies in traditional project management processes in the construction industry

The inefficiencies in traditional processes were first identified through an extensive literature review and then later rated by the industry stakeholders. For the literature review. Research papers from various resources such as "GOOGLE SCHOLAR," "SCIENCE DIRECT," "CITAVI," "MENDELEY" etc. were utilized. Fifteen relevant papers were studied and the twenty most frequently occurring inefficiencies were identified and selected as a basis for further research.

The inefficiencies were first tabled along with their frequency of occurrence and their significance as mentioned by the respective authors of research papers and their qualitative score was found with high significance rated as five, medium as three and low as one.

The literature score was then calculated for each factor using the formula mentioned by (Kimberly & Anthony, 1998) The formula is:

$$(\boldsymbol{qualitative\ score} * \boldsymbol{frequency})/(\boldsymbol{number\ of\ factors} *$$
$$\boldsymbol{highest\ qualitative\ score}) \ldots \textbf{eq.1}$$

The normalized score was then calculated for each factor using the formula mentioned (Kimberly & Anthony, 1998). The formula is:

$$Normalized\ Score = \frac{\boldsymbol{literature\ score\ of\ the\ factor}}{\boldsymbol{sum\ of\ literature\ score\ of\ all\ factors} * \boldsymbol{27}}$$

The factors were ranked 1-20 according to decreasing normalized scores.

A preliminary survey was then conducted among the 3 Cs of the construction industry:

1. Consultants

2. Contractors

3. Clients,

Furthermore, interviews with industry officials from the three sectors were also conducted. These officials were from Chimbals, Fellows Engineering Consultants and INN. The questionnaire was filled in by them related to the hurdles faced by them in the timely management of schedule and resources for the construction project and delay management in construction.

To verify the inefficiencies in schedule management processes. For this purpose, an online questionnaire was circulated among the participants. The questionnaire was composed of two parts:

1. The demographics of the participants

2. Impact ranking of inefficiencies.

Based on their experience and knowledge of the construction industry, the participants evaluated the inefficiencies based on Relative Important Index (RII) technique (equation 3). The evaluation was based on a 5-point Likert scale, with "1" denoting a "Very Low" importance and "5" denoting a "Very High" (Kamari, et al., 2021).

The participants were also encouraged to add any other inefficiency along with the rating of their choice to strengthen the targeted framework.

$$RII = \frac{\sum W}{A*N} \quad \text{............................} \quad \text{eq.3}$$
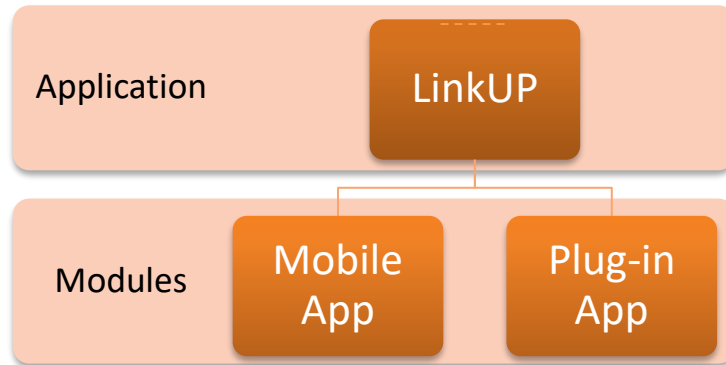
$(0 \leq RII \leq 1)$

Where W = The weight assigned by respondents to each factor. A

Highest Significant Weight, i.e., 5

N = The number of participants

## 3.3 Mobile Application for Labor Acquisition

Figure 2: Structural Overview of the Application

 Module One (Mobile Application) comprises two distinct interfaces: the Client interface and the Labor interface. The client interface opens to the Dashboard, which is designed with a complete list of all available job postings. Furthermore, individuals can create job postings and opportunity details on their own, which include all the necessary information such as the title, description, location, and the required media files. The screen also shares the biography of the laborers, giving the details of their names and the positions they hold, etc. Clients can straight away liaison with the laborer through this interface, with an initiation of the hiring process. Normally, it happens with the interaction as a notification within the laborer's interface between the laborers and the clients being displayed. Moreover, they are featured with a list filtering functionality which is categorial. The other part of the interface has a chat feature as well as an account interface through which they can access the important details of their account and all the key account functionalities key account functionalities.

Figures 3 and 4 show the flow and structural diagram of module one respectively.
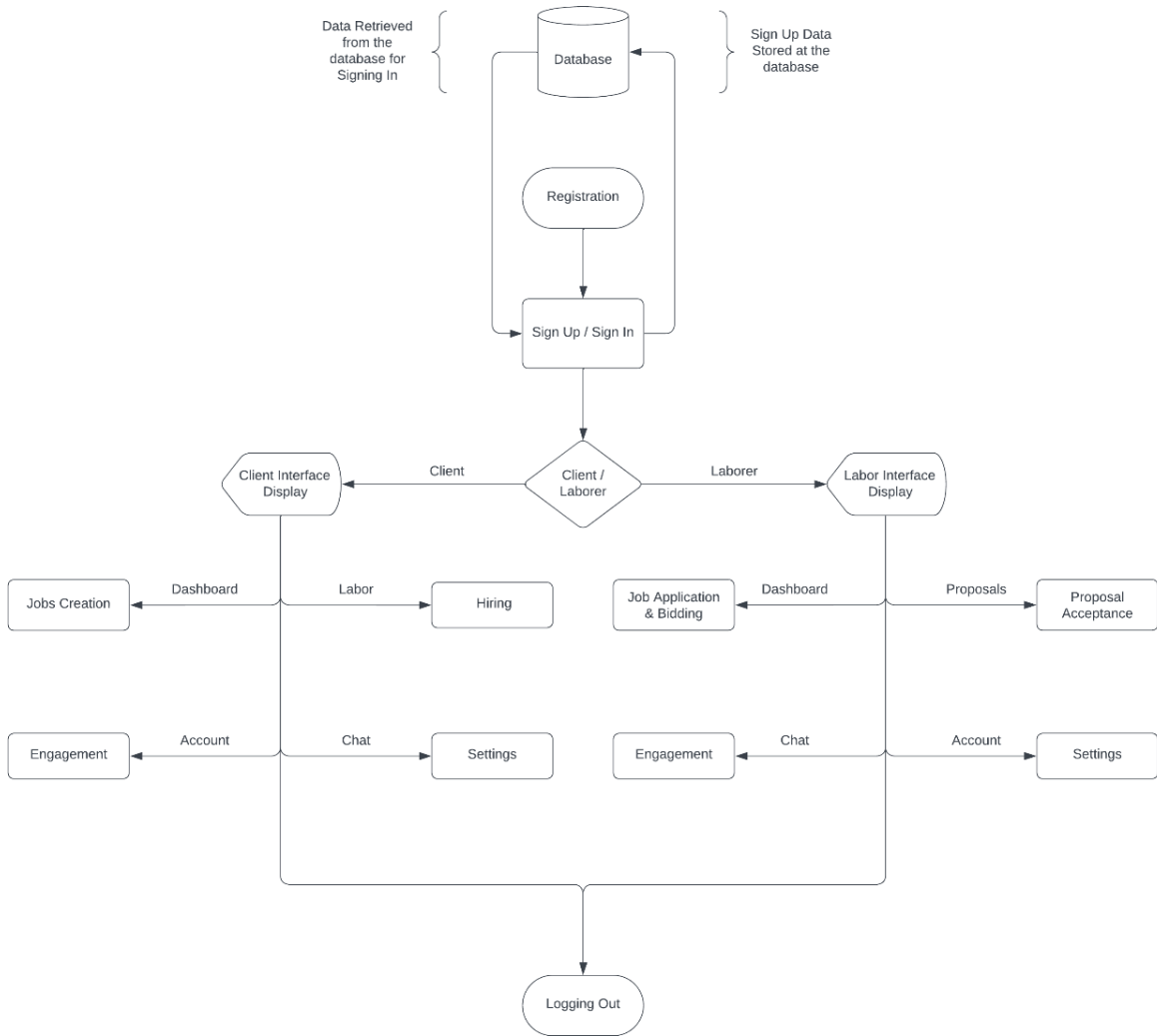
Figure 3: Flow diagram of Module One
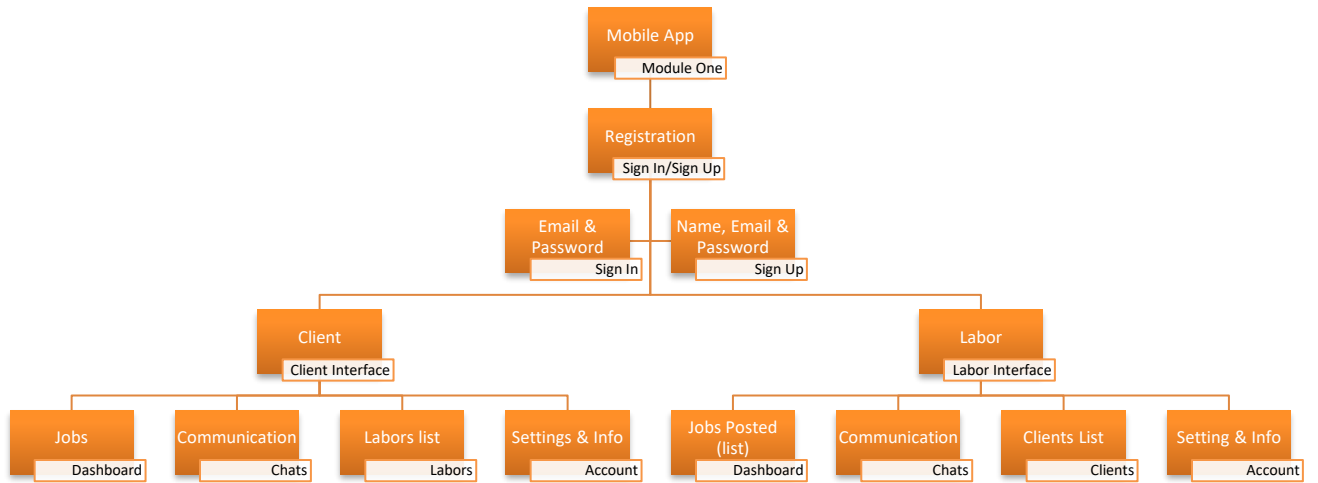
Figure 4 :Basic Structure of Module One

3.4 Framework for Revit Plugin

Module Two, a Revit Plugin, is an Autodesk Revit add on that complements Revit by allowing the software to integrate morphing Revit objects directly into the application. This plugin is written in C# coding language and provides you with a simple installation process.

The users log in by using the same password that they use in Module 1 to make certain that the whole process of authentication is reliable and secure. Initiating a Revit project, there is a prompt window where the name of the project and its ID should be entered. This detail is essential for accumulating data from projects correctly.

The user will now have the ability to initiate the project and select specific parts of the Revit model to be "quantified" in the export process. In addition, users can define project duration and modify preferences with ease via the the user-friendly interface. These preferences will help adjust the tasks' duration to what is required.

The plugin contains latest-generation supervised machine learning algorithms that build programs out of the given input. These schedules will be designed with the consideration of pre-determined number of workers required for certain tasks to meet the overall employment needs. If there are demands from customers for changing the schedule, the project continues to remain on track, due to the logical and adaptive changes that are programmed, which are facilitated by the reinforced learning capabilities of the plugin.

Module Two is concerned with extensive quantities export from the Revit model to an underlying database for proper data handling and reports.in Module One, these working hours are further combined and used for an efficient distribution of laborers to their individual roles.

