# Analysis of the COVID-19 pandemic spreading in India by an epidemiological model and fractional differential operator.

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# Analysis of the COVID-19 pandemic spreading in India by an epidemiological model and fractional differential operator.

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**Abstract**

Fractional differential mathematical model unfolding the dynamics of COVID-19 pandemic in India is presented and explored in this paper. The purpose of this study is to estimate the future outbreak of disease and potential control strategies using mathematical model in India as a whole country as well as in some of states of the country. This model is calibrated based on reported cases of infections over the month of April 2020 in India. We have used iterative fractional complex transform method to find approximate solutions of model having modified Riemann Liouville fractional differential operator. We have also carried out comparative analysis between actual and estimated cumulative cases graphically, moreover most sensitive parameters for basic reproduction number($R_0$) are computed and their effect on transmission dynamics of COVID-19 pandemic is investigated in detail.

**Keywords** : Compartmental model; COVID-19; modified Riemann Liouville fractional differential operator; Basic reproduction number; Numerical simulations.

**2010 Mathematics Subject Classifications** : Primary: 35A20, 35A22, 34A08, 35R11

## 1 Introduction

The COVID-19 pandemic has taken the globe by storm and caused a global awareness of the public health emergency [1]. It has already taken a toll in advanced countries known for their health care infrastructure and accessibility. On December 31, 2019 in Wuhan city, Hubei Province of China, the coronavirus disease initially identified. This exceptionally infectious and lethal infection spreads fundamentally when individuals

contact surfaces where the infection has been deposited by tainted idividuals and contact their eyes, nose or mouth. Most of countries are counting actual reported cases rather than number of people have the virus beacuse the symptoms of COVID-19 are mild and self-treated which misleads the count of disease evolution and forcasting the outbreak by general practitioner and hospital reports at early stage.
India reported the first case of coronavirus late January, when a three students having a travel history from Wuhan, China landed in Kerala and tested positive. The disease transmission gradually increased over the month of March 2020, after a significant number of cases were accounted for in the country, a large portion of which were connected to individuals landed from influenced countries. Since then, India is focused on detecting Infections, referring identified patients for treatement to dedicated COVID-19 centers. As of 10 May 2020, India had seen 62,939 confirmed cases out of which 41472 are active cases, 19,358 recovered peoples and 2,109 deaths due to COVID-19 infections [2].

## 1.1 Mathematical Model

The Covid-19 pandemic has just begun demonstrating colossal negative effect on politics, education, socio-economics and other important worldwide aspects. Besides this, the condition of health related crisis is turning out to be increasingly more grim by each spending day. Hence, to analyze, forecast and examine the behaviour of viruses, threads, infections and others it is necessary to develop a mathematical model that effectively depicts transmission dynamics of the disease to assist policymakers with making significant choices dependent on the compelling presumptions given by the model. The benefit of simulations with the help of computational approaches of epidemic mathematical models is that they adjust dynamically and sensitive to various parameters, like behaviour of people, government stratergies of disease control and many more which affect the model output and helps to analyze infections within populations.

In recent times, researchers around the globe have done remarkable studies about the transmission dynamics, forcasting future growth, control stratergies and estimation for the infection of COVID-19. For example, In [3] Li et al. estimated the epidemic doubling time and the basic reproductive number. Khan et al. [4] formulated Mathematical model of coronavirus versus people. Asymptomatic carrier transmission of COVID-19 is analysed in [5]. In [6] chen et. al examined a mathematical model for simulating the phasebased transmissibility of a novel coronavirus. In [7], Lin et. al. suggested conceptual model for the coronavirus disease 2019, which successfully captures the course of the COVID-19 outbreak. More research pertaining to COVID-19 is found in ([8, 9, 10]).

Mathematical models, utilizing system of ordinary differential equations with integer-order, have been demonstrated significantly for understanding the dynamics of biological systems. The study of epidemiological dynamical processes involving memory effects is appropriate on the grounds that such frameworks rely on strenght of memory which is constrained by the order of fractional derivative operator. The

purpose of formulating mathematical models using fractional differential equations is to improve and generalize several ordinary differential systems. Hence, demonstrating some real world phenomena using fractional derivative operator has attracted the consideration of many researchers in the field of applied sciences [11, 12, 13, 14, 15, 16]. In this study, we consider the compartmental model to analyse and simulate the transmission dynamics of the COVID-19 pandemic [18]. We use the total number of confirmed cumulative cases reported over the month of April 2020 as per the data collected through public health authorities announcements and Ministry of health and family welfare [2]. The total population is compartmentalized into eight components of the epidemic flow at time t given as $N = S + E + I + R + S_p + E_p + I_p + Q$, where,

- $S$ is the number of susceptible individuals which are not traced.
- $E$ denotes the latent but not traced population.
- $I$ is the number of infectituos population which are not traced.
- $R$ is the number of recovered (through self-isolation or treatment) population.
- $S_p$ represent the uninfected but traced population which stay at home and take self isolation.
- $E_p$ is the number of infectituos and traced individuals.
- $I_p$ is the number of infected and quarntined population which are traced.
- $D$ is the number of dead population.

The complete transformation process is depicted in Fig. 1.