It thus guarantees that the labor force is employed in a proper manner thus increasing the project productivity and efficiency.
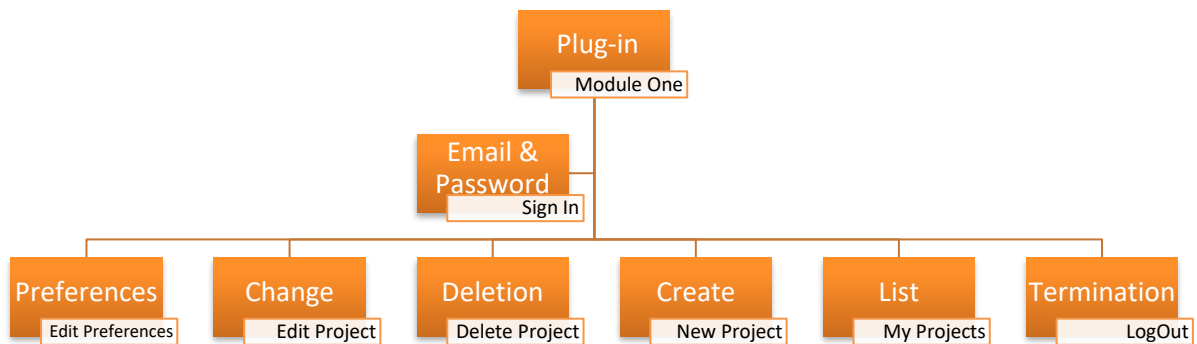
In the end, Module Two helps with enriching already successful capabilities of Revit by implementing sophisticated project regimens, automated planning, and incorporating with the already existing systems together with C# technologies and machine learning features.
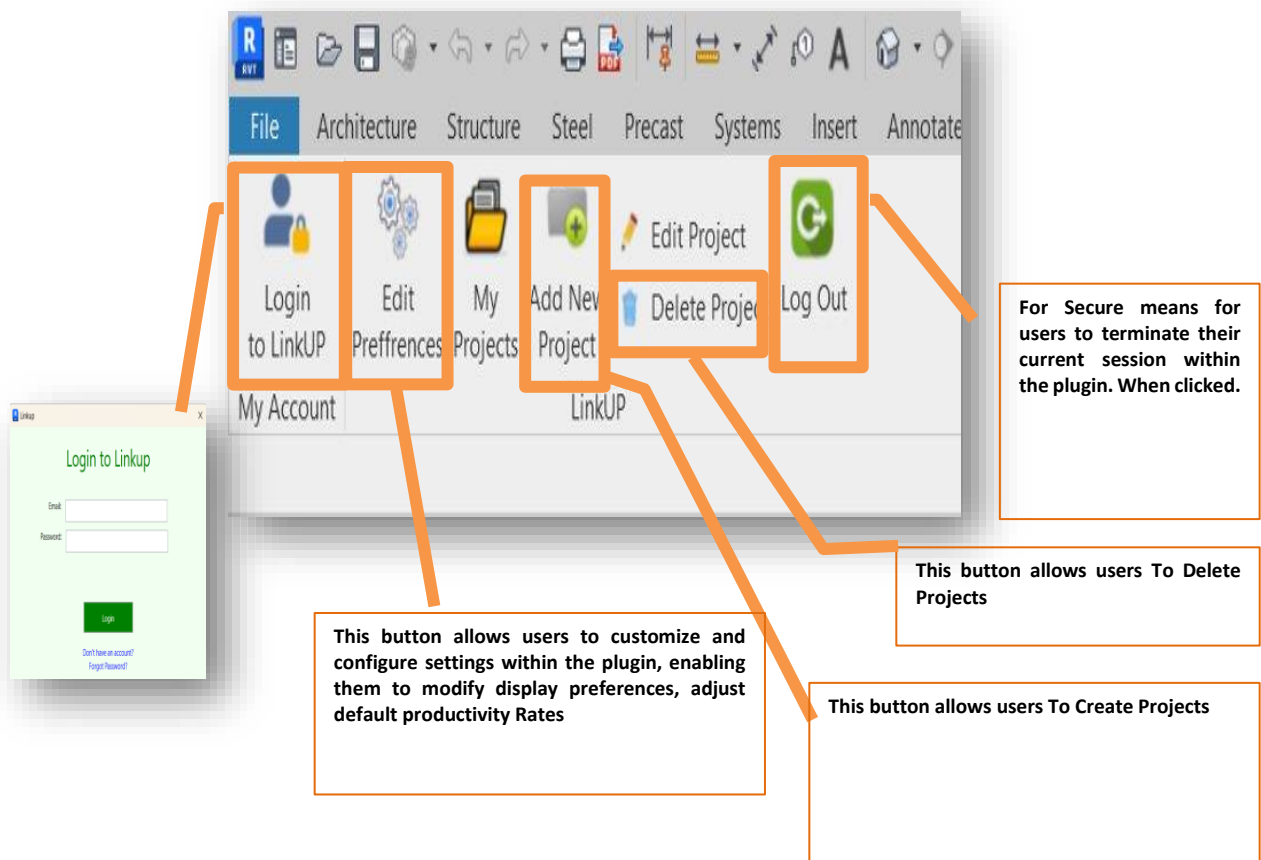
Figure 5 : Revit ribbons
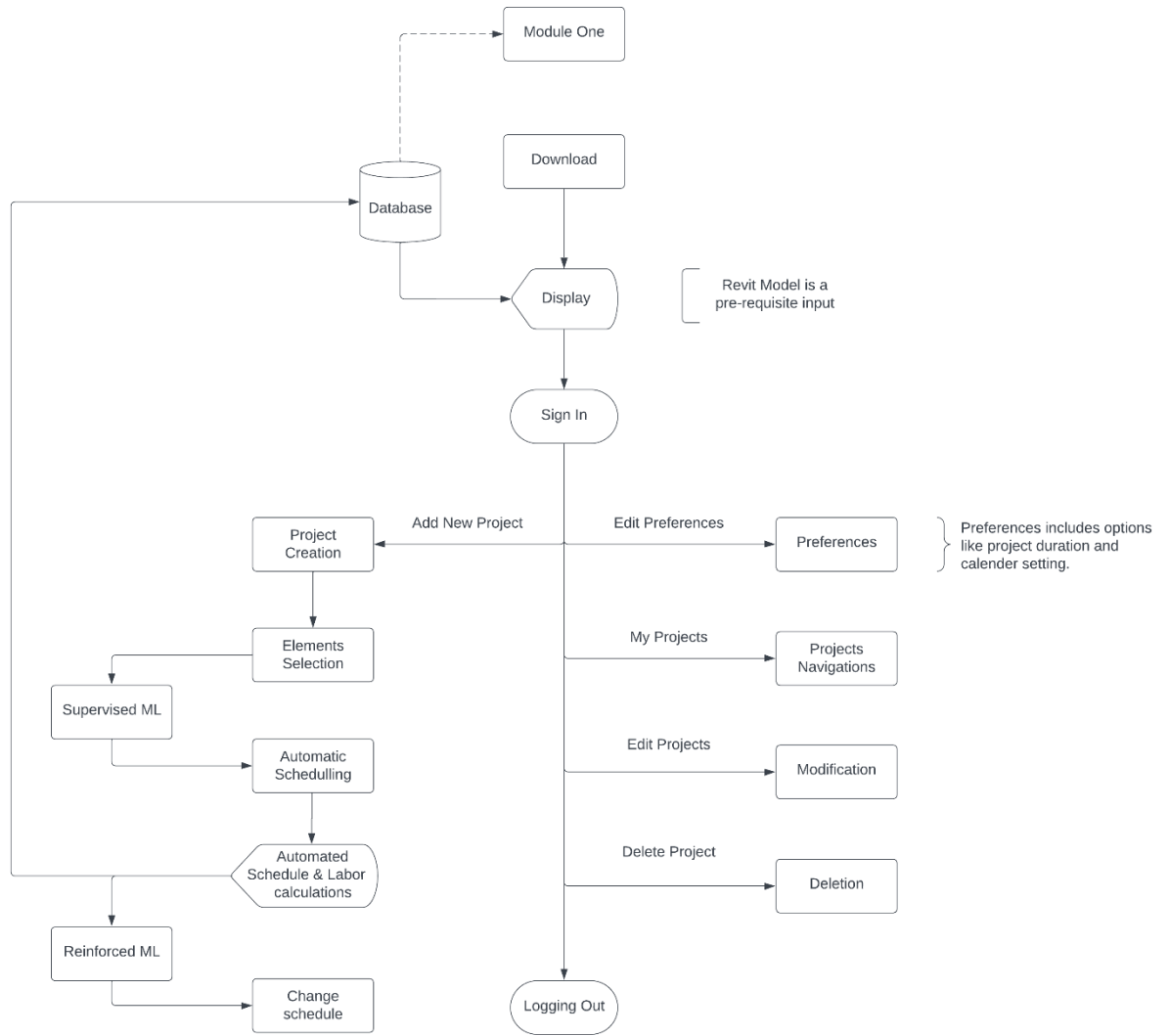
Figure 6 :Flow Diagram of Module Two

Figure 7 : Basic Structure of Module Two

CHAPTER 4

RESULTS AND ANALYSIS

4.1 Identification of inefficiencies in traditional project management and Labor Acquisition systems

During a construction project's lifecycle, many factors influence the efficiency of material and inventory management. Based on previous research and market analysis, different issues were identified as a hurdle in the smooth flow of the process. For the literature review, various sources such as "Google Scholar," ASCE" and "ICE VIRTUAL LIBRARY" were utilized whereas to cover the market analysis, a survey questionnaire was floated in construction industries of multiple cities in Pakistan gathering a response of 100+ respondents from the industry. Fifteen (15) papers were analyzed and the twenty most frequently occurring issues were scrutinized.

A table lists the twenty identified issues in inventory and materials management along with the frequency of their occurrence. From this, it was ascertained that these issues had a negative impact on material and inventory management in the construction industry.

4.2 Revit Plugin

Module Two as a Revit plugin, which is created with C#, is one of the most indispensable modules for Autodesk Revit. The plugin extends the basic capabilities of Revit by enabling users to work on projects, select model entities, extract quantities, dimensions and other properties and generate detailed work schedules and Quantity Takeoff (QTO) reports. Python web application as a back-end function provided by PythonAnywhere guarantees the smooth processing of data as well as the fast generation of reports.

4.2.1 Technologies Used

C#: This Plugin is designed for Revit to facilitate co-existence and allow a flawless user experience within the Revit environment.
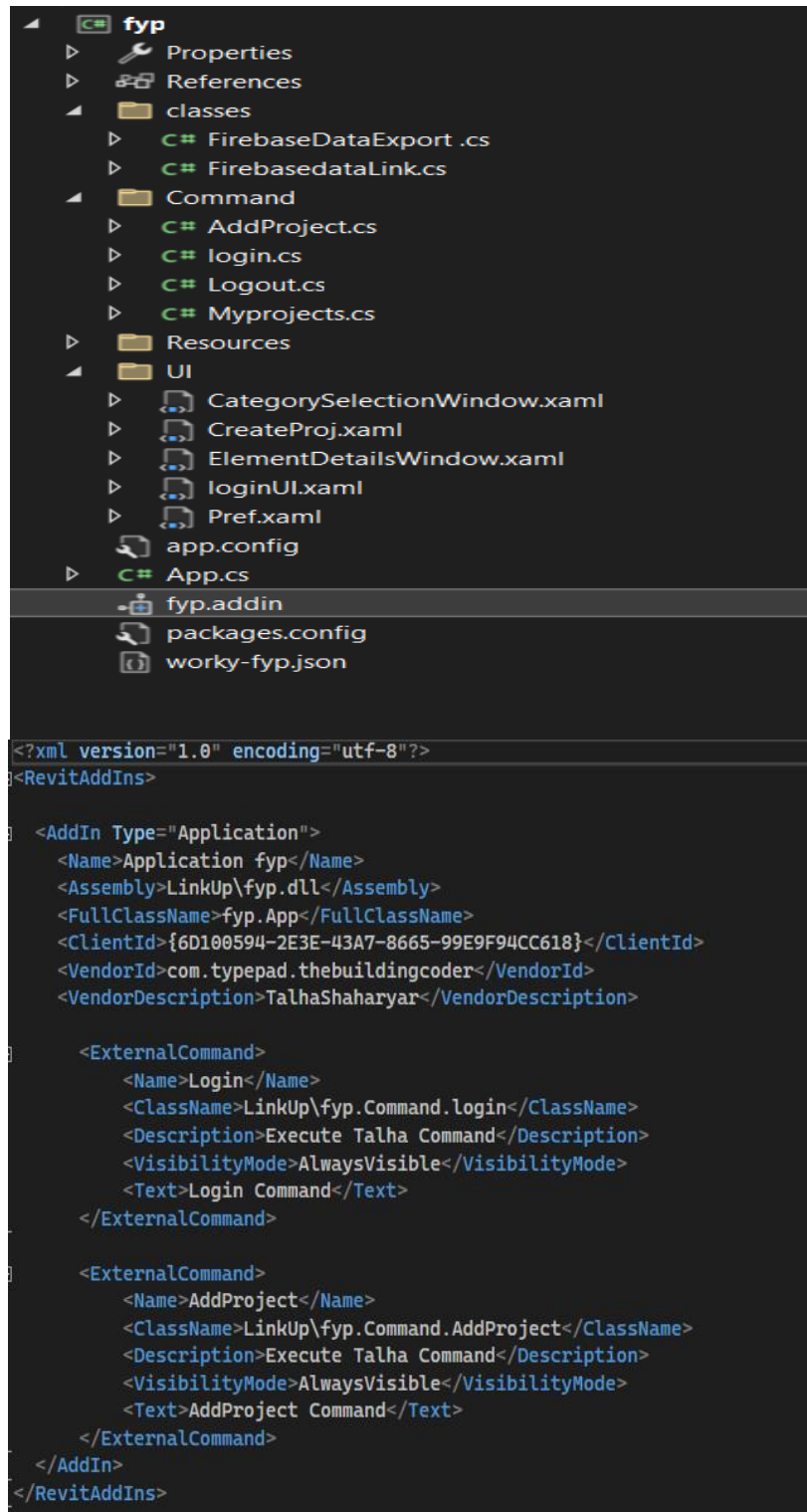

Figure 8: Plugin breakdown (properties and add in)

```csharp
public class App : IExternalApplication
{
    0 references
    public Result OnShutdown(UIControlledApplication application) { return Result.Succeeded; }
    0 references
    public Result OnStartup(UIControlledApplication application)
    {
        // Assembly
        string assemb = Assembly.GetExecutingAssembly().Location;
        string path = Path.GetDirectoryName(assemb);

        // Create the tab
        string tabName = "LinkUp";
        application.CreateRibbonTab(tabName);

        // Create panels
        var linkUpPanel = application.CreateRibbonPanel(tabName, "My Account");
        var accountPanel = application.CreateRibbonPanel(tabName, "LinkUP ");

        // Buttons
        PushButtonData loginButton = new PushButtonData("Login", "Login" + Environment.NewLine + "to LinkUP", assemb, "fyp.Command.Login");
        PushButtonData logOutButton = new PushButtonData("LogOut", "Log Out", assemb, "fyp.Command.Logout");
        PushButtonData userPrefButton = new PushButtonData("Edit_Preffrences", "Edit" + Environment.NewLine + "Preferences", assemb, "fyp.Command.WALL");
        PushButtonData myProjButton = new PushButtonData("Projects", "My" + Environment.NewLine + "Projects", assemb, "fyp.Command.Myprojects");
        PushButtonData createButton = new PushButtonData("CreateProj Button", "Add New" + Environment.NewLine + "Project", assemb, "fyp.Command.AddProject");
        PushButtonData deleteButton = new PushButtonData("DeleteButton", "Delete Project", assemb, "fyp.Command.Login");
        PushButtonData editButton = new PushButtonData("EditProj", "Edit Project", assemb, "fyp.Command.Login");

        // Set button images
        loginButton.LargeImage = new BitmapImage(new Uri(path + @"\Resources\login.ico"));
        logOutButton.LargeImage = new BitmapImage(new Uri(path + @"\Resources\logout.ico"));
        userPrefButton.LargeImage = new BitmapImage(new Uri(path + @"\Resources\settings.ico"));
        myProjButton.LargeImage = new BitmapImage(new Uri(path + @"\Resources
        createButton.LargeImage = new BitmapImage(new Uri(path + @"\Resources   class System.String
        deleteButton.Image = new BitmapImage(new Uri(path + @"\Resources\del   Represents text as a sequence of UTF-16 code units.
        editButton.Image = new BitmapImage(new Uri(path + @"\Resources\edit.ico"));

        // Add buttons to panels
        linkUpPanel.AddItem(loginButton);
        accountPanel.AddItem(userPrefButton);
        accountPanel.AddItem(myProjButton);
        accountPanel.AddItem(createButton);
        accountPanel.AddStackedItems(editButton, deleteButton);
        accountPanel.AddItem(logOutButton);
        logincheck(accountPanel);
        return Result.Succeeded;
    }
    1 reference
    private void logincheck(RibbonPanel accountPanel)
    {
        if(Properties.Settings.Default.FirebaseAuth != null)
        { accountPanel.Enabled = true; }
        else
        { accountPanel.Enabled = false; }
    }
}
```

Figure 9: Main App.css Command

- Firebase: We have considered the database solution to store project data, quantities, and other information as being employed with the utmost level of security.

- Python: Used for backend processing (such as timetable generation and class attendance data collection).

- PythonAnywhere: hosting and deploying python web app, adding remote process and report generation.

- HTTP Token Calls: Guarantees secure data exchange in between the Revit Plugin and the Python web application.

4.2.2 Project Creation and Initialization

- **User Input**: The user initiates the process by clicking on "Add New Project" within
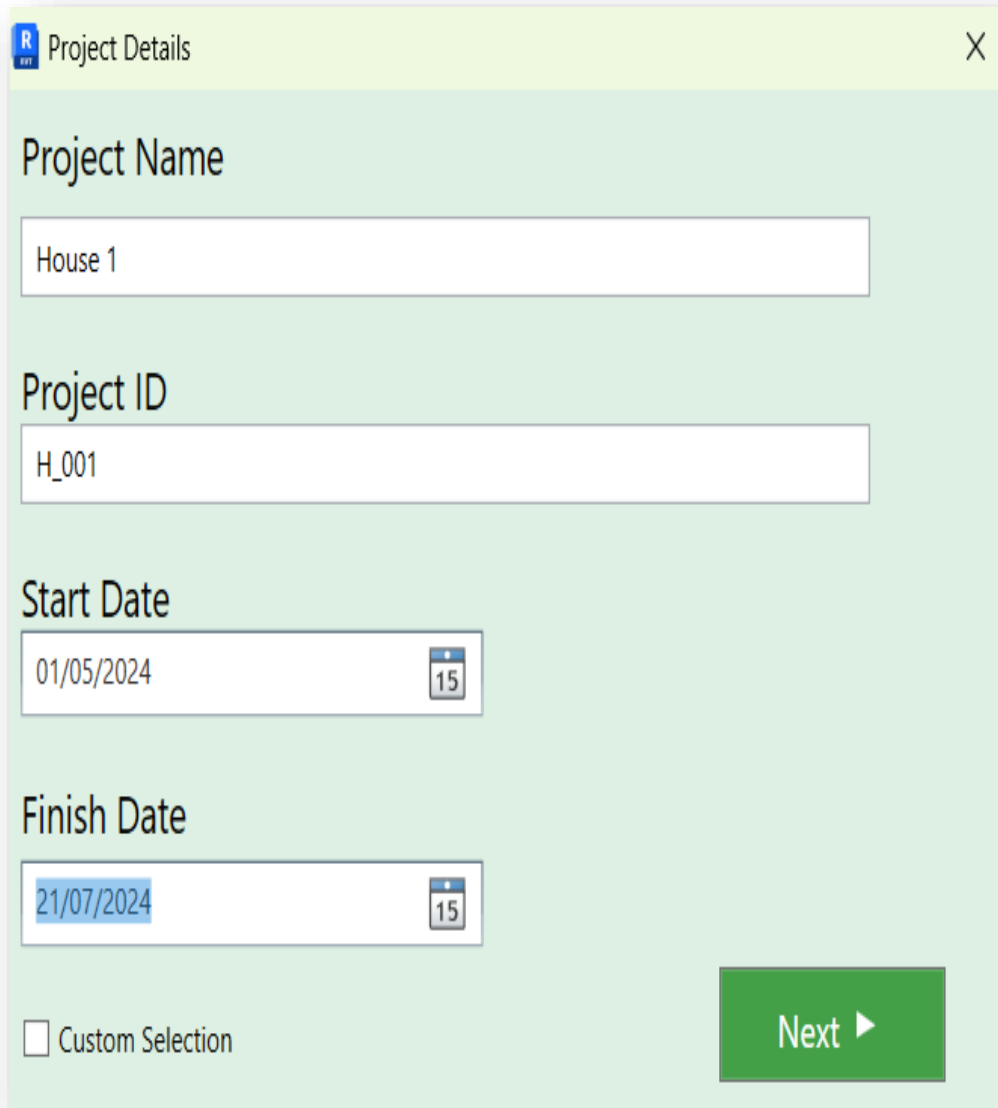
34

the Revit Plugin. They are prompted to enter the project name, project ID, start date, and end date.

This button allows users To Create Projects
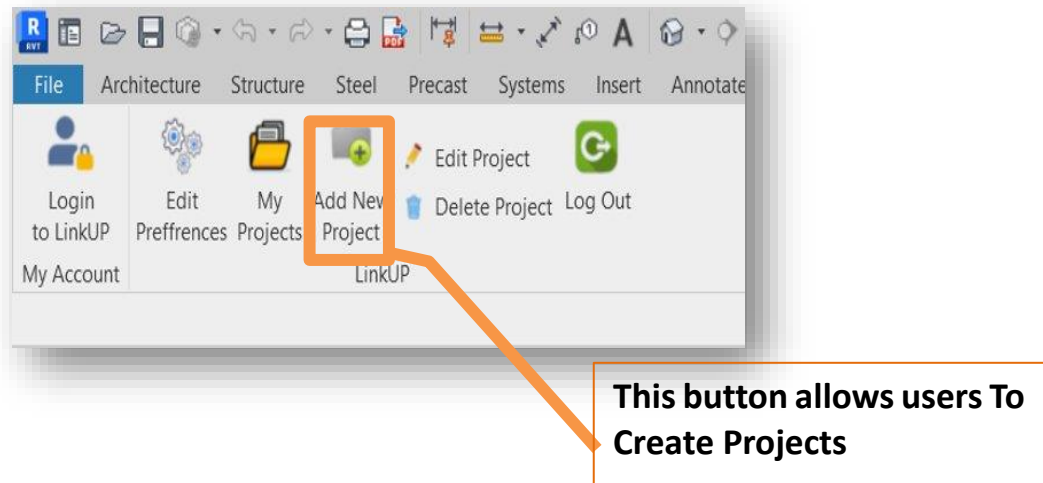
Figure 10: **Example Project Used in Revit**

4.2.3 Project Setup:

These data are extremely important as they are useful for scheduling and tracking the progress of the project. After getting in the project, it is created and ready for other users' actions.

Figure 11: Project setup in Revit

Figure 12: **Backend Code of Project Setup**

4.2.4 Element Selection in Revit Model

- ## Individual Element Selection：

Users have an option of taking individual components within the Revit model that are

crucial to the project in question. For that user First has to select the elements and

then he has to tap on add new Project Button on Our Addin (he has to select the

Check Box on the Project Detail Window

If user want to select the Individual Element

- **Category Selection**: Moreover, users can pick up items by category, that in turn facilitates selection of items by type in the whole project. This flexibility implies that users will find it easier to maintain and manage even the most complicated and large-scale models.

- It Shows all The categories user has used in His Project in paticuar exalaample user only used the Door,Floors ,Walls and Windows user can select any category he want
- it will only extract the quanties of those categories
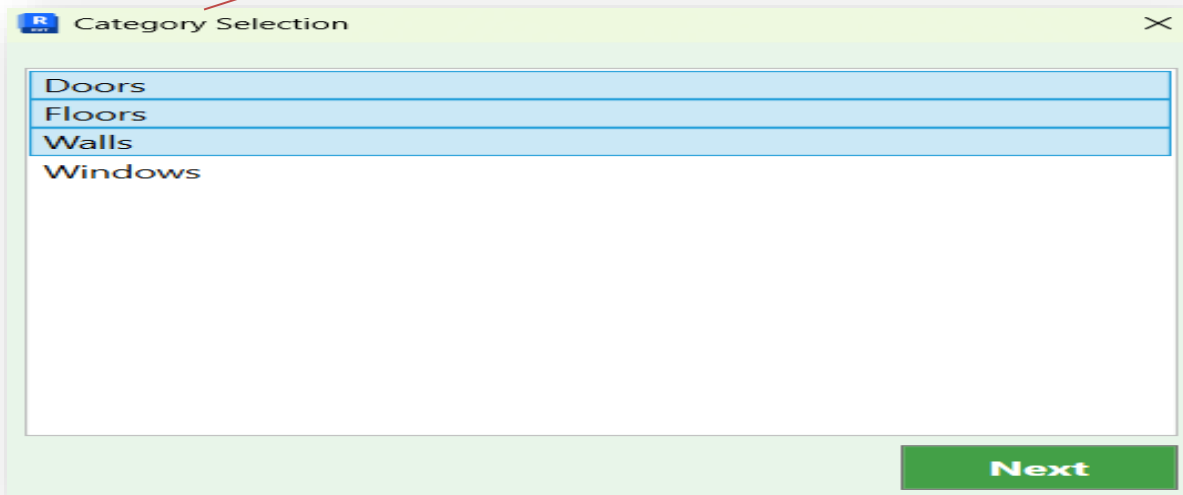
Figure 13: Element selection in Revit model


```
try
{
    if (uidoc.Selection.GetElementIds().Count == 0)
    {

        MessageBox.Show("Please select at least one element.", "LinkUP", MessageBoxButton.OK, MessageBoxImage.Warning);
        return Result.Failed;
    }

    // Get the selected element ids
    ICollection<ElementId> selectedElementIds = uidoc.Selection.GetElementIds();

    // Create a list to store selected elements
    List<Element> selectedElements = new List<Element>();

    // Loop through the selected element ids and get the corresponding elements
    foreach (ElementId elementId in selectedElementIds)
    {
        Element selectedElement = doc.GetElement(elementId);
        selectedElements.Add(selectedElement);
    }
    ElementWindow(selectedElements, Path, doc);
    // Do something with the list of selected elements (e.g., print their names)
}
catch (Autodesk.Revit.Exceptions.OperationCanceledException)
{
    // User cancelled the selection
    return Result.Cancelled;
}

return Result.Succeeded;
```

Figure 14: **Category selection logic code**

```
List<BuiltInCategory> physicalObjectCategories = new List<BuiltInCategory>
{
    BuiltInCategory.OST_Doors,
    BuiltInCategory.OST_Walls,
    BuiltInCategory.OST_Floors,
    BuiltInCategory.OST_Roofs,
    BuiltInCategory.OST_Ceilings,
    BuiltInCategory.OST_Columns,
    BuiltInCategory.OST_Purlin,
    BuiltInCategory.OST_Windows,
    BuiltInCategory.OST_StructuralColumns,
    BuiltInCategory.OST_StructuralFraming,
    BuiltInCategory.OST_StructuralFoundation,
    BuiltInCategory.OST_StructuralTruss,

    // Add other categories as needed

HashSet<string> usedCategories = new HashSet<string>();

foreach (BuiltInCategory bic in physicalObjectCategories)
{
    FilteredElementCollector collector = new FilteredElementCollector(doc)
        .OfCategory(bic)
        .WhereElementIsNotElementType();

    if (collector.Any()) // Check if the category has any elements
    {
        Category category = Category.GetCategory(doc, bic);
        if (category != null)
        {
            usedCategories.Add(category.Name);
        }
    }
}

// Sort categories for better readability
List<string> sortedCategories = usedCategories.ToList();
sortedCategories.Sort();
if (sortedCategories.Count == 0)
{
    MessageBox.Show($"Oops! It seems there are no instances available at the moment." +
        $" Please double - check your selections and try again.", "LinkUP", MessageBoxButton.OK, MessageBoxImage.Warning);
    return Result.Cancelled;
}
CategorySelectionWindow categorySelectionWindow = new CategorySelectionWindow(sortedCategories);
if (categorySelectionWindow.ShowDialog() == true)
{
    // Retrieve the selected categories from the window
    List<string> selectedCategories = categorySelectionWindow.GetSelectedCategories();

    // Collect elements of all selected categories
    List<Element> allElements = new List<Element>();
    foreach (string category in selectedCategories)
    {
        List<Element> elementsInCategory = GetElementsInCategory(doc, category);
        allElements.AddRange(elementsInCategory);
    }
```

Figure 15: Extract the Categories used in BIM model

4.2.5 Extraction of Quantities and Properties

- **Data Extraction**: Once the elements are picked, it pulls quantities, elevation, and dependent elements among others. It is the comprehensive extraction which satisfies all the requirements for proper project management.

Elevation of Each elemenet will help in Scedulling

Material used in Each elemenet will help in Scedulling

Elements which are Dependent on Element will help in Scedulling

ID	Name	Volume	Level	Elevation	Area	Category	Material	DependentElemen
321302	Wall-Ext_102Bwk-7	8.07 m³	Ground Floor	0	26 m²	Walls	Brick, Common,Plas	327984
321356	Wall-Ext_102Bwk-7	1.44 m³	Ground Floor	0	5 m²	Walls	Brick, Common,Plas	322401
321396	Wall-Ext_102Bwk-7	6.30 m³	Ground Floor	0	21 m²	Walls	Brick, Common,Plas	323819,329141
321442	Wall-Ext_102Bwk-7	14.65 m³	Ground Floor	0	48 m²	Walls	Brick, Common,Plas	328028,328086
321469	Wall-Ext_102Bwk-7	14.28 m³	Ground Floor	0	47 m²	Walls	Brick, Common,Plas	323694,323787
321525	Wall-Ext_102Bwk-7	14.68 m³	Ground Floor	0	48 m²	Walls	Brick, Common,Plas	323239,323289
321569	Wall-Ext_102Bwk-7	5.76 m³	Ground Floor	0	19 m²	Walls	Brick, Common,Plas	
321623	Wall-Ext_102Bwk-7	5.24 m³	Ground Floor	0	17 m²	Walls	Brick, Common,Plas	323509
321766	Wall-Ext_102Bwk-7	5.24 m³	Ground Floor	0	17 m²	Walls	Brick, Common,Plas	323585
321828	Wall-Ext_102Bwk-7	2.27 m³	Ground Floor	0	7 m²	Walls	Brick, Common,Plas	323434
321855	Wall-Ext_102Bwk-7	2.27 m³	Ground Floor	0	7 m²	Walls	Brick, Common,Plas	323359
321999	Wall-Ext_102Bwk-7	4.92 m³	Ground Floor	0	16 m²	Walls	Brick, Common,Plas	329310
322064	Wall-Ext_102Bwk-7	4.37 m³	Ground Floor	0	14 m²	Walls	Brick, Common,Plas	322515
322099	Wall-Ext_102Bwk-7	9.20 m³	Ground Floor	0	30 m²	Walls	Brick, Common,Plas	329403
322292	Wall-Ext_102Bwk-7	4.46 m³	Ground Floor	0	15 m²	Walls	Brick, Common,Plas	
322324	Wall-Ext_102Bwk-7	1.86 m³	Ground Floor	0	6 m²	Walls	Brick, Common,Plas	
322971	Wall-Ext_102Bwk-7	6.13 m³	Ground Floor	0	20 m²	Walls	Brick, Common,Plas	
325030	Wall-Ext_102Bwk-7	8.07 m³	First Floor	13.1233595800525	26 m²	Walls	Brick, Common,Plas	328241
325031	Wall-Ext_102Bwk-7	2.60 m³	First Floor	13.1233595800525	9 m²	Walls	Brick, Common,Plas	
325032	Wall-Ext_102Bwk-7	6.95 m³	First Floor	13.1233595800525	23 m²	Walls	Brick, Common,Plas	325057
325033	Wall-Ext_102Bwk-7	16.35 m³	First Floor	13.1233595800525	54 m²	Walls	Brick, Common,Plas	
325034	Wall-Ext_102Bwk-7	14.28 m³	First Floor	13.1233595800525	47 m²	Walls	Brick, Common,Plas	325055,325056
325035	Wall-Ext_102Bwk-7	14.68 m³	First Floor	13.1233595800525	48 m²	Walls	Brick, Common,Plas	325049,325050
325036	Wall-Ext_102Bwk-7	5.76 m³	First Floor	13.1233595800525	19 m²	Walls	Brick, Common,Plas	

Figure 16: Extraction of Quantities and Properties

```
1 reference
public ElementDetailsWindow(List<Element> elements, string Path,Document doc)
{
    doc1 = doc;
    MyList = elements;
    path = Path;

    InitializeComponent();

    // Populate the DataGrid with element details
    dataGrid.ItemsSource = elements.Select(element => new
    {
        Id = element.Id.IntegerValue,
        Name = element.Name,
        Volume = GetParameterAsString(element, "Volume"),
        //Level = GetParameterAsString(element, "Level"),
        Level = level(element, doc, "Level"),
        Elevation =level(element,doc,"Elevation"),
        Category = element.Category.Name,
        Area = GetParameterAsString(element, "Area"),
        Material = GetMaterialNames(element),
        DependentElementIds = GetDependentElementIds(element),
        //per =element.Parameters.


        // Add more properties as needed
    });
}
```

Figure 17: Data Extraction

```
public string GetMaterialNames(Element element)
{
    // Get the list of material ElementIds associated with the element
    List<ElementId> materialIds = element.GetMaterialIds(false).ToList();

    // Get the names of materials using LINQ
    IEnumerable<string> materialNames = materialIds.Select(materialId =>
    {
        Material material = element.Document.GetElement(materialId) as Material;
        return material?.Name;
    });

    // Join the names using comma separator
    return string.Join(",", materialNames);
}
2 references
public string GetDependentElementIds(Element element)
{
    // Initialize an empty list to store dependent element IDs
    List<int> dependentElementIds = new List<int>();
    ElementFilter[] filters = new ElementFilter[]
    {
            new ElementClassFilter(typeof(Wall)),
            new ElementClassFilter(typeof(Floor)),
            new ElementClassFilter(typeof(Ceiling)),
            new ElementClassFilter(typeof(FamilyInstance))
    };

    ElementFilter combinedFilter = new LogicalOrFilter(filters);
    // Get the dependent elements of the given element
    ICollection<ElementId> dependentElements = element.GetDependentElements(combinedFilter);

    // Iterate through the dependent elements and extract their IDs
    if (dependentElements != null)
    {
        // Iterate through the dependent elements and extract their IDs
        foreach (ElementId dependentElementId in dependentElements)
        {
            if (dependentElementId.IntegerValue != element.Id.IntegerValue)
            {
                dependentElementIds.Add(dependentElementId.IntegerValue);
            }
        }
    }
```

Figure 18: Data Extraction

- **Data Upload**: The extracted data is then uploaded to Firebase with confidence that the data is well secured for futher processing.
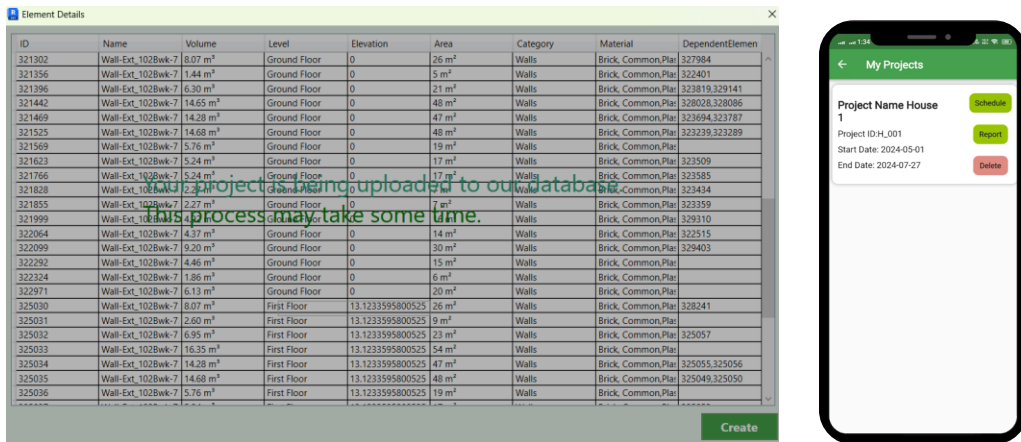
Figure 19:Data Upload

- **Backend Functionality**: All the data that was uploaded to Firebase was processed by our web application that is written in Python. This application hosted on PythonAnywhere would initiate through HTTP token calls to provide safe and quick data exchange.

- **Explicit Programming for Schedule Creation:** We do not use machine learning in the process creating project schedules, but we use explicit programming methods instead. This means rules that operate automatically and employ logic to determine the best possible schedule based on the project parameters, task dependencies and the available resource.

- **Report Compilation:** The rear end assembles a neat QTO report using the data that was extracted. The report has all the necessary values and properties that are well organized in a way that you can easily understand.

- **PDF Generation:** Both the schedule and QTO reports are generated in PDF format using library as Report Lab or Weasyprint. These briefs are formatted to look professional, simple to read and can be used for project management and client communication directly.

![LinkUp QTO Report of House 1]

QTO Report of House 1

| Id	Name	Catagory	Level	Elevation	Volume	Area
320987	Plain	Ceilings	Level 0	0	6.23 m²	109 m²
321001	Plain	Ceilings	Level 1	13.1233585800525	6.23 m²	109 m²
321460	1810x2110mm	Doors	Level 0	0	0.19 m²	5 m²
320844	Floor-Grnd-Susp_65Scr-80Ins-100Blk-75PC	Floors	Level 0	0	55.20 m²	117 m²
320857	Floor-Grnd-Susp_65Scr-80Ins-100Blk-75PC	Floors	Level 1	13.1233585800525	78.47 m²	167 m²
320975	Floor-Grnd-Susp_65Scr-80Ins-100Blk-75PC	Floors	Level 1	13.1233585800525	78.47 m²	167 m²
320692	Wall-Ext_102Bwk-75Ins-100LBk-12P	Walls	Level 0	0	8.01 m²	28 m²
320708	Wall-Ext_102Bwk-75Ins-100LBk-12P	Walls	Level 0	0	4.55 m²	16 m²
320729	Wall-Ext_102Bwk-75Ins-100LBk-12P	Walls	Level 0	0	4.24 m²	15 m²
320746	Wall-Ext_102Bwk-75Ins-100LBk-12P	Walls	Level 0	0	8.01 m²	28 m²
320777	Wall-Ext_102Bwk-75Ins-100LBk-12P	Walls	Level 0	0	12.01 m²	41 m²
320803	Wall-Ext_102Bwk-75Ins-100LBk-12P	Walls	Level 0	0	13.42 m²	46 m²
320944	Wall-Ext_102Bwk-75Ins-100LBk-12P	Walls	Level 1	13.1233585800525	8.01 m²	28 m²
320945	Wall-Ext_102Bwk-75Ins-100LBk-12P	Walls	Level 1	13.1233585800525	5.66 m²	20 m²
320946	Wall-Ext_102Bwk-75Ins-100LBk-12P	Walls	Level 1	13.1233585800525	4.24 m²	15 m²
320947	Wall-Ext_102Bwk-75Ins-100LBk-12P	Walls	Level 1	13.1233585800525	8.01 m²	28 m²
320948	Wall-Ext_102Bwk-75Ins-100LBk-12P	Walls	Level 1	13.1233585800525	12.01 m²	41 m²
320949	Wall-Ext_102Bwk-75Ins-100LBk-12P	Walls	Level 1	13.1233585800525	13.42 m²	46 m²
321022	910x910mm	Windows	Level 0	0	0.04 m²	2 m²
321087	910x910mm	Windows	Level 0	0	0.04 m²	2 m²
321104	910x910mm	Windows	Level 0	0	0.04 m²	2 m²
321134	910x910mm	Windows	Level 0	0	0.04 m²	2 m²
321172	910x910mm	Windows	Level 0	0	0.04 m²	2 m²
321196	910x910mm	Windows	Level 0	0	0.04 m²	2 m²
321242	910x910mm	Windows	Level 0	0	0.04 m²	2 m²
321266	910x910mm	Windows	Level 0	0	0.04 m²	2 m²
321284	910x910mm	Windows	Level 0	0	0.04 m²	2 m²
321406	910x910mm	Windows	Level 0	0	0.04 m²	2 m²
321580	910x910mm	Windows	Level 1	13.1233585800525	0.04 m²	2 m²
321581	910x910mm	Windows	Level 1	13.1233585800525	0.04 m²	2 m²
321582	910x910mm	Windows	Level 1	13.1233585800525	0.04 m²	2 m²
321583	910x910mm	Windows	Level 1	13.1233585800525	0.04 m²	2 m²
321584	910x910mm	Windows	Level 1	13.1233585800525	0.04 m²	2 m²
321585	910x910mm	Windows	Level 1	13.1233585800525	0.04 m²	2 m²
321586	910x910mm	Windows	Level 1	13.1233585800525	0.04 m²	2 m²
321587	910x910mm	Windows	Level 1	13.1233585800525	0.04 m²	2 m²

Figure 20:Quantities Report

4.2.6 Storage and Access Generated Reports

- **Firebase Storage**: The generated schedule.pdf and qto.pdf are uploaded to Firebase, ensuring they are securely stored and accessible from our Mobile Application which will elp user to find how many labors user need for any activity Scheduled.

- **Notification to User**: The backend sends a notification to the Revit Plugin, indicating that the project is live on Linkup.

Activity Name	Start	finish	Skilled labour	Unskilled labour
BrickStonework of Walls on Level 0	2024-05-01	2024-05-15	2.0	3.1
FormWork_Creation of Floors on Level 1	2024-05-15	2024-05-28	4.1	6.1
FormWork_installation of Floors on Level 1	2024-05-28	2024-06-13	4.1	6.1
Concreting of Floors on Level 1	2024-06-14	2024-06-21	2.0	3.1
BrickStonework of Walls on Level 1	2024-06-21	2024-07-05	2.0	3.1
Window_Installation of Windows on Level 0	2024-06-25	2024-06-25	2.0	2.0
Window_Installation of Windows on Level 1	2024-07-02	2024-07-02	2.0	2.0
Plasterwork of Walls on Level 0	2024-07-06	2024-07-14	2.0	3.1
Plasterwork of Walls on Level 1	2024-07-06	2024-07-14	2.0	3.1
Flooring of Floors on Level 0	2024-07-06	2024-07-08	2.0	3.1
Ceiling_Installation of Ceilings on Level 1	2024-07-15	2024-07-17	4.1	6.1
Paint of Ceilings on Level 1	2024-07-15	2024-07-17	2.0	2.0
Paint of Walls on Level 1	2024-07-15	2024-07-19	2.0	2.0
Tilling of Floors on Level 1	2024-07-15	2024-07-26	2.0	3.1
Door_Installation of Doors on Level 0	2024-07-17	2024-07-17	4.1	6.1
Ceiling_Installation of Ceilings on Level 0	2024-07-17	2024-07-19	4.1	6.1
Paint of Doors on Level 0	2024-07-17	2024-07-17	2.0	2.0
Paint of Walls on Level 0	2024-07-17	2024-07-21	2.0	2.0

Figure 21: Resource Calculation Report
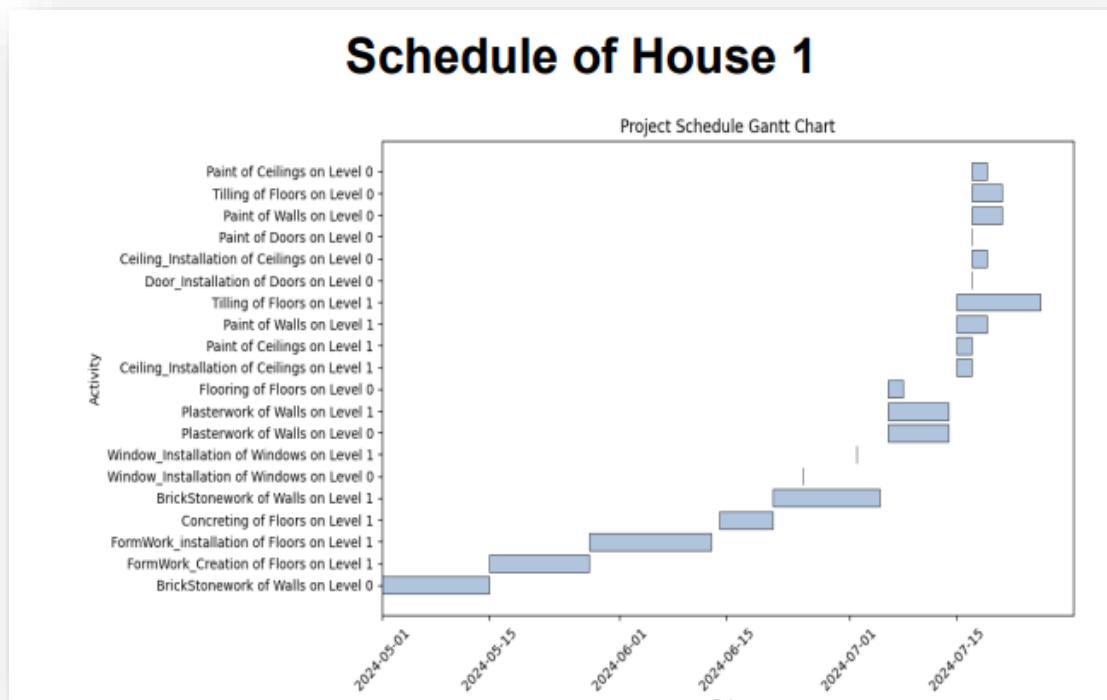
Figure 22: BIM generated Schedule (automatic schedule)

4.2.7 User Access and Download

- **My Projects Tab**: Users can access the "My Projects" tab within the mobile application (Module One) to view and download the generated reports from the app

- **Download Option**: The reports are available for download, allowing users to save them locally for offline access or share them with stakeholders as needed.
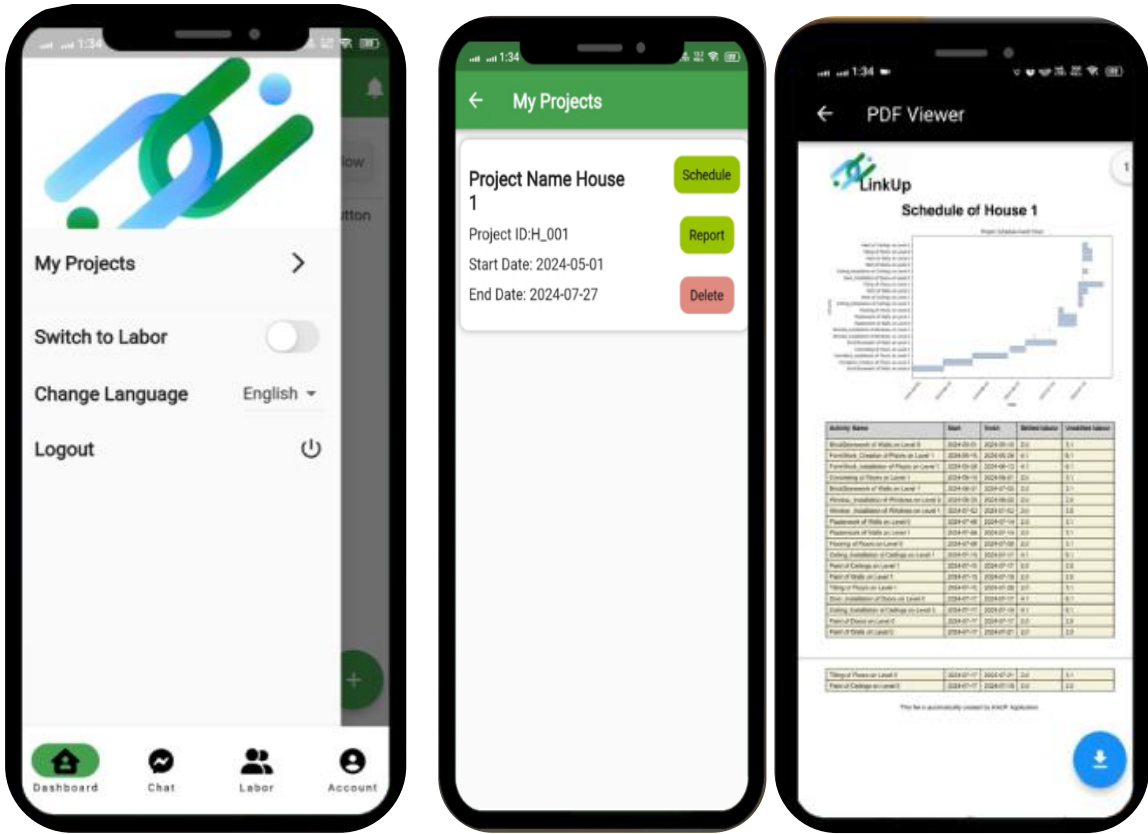
Figure 23: User access and Download

4.3 Linkup mobile application

In another phase, a mobile app with a user-friendly interface was developed which would make it easy for the users to have an overview of the project. The app has an where client and labor data is stored. It also has the option to hire the labor of the projects. It has two (02) login portals, one each for contractors and clients. The contractors can keep a record of all their undergoing projects whereas it also has a direct messaging portal for communication between the stakeholders. Module One makes it possible for the employer to meet face-to-face with workers and the other way around too. The customer may simply place an order for a job to be done by laborers who submit their respective bids to win the job. The employer provides such opportunities that workers can choose as agreed. They can simply chat with each other in the chat. Each stakeholder can see his or her account details and can access various settings as well they can always alert themselves of past projects done.

The methodology used in this project involved the use of several software and tools to ensure that the application was developed to meet the required specifications. The project was divided into two phases: the design phase and the development phase.

4.3.1 Design phase.

The design phase involved the use of Figma software to create the user interface and experience design for the application. Figma was chosen for its collaborative features which allowed multiple team members to work on the same project simultaneously. The design phase involved creating the wireframes, prototyping, and designing the user interface. The design was created based on the recommendations provided by the supervisor and user feedback was taken into consideration when making design decisions

4.3.2 Development phase

The development phase involved the use of Visual Studio and Flutter Framework supported by Dart language to code the Android version of the application. Flutter framework was chosen for its ease of use and the fact that it supports multiple programming languages. The coding phase involved creating the login page, the home screen, and the distinct options available to the user.

The coding phase was completed in 12 weeks and once the Android version was completed, it was evaluated on multiple devices to ensure that it was working as expected.

4.3.3 Testing

The testing phase was a critical part of the development process, involving both manual and automated testing to thoroughly evaluate the application. Automated testing was conducted using Appium, a popular automation tool for mobile applications. Appium facilitated the creation of a suite of automated tests that covered a wide range of scenarios, from simple user interactions to complex workflows, which helped save time and improve the efficiency of the testing process. These automated tests were run continuously to catch regressions early and ensure ongoing stability.

In parallel, manual testing was performed to validate the user interface and user experience across different devices. This included checking for consistency in layout, responsiveness, and overall usability. Testers simulated real-world usage conditions to identify any potential issues that might not be caught by automated tests. They also paid close attention to performance metrics, such as load times and memory usage, to ensure the application was both fast and resource-efficient.

The testing phase was completed in two weeks. During this time, any issues discovered were documented, prioritized, and addressed promptly. Once the application passed all tests and

met the acceptance criteria, it was submitted to the client for final approval. Upon receiving the client's approval, the application was prepared for release. This involved creating app store listings, ensuring compliance with store guidelines, and performing final checks to make sure the app was ready for users.

The successful completion of the testing phase marked the readiness of the application for public release. It was then deployed to app stores, making it accessible to users who could benefit from its features. The meticulous testing process ensured that the application delivered a high-quality, reliable, and user-friendly experience from day one.

4.3.4 Methodology

The development phase involved the use of Visual Studio and Flutter Framework, supported by the Dart language, to code the Android version of the application. Flutter framework was chosen for its ease of use and its capability to support multiple programming languages, making it an ideal choice for cross-platform development. The coding phase was meticulously planned and executed, starting with the creation of the login page, followed by the development of the home screen, and finally incorporating the distinct options available to the user. Each component was crafted with attention to detail to ensure a seamless user experience.
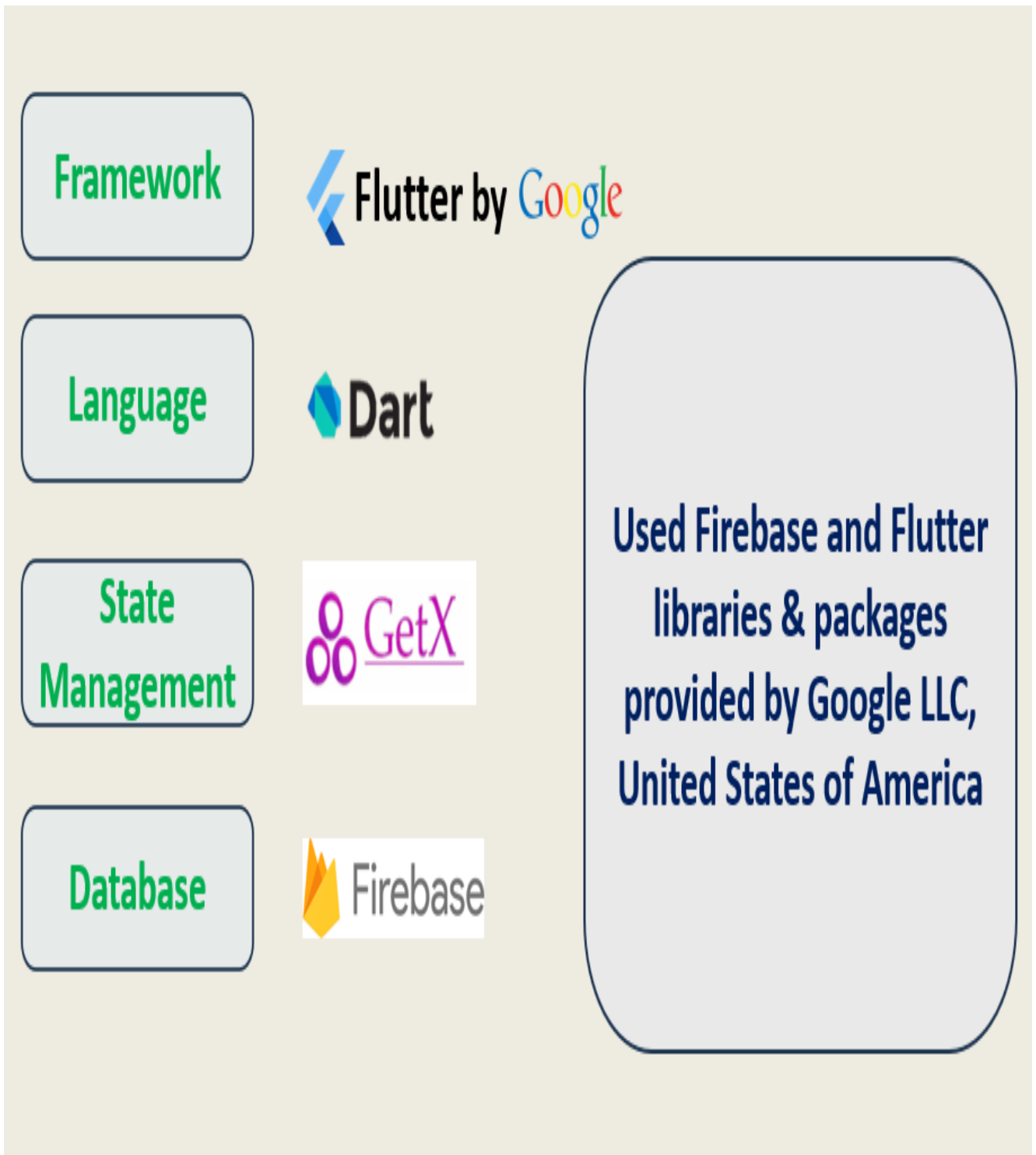
Figure 24: Application Methodology

4.3.5 App features

- **Sign** up/ login:

    The app begins with a login page, offering users the options to sign in or sign up. The Sign-Up process starts by asking the user to choose between signing up as a client or a contractor, although the initial signup steps are the same for both user types. Users are prompted to enter their details, such as name, email, password, and phone number, to create a new account. After entering their details, users must verify their account using a phone number verification process, which ensures the authenticity of the user.Once the account is created and verified, users can log in using their email and password. The login page also includes features to reset the password if forgotten, and an option to sign in using a One-Time Password (OTP) sent to the user's registered phone number, providing a convenient and secure alternative to traditional password-based login.
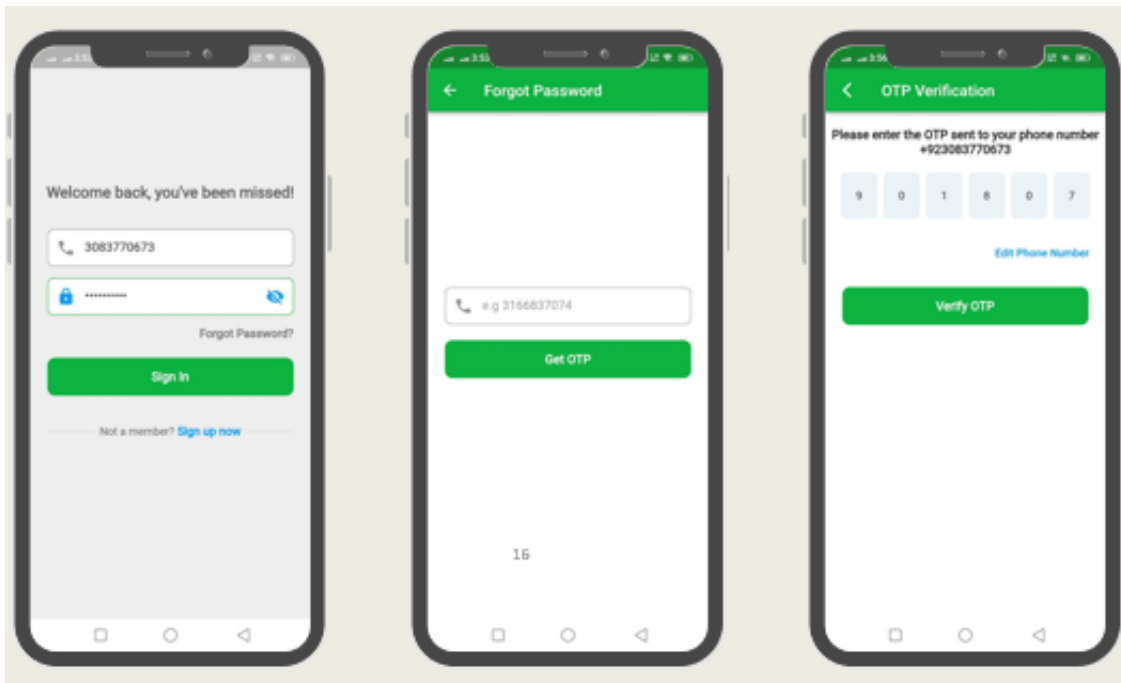
Figure 25: Application login Screen

- **User profile:**

  Once logged in, the user is greeted with the home screen that provides the user profile icon and details. The user can update their profile information, such as name, contact details, and profile picture. So, there are two interfaces in our app, one for clients which could be individuals or businesses and the other one for labor which could be mason, laborer, electrician, plumber and so on.

- **Flow chart for client interface:**
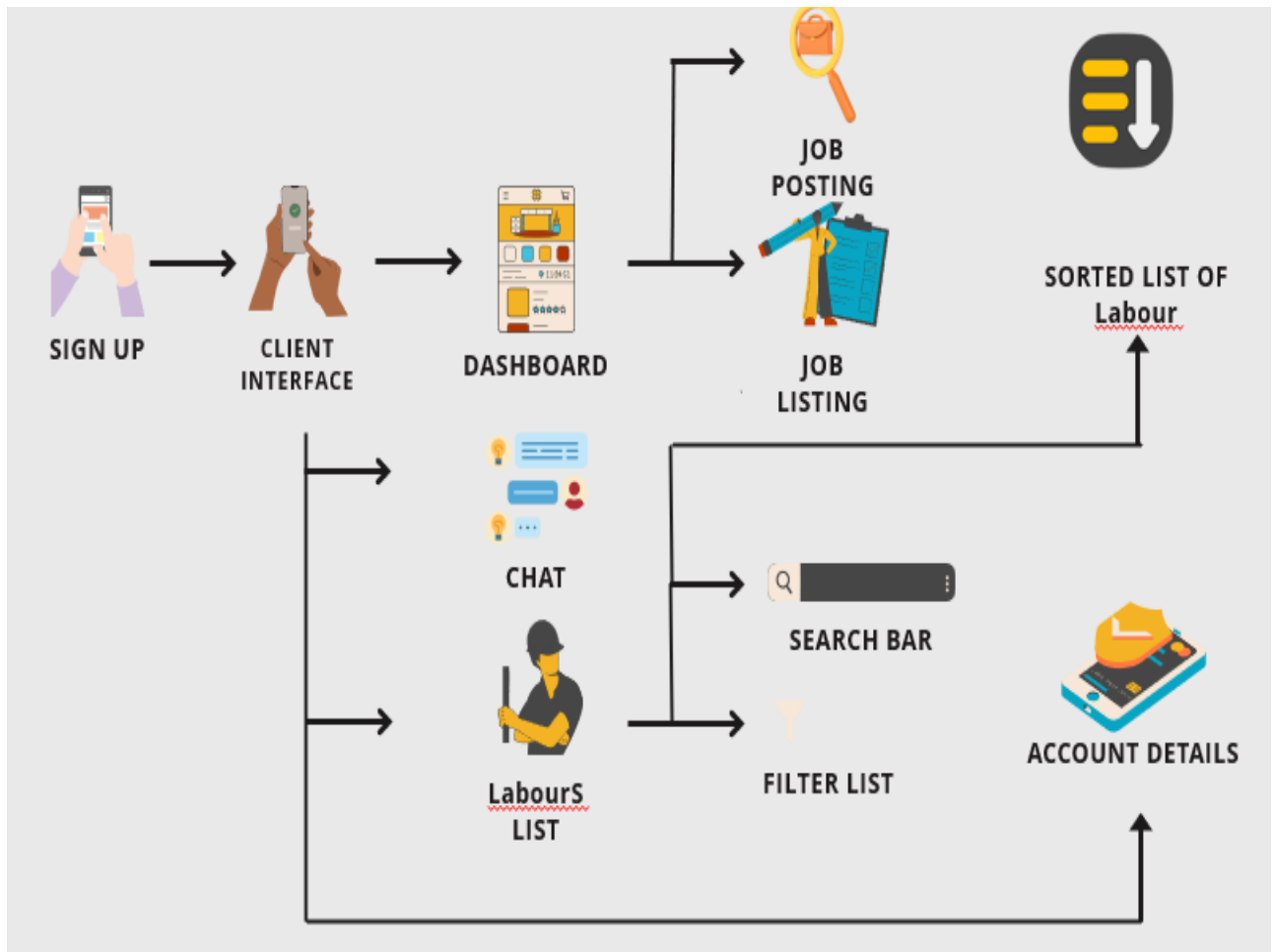
Figure 26: Flow chart for client interface

- **Client Interface:**

  In Client Interface, after signup process, there are 4 major screens**.**

  - Dashboard

  - Chat

  - Labors

  - Account details

- **Project dashboard:**

  On the dashboard screen, users will find a prominently placed floating action button designed for publishing new jobs. This button provides quick and easy access to the job posting feature. Once clicked, users are directed to a job creation form where they can enter all necessary details in their preferred language. This form includes fields for job title, description, location, required skills, and other pertinent information. Additionally, users have the option to attach site images to provide a clearer understanding of the job requirements and environment.

  All published jobs will be displayed in a comprehensive list on the dashboard screen, each entry providing a brief overview of the job details. To view the full job description, users can click on any listed job. This action opens a detailed view containing all the information initially entered during the job creation process, including any attached images.

  Within this detailed view, users also have the ability to manage their job listings. There is an option to delete the job, allowing users to remove any listings that are no longer relevant or needed. This functionality ensures that users can maintain an up-to-date and accurate list of job postings.
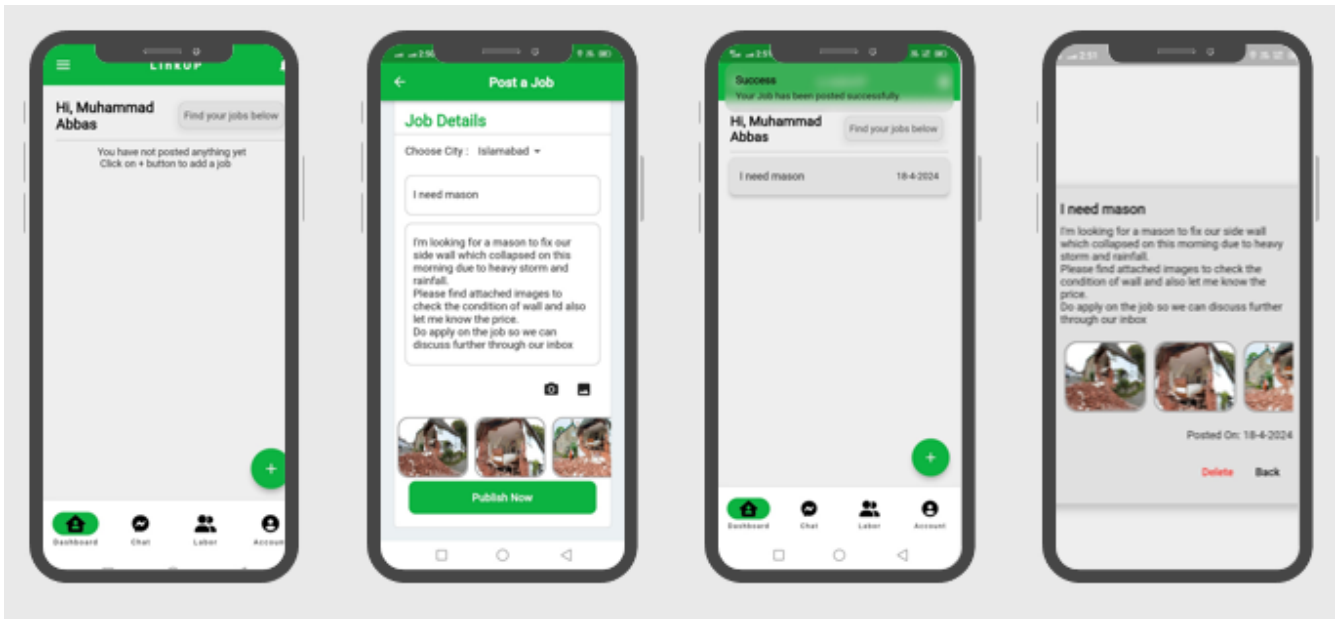
Figure 27: Project Dashboard Screen

- **Chat:**

  In the message portal, the user can view the conversations with the clients. This feature helps to keep track of communication between the user and the clients, this is where both individuals communicate.
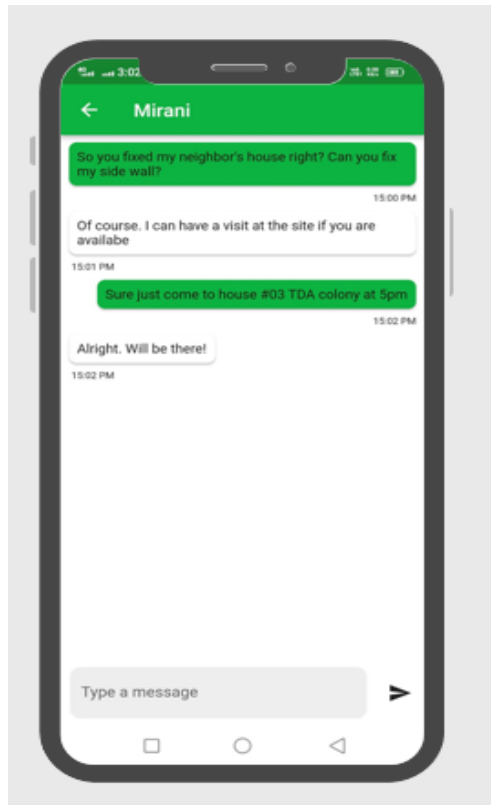
Figure 28: Chat Screen

- **Labors List:**

  If you are looking for an individual for a simple task, you can browse through a diverse

  pool of skilled workers, filter your search by name and category.
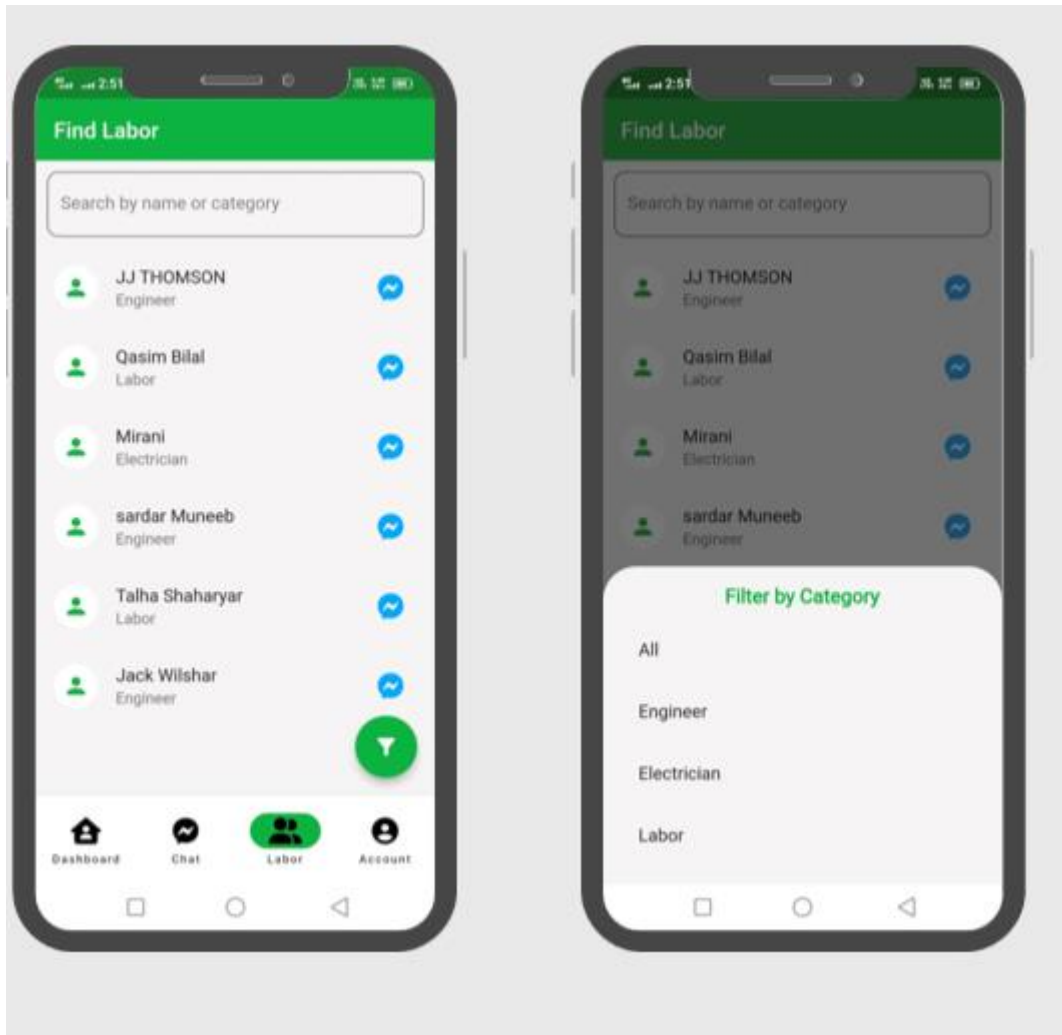
Figure 29: Labor List

- **Account Details:**

  Now, coming to the last navigation screen where we can see our account details and we

  can change our password and delete our account anytime.
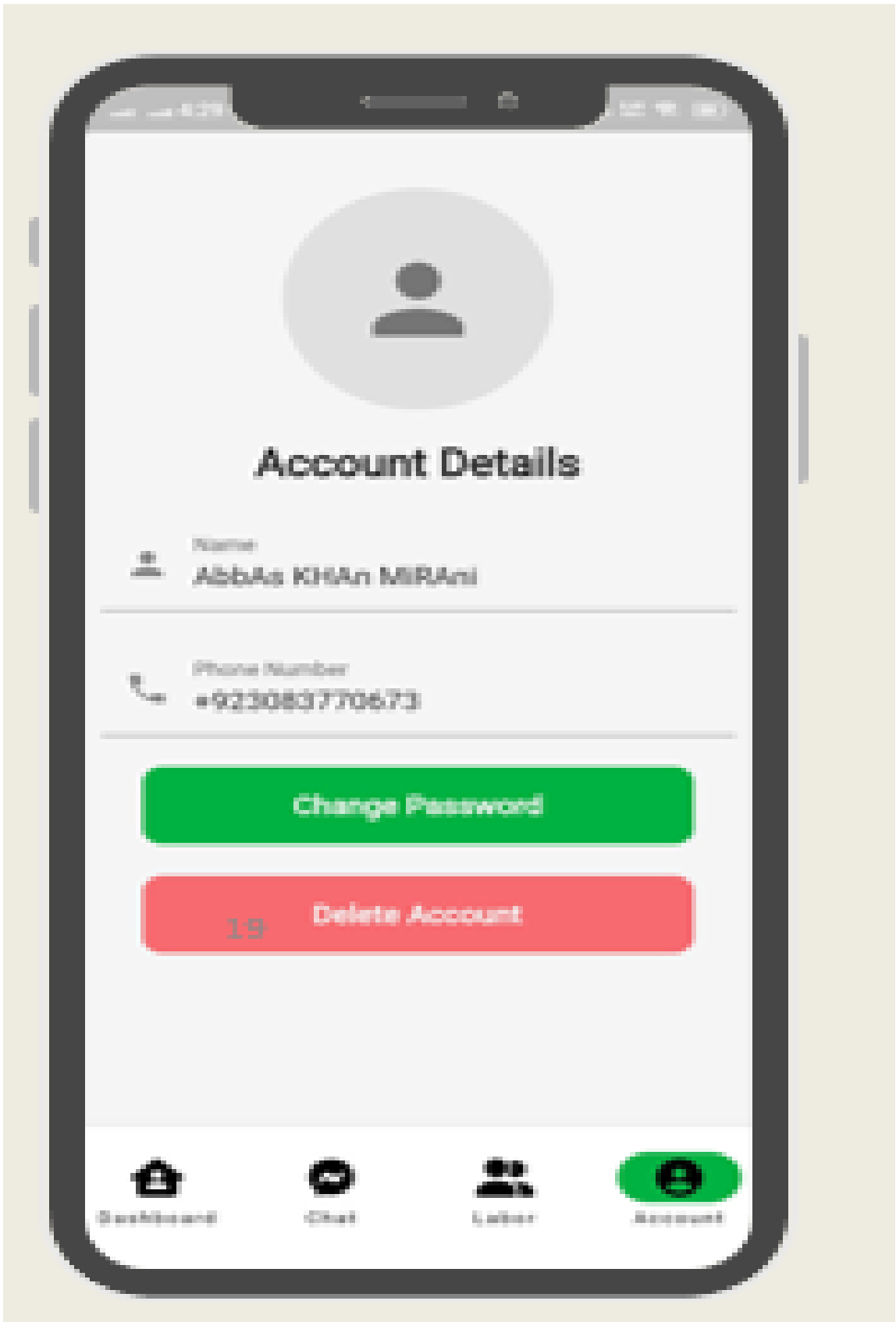
Figure 30: Account Info Screen

- **Projects Reports:**

    As the client is engaged in Revit projects, we've implemented a feature   allowing them
    to open their projects within our app. They can then download schedules and reports, as
    well as delete projects to remove them from the database.
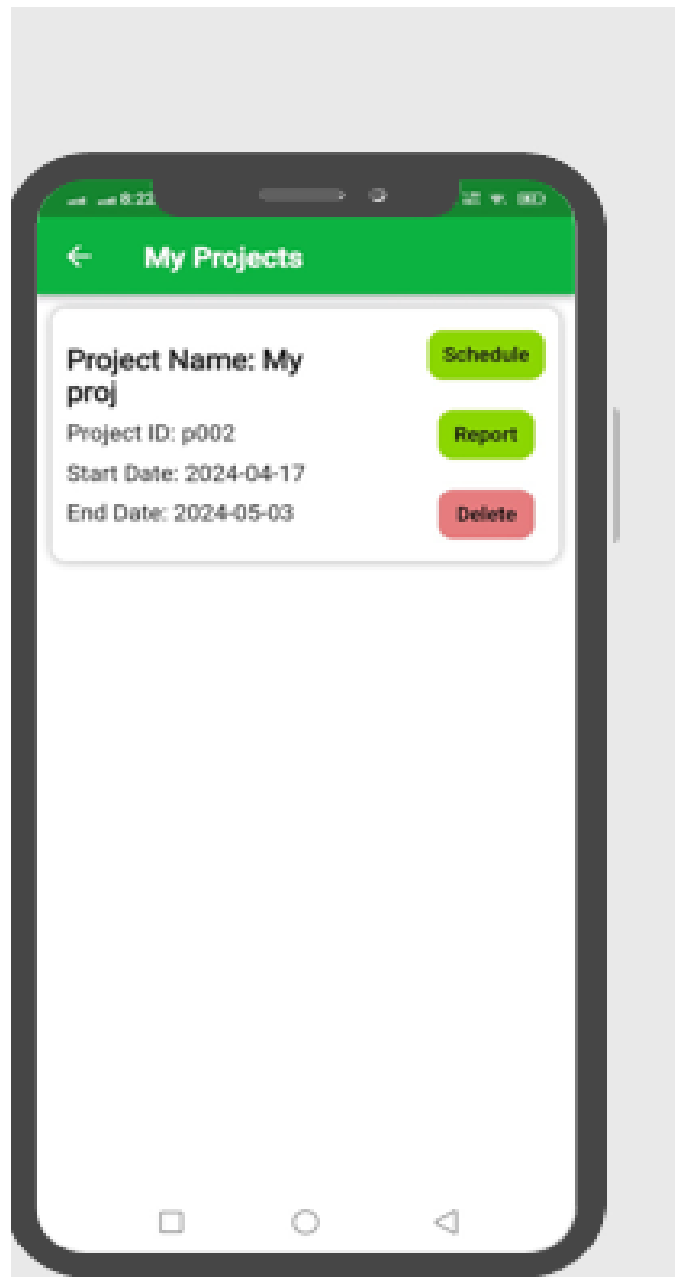
Figure 31: My projects Screen

- **Client Interface:**

- **Flow chart for client interface.**
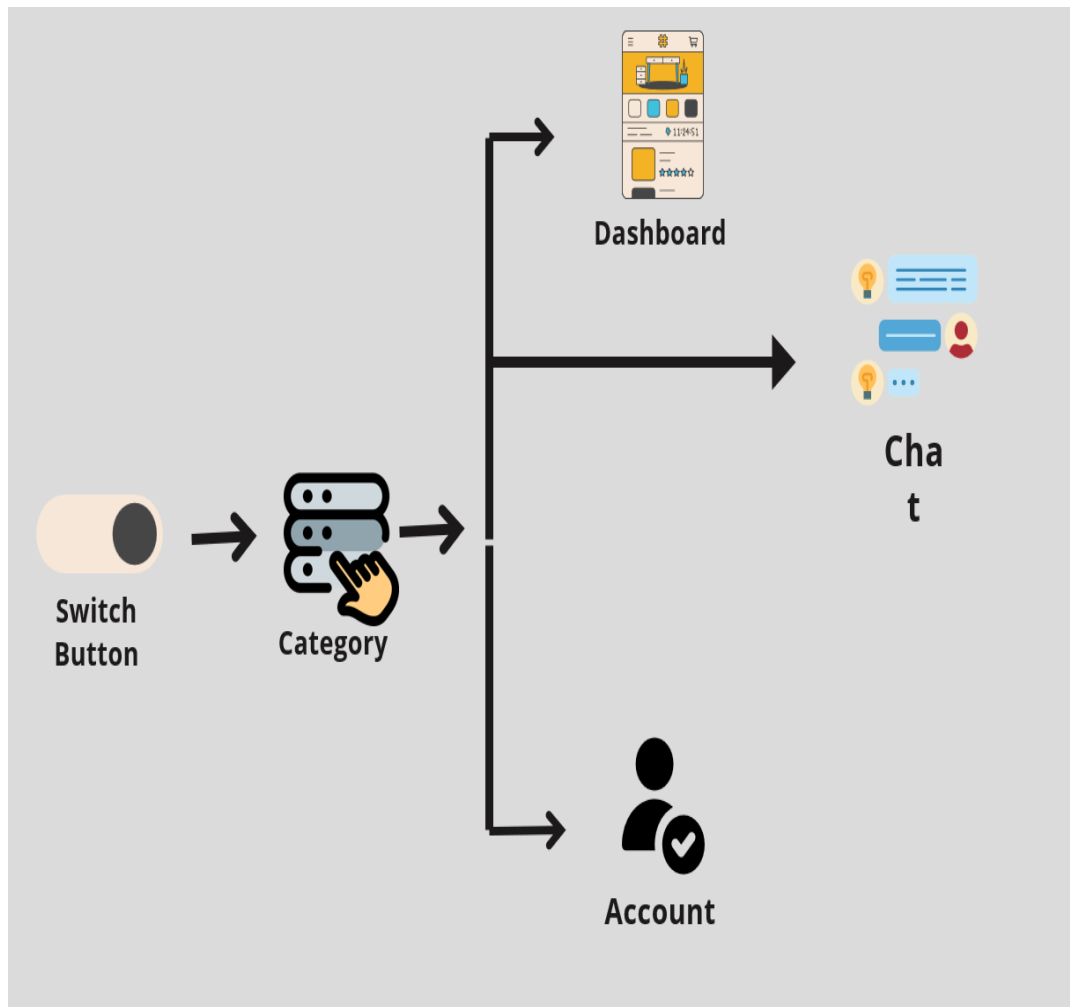
Figure 32: Flow Chart for client interface

- **Switch to Labor Screen:**

   Switch button is provided to switch from client to labor screen. Upon first time switching, labor would be selecting his/her profession to become a part of labor in the Labors List of Client Interface. Afterwards, labor can switch any time without this required parameter.

   Now, for Labor Interface, major screens are same with a minor difference on Dashboard

screen.

Figure 33: Switch Button

view project details such as project name, project description, start date, and end date.

Dashboard: This screen is crucial for labor. It displays all the jobs posted by clients. Labor

can apply for jobs that match his/her skills and await a response from the client.

Labor job Application Screen
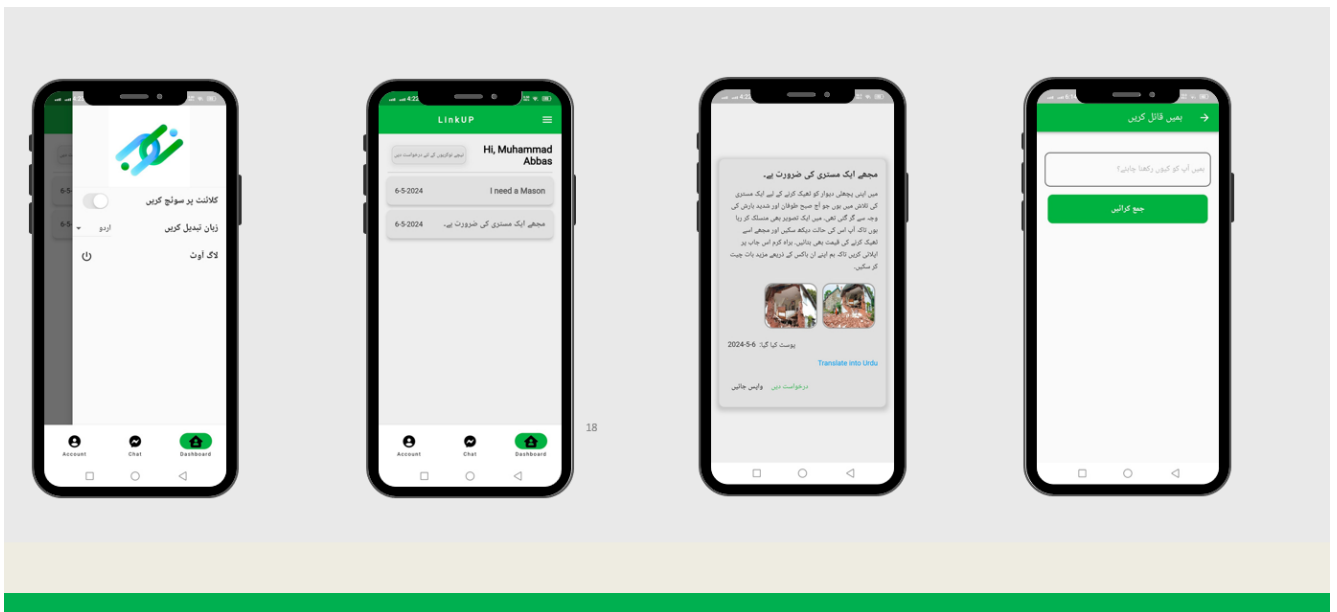
Figure 34: Job Application Screen

- **Notification Screen:**

Once applied for a job, the client is notified and can review bid and can then send client

a direct message for further discussion and to confirm the job.
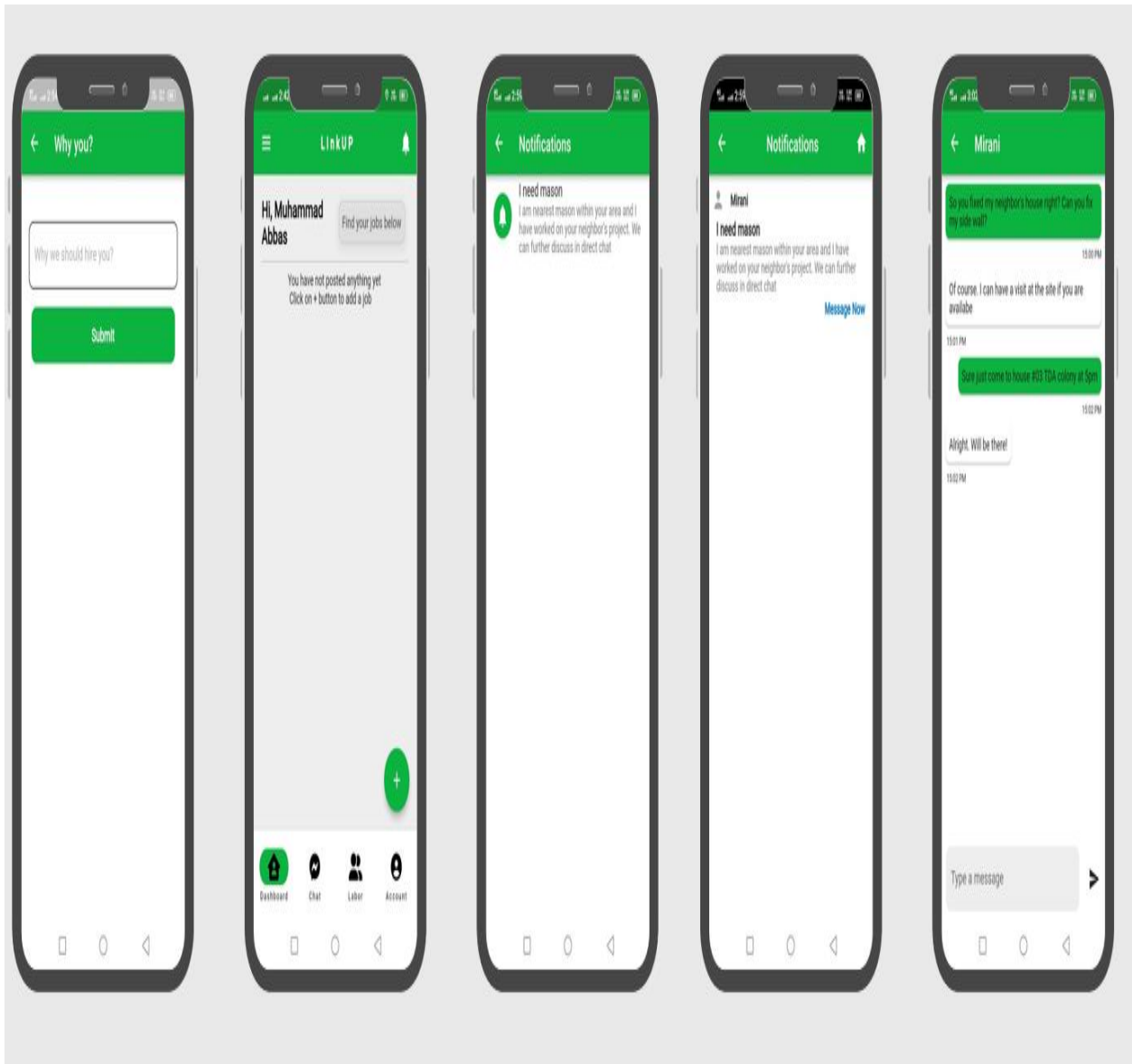
Figure 35: Notification Screen

- **User profile settings**

   At the bottom of the home screen, there are options to go to Messages Portal, and User

   Profile Settings. The user profile settings allow the user to manage their account details

   such as name, email, and password.
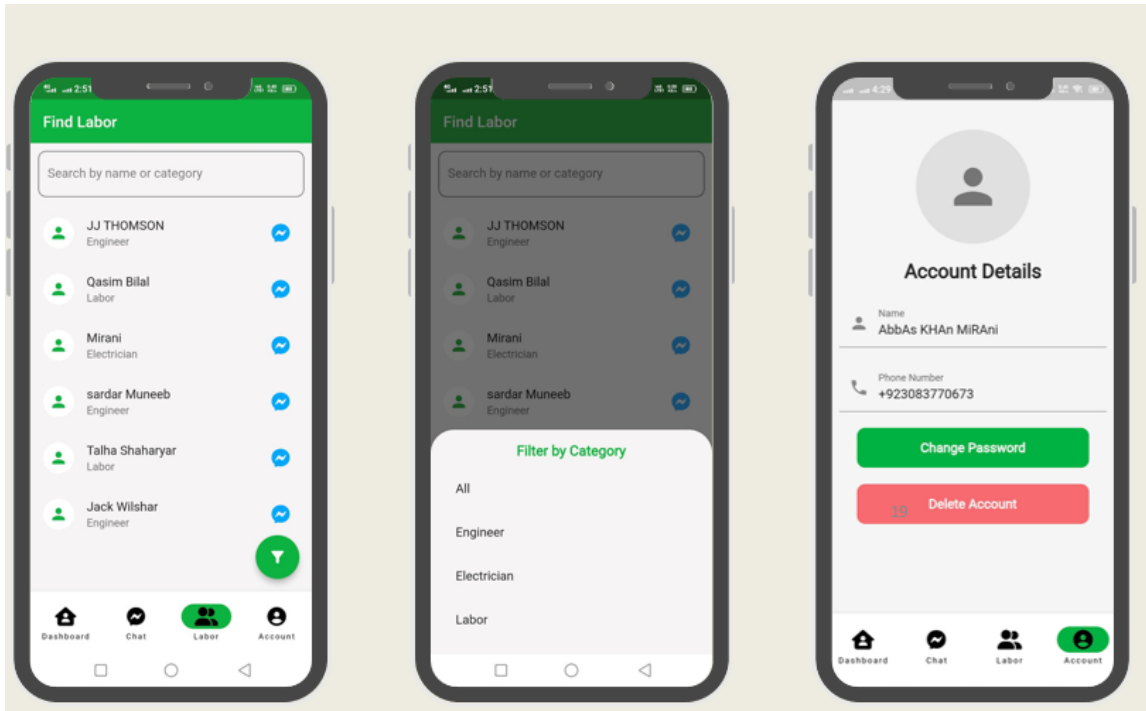
Figure 36: User Profile Settings

CONCLUSION

5.1 Lessons Learned

1. The importance of adopting Building Information Modeling (BIM) in the construction industry is evident. It enhances collaboration among stakeholders, streamlines the material procurement process, and helps reduce delays and cost overruns in construction projects.

2. Efficiency gains can be achieved by integrating BIM with other technologies, such as Geographic Information Systems (GIS). This integration can further optimize resource utilization and labour acquisition, leading to improved project performance.

3. The development of a BIM-based framework and mobile app can significantly improve project management and labor acquisition in construction projects. It not only simplifies the process but also provides real-time information to stakeholders, enabling them to make informed decisions and prevent potential issues.

4. Addressing inefficiencies in traditional project management and labor acquisition practices can result in considerable cost savings and better overall project outcomes. This highlights the need for construction companies to adopt modern technology and management practices.

5. The study's relevance to national needs, such as the digitization of the construction industry in Pakistan, is significant. By adopting these technological advancements, project performance can be optimized, and the overall success rate of construction projects can be improved.

6. This leads to better project outcomes, reduced delays and cost overruns, and enhanced collaboration among stakeholders. The construction industry needs to embrace these.

technological advancements to achieve higher efficiency and improved project performance and also helps in reducing poverty.

5.2 Future recommendations

Based on the findings and lessons learned from this study, several recommendations can be made for future research and practical implementation in the construction industry:

1. Expand the scope of research: Future studies should explore the integration of BIM with other emerging technologies, such as the Internet of Things (IoT), Augmented Reality (AR), and Artificial Intelligence (AI), to further enhance the efficiency and effectiveness of material procurement and inventory management in construction projects.

2. Conduct more case studies: To generalize the findings and validate the proposed BIM-based framework, more case studies should be conducted in different geographical locations and construction sectors, such as residential, commercial, and infrastructure projects.

3. Develop a standardized BIM-based framework: Researchers and industry practitioners should collaborate to develop a standardized BIM-based framework for material procurement and inventory management that can be adapted to various construction projects and contexts.

4. Promote the adoption of BIM and related technologies: Governments, professional bodies, and educational institutions should promote the adoption of BIM and other advanced technologies in the construction industry through policymaking, capacity building, and awareness campaigns.

5. Assess the impact of training and education: Future research should investigate the impact of training and education on the successful adoption and implementation of the BIM-based material procurement and inventory management in construction projects. This will help identify the specific skill sets required by industry professionals and guide future training

programs. Evaluate cost-effectiveness: Further research should be conducted to assess the cost- effectiveness of implementing a BIM-based framework and mobile app for project management and labor acquisition in construction projects. This will provide valuable insights for construction companies considering the adoption of these technologies.

6. Investigate barriers to adoption: Future research should explore the barriers to adopting BIM and other advanced technologies in the construction industry, such as resistance to change, lack of technical skills, and financial constraints. This will help identify strategies for overcoming these challenges and promote wider adoption.

5.3 Discussion

In the discussion, we'll delve into the meaning of our finding and their importance in taking action and targeting the construction industry. The statement above implies that solving these problems is not just a business move but is basically to address critical construction industry problems like schedule inefficiency, labor productivity challenges, time delays, labor shortages, turnover, retention, coordination, and communication issues. The technological framework that allows the implementation of module 1 incorporates the Flutter framework (DART) for a speedy process of labor management and scheduling optimization. This report's finding conforms to earlier studies, which state that labor shortage is among the key factors contributing to project delays (NAHB). Our solution will provide a convenient channel for interaction between construction entities and laborers to ensure steady workflow, reduced scheduling inconveniences, and shorter project durations. As such, the problem of inefficient projects will be resolved.

Moreover, Module Two is shouldered on the plug-in, supervised machine learning technique, and reinforced learning. It resolves the concerns regarding labor availability and productivity. Existing literature supports the relationship between labor shortage and decreased productivity present in the construction industry (Smith et al., 2019). Being able to organize labor productivity by controlling time and making labor productivity an efficient outcome through automated scheduling and optimized labor allocation. Our solution aims to improve the reliability of digital labor acquisition in the construction industry.

Not only does our platform solve the problem of the shortage of qualified workers, but it will also be used to help construction companies get access to a diverse pool of workers. Human resources and the cost of labor especially in the sector of construction are two of the most significant challenges identified, which often lead to higher costs and lapses in

the projected delays (Smith et al., 2019). Our solution focuses on closing this gap through better dissemination of information to improve the dialogue between contractors and workers and provide work opportunities to any interested. This way, we expect to raise the retention rates and free the labor market of shortages, which subsequently will add to the stability and continuous progress of the projects.

The first step of our journey had many achievements, that are: the registration with the phone numbers verified by OTP, easy transitioning between laborers' and clients' interfaces, and also adding pictures and documents to the job applications. Both parties' communication was enabled via direct chat. Quantities from the Revit model is precisely extracted to simplify labor productivity estimation. Improved scheduling systems also encouraged decision-making, while user-friendly interfaces promoted simple installation and registration.

Additionally, given the platform, such as real-time chat functionalities and convenient interfaces can assist in overcoming collaboration and communication problems. The success of the project depends on effective joint execution and joint work. Being a tool for ensuring good communication and teamwork among the project members, our application works to minimize the conflicts between them and improves cooperation as well as the results of their work.

However, our first mission encounters some drawbacks. It does not give any existing wages or transaction system. You will have to bid only indirectly by chatting with clients. On top of that, there is no opportunity to share the location of work which must be worked out via chat again. The accuracy of labor calculations from the automated schedules is based on an AI model trained with a limited amount of data. With the new updates, we aim to address these key problems and add more lucrative features that will ultimately serve the construction industry.

We have carried out a prototype usage survey with engineers of well-reputed companies and almost 75% rated our app as easy to use while 80% were able to post a job easily. In addition to this, 70% of the job seekers ' satisfaction favored our platform, and 80% of them felt that our platform was effective and rated beneficial to the market. However, 80% of them identified the given features as inadequate for the optimum operation. The overall field engineer's satisfaction level with the app's functionalities is composed of 70% of individuals. Given that it's a debut release, we consider this a successful work.

5.4 Conclusion

Thus, the system has proposed an all-around solution to the strategic complexities that slow down the pace of development in the construction sector. All these goals and objectives have been achieved through the innovation of our digital platform to shape the future of the management of labor, effectiveness, and productivity, as well as the success of a given project. The results acquired from the first survey with 30 engineers from various backgrounds demonstrate the importance of our app in the user journey and suggest a forecast of a successful launch. The testimonials gathered from users highlight that this platform is very user-friendly, there is no trouble posting jobs, and it is also responsive to changes in the market. Such responses ultimately give testimonies to its initial success.

However, the existing shortcomings within the first build raise both the challenges and potentialities involved as we proceed to the journey optimization. Though the program provided positive feedback for its functionality, it also indicated the areas that need to be enhanced. It is here that we are guaranteed to find the biggest potential for errors to set in and to know how to get ourselves out of possibly dangerous situations. While the app is usable for field engineers and they enjoy the current experience, the improvement of the

field engineers' satisfaction rates provides evidence that the functions dedicated to such advisors are essential. Our path to success is plotted and we have kept the bar high. The next versions of the program will concentrate on the fixation of found flaws, the extension of additional features, and the dynamic development of the efficiency of the system in other directions too.

The end of our journey in reforming the construction business is not in sight and we pledge robust cooperation to bring new transformations for sustainable benefits. With steadfastness and unswerving commitment along with the constant pursuit of innovation, we still rest on our laurels as the driving force behind this trade's positive changes and this continuing inspiration to all stakeholders as we deliver the towering value these parties deserve.

The system has proposed an all-around solution to the strategic complexities that slow down the pace of development in the construction sector. Through the innovation of our digital platform, we have achieved goals and objectives that shape the future of labor management, effectiveness, productivity, and project success. The initial survey, conducted with 30 engineers from various backgrounds, underscores the importance of our app in the user journey and forecasts a successful launch. User testimonials highlight the platform's user-friendliness, ease of posting jobs, and responsiveness to market changes, attesting to its initial success.

Despite this, the first build's shortcomings highlight the challenges and potentialities as we proceed with journey optimization. Positive feedback on functionality was accompanied by indications of areas needing enhancement, revealing the potential for errors and strategies to avoid them. Field engineers find the app usable and enjoyable, and their improved satisfaction rates show the necessity of functions dedicated to such advisors. Our path to success is plotted, and we maintain high standards. Future program versions

will focus on fixing flaws, extending additional features, and dynamically improving system efficiency in other areas.

Our journey to reform the construction business is ongoing, and we pledge robust cooperation for sustainable transformations. With steadfast commitment and continuous innovation, we remain the driving force behind positive changes in this trade, inspiring all stakeholders as we deliver the towering value they deserve.

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