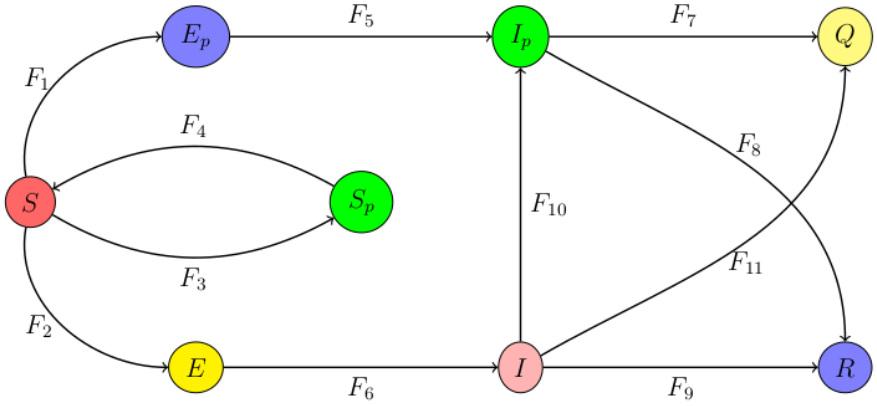



Figure 1: Transformation process of Model

Where $F_1 = \eta\alpha\mu S(I + \gamma E)$, $F_2 = (1 - \eta)\alpha\mu S(I + \gamma E)$, $F_3 = \eta(1 - \alpha)\mu S(I + \gamma E)$, Infected and traced $= F_4 = \eta\alpha\mu S(I + \gamma E)$, $F_5 = \tau E_p$, $F_6 = \tau E$, $F_7 = \rho\kappa I_p$, $F_8 = (1 - \rho)\kappa I_p$, $F_9 = (1 - \sigma)(1 - \phi)\delta I$, $F_{10} = \phi\delta I$, $F_{11} = \delta(1 - \phi)\delta I$

The contact rate, trace rate and probability of infection of are denoted by $\mu$, $\eta$ $\alpha$ respectively. Also the the proportion of infectious ability in latent individuals is denoted by $\gamma$. Then the variation of the susceptible S consists of three parts: the uninfected but traced $F_3$, the infected and traced $F_1$ and the infected but not traced $F_2$.
The infected but not traced move to the latent compartment E, while the infected and traced move to $E_p$, and the uninfected but traced move to $S_p$ . The latent individuals no matter whether they were quarantined are becoming the infectious with the rate $\tau$. The infectious but not quarantined individuals are sent to some hospital settings (i.e., they move to $I_p$) with the rate $\phi\delta$ . The infectious but not quarantined individuals are dead with the rate $(1-\phi)\sigma\delta$. The infectious and quarantined individuals are dead with the rate $\rho\kappa$. The infectious but not quarantined individuals recover with the rate $(1-\phi)(1-\sigma)\delta$. The infectious and quarantined individuals recover with the rate $(1-\phi)\delta$.
Further, the infection process of coronavirus virsus is displayed as a system of differential equations which describes the change in the population size of each compartment with respect to time t. Inspired by the above significant applications of fractional calculus in modeling of infectious deseases, we are simulating dynamics of COVID-19 model suggested by wang et.al.[18] in the form of modified Riemann-Liouville fractional differential system of equations of order $\beta$ such that $\beta \in (0,1]$. given by

$$\begin{cases} D_t^\beta S(t) = -\eta(1-\alpha)\mu S(I+\gamma E) - \eta\alpha\mu S(I+\gamma E) - (1-\eta)\alpha\mu S(I+\gamma E) + \psi S_p, \\ D_t^\beta E(t) = (1-\eta)\alpha\mu S(I+\gamma E) - \tau E, \\ D_t^\beta I(t) = \tau E - (1-\phi)(1-\sigma)\delta I - (1-\phi)\sigma\delta I - \phi\delta I, \\ D_t^\beta R(t) = (1-\phi)(1-\sigma)\delta I + (1-\rho)\delta I_p, \\ D_t^\beta S_p(t) = \eta(1-\alpha)\mu S(I+\gamma E) - \psi S_p \\ D_t^\beta E_p(t) = \eta\alpha\mu S(I+\gamma E) - \tau E_p, \\ D_t^\beta I_p(t) = \tau E_p + \phi\delta I - (1-\rho)\kappa I_p - \rho\kappa I_p, \\ D_t^\beta Q(t) = (1-\phi)\sigma\delta I, \end{cases} \tag{1.1}$$

with initial conditions

$$\begin{aligned} S(0) = S_0 > 0,\ E(0) = E_0 > 0,\ I(0) = I_0 > 0,\ R(0) = R_0 > 0, \\ S_p(0) = S_{p_0} > 0\ \ E_p(0) = E_{p_0} > 0,\ I_p(0) = I_{p_0} > 0,\ D(0) = D_0 > 0. \end{aligned} \tag{1.2}$$

The rest of this paper is sorted out as follows. In Section 2, we have discussed the iterative fractional complex method by presenting preliminary definitions. In Section 3, Simulations result and forecast of the COVID-19 pandemic in INDIA as a whole and some of the states along with plots and tables is presented. Further, various control stratergies and prevetive measures predicted by using plots is discussed in section 4. Section 5 is about conclusions.

# 2 Analysis of itrative fractional complex transform method

## 2.1 Preliminaries

In this section we present some required definitions of fractional derivative operators. Further, we describe one of the reliable and efficient techniques to find approximate solutions of fractional differential equations known as iterative fractional complex transform method. This method is a combination of frational complex transform and new iterative method.

**Definition 2.1.** *The Riemann-Liouville fractional integral of order $\beta$ is defined as*

$$I_t^{\beta} u(t) = \frac{1}{\Gamma(\beta)} \int_0^t (t-\zeta)^{\beta-1} u(\zeta) d\zeta,$$

*where, $\beta \in (-\infty, \infty)$.*

**Definition 2.1.** *The Caputo fractional derivative operator of order $\beta(\beta \geq 0)$ and $n \in \mathbb{N} \cup \{0\}$ is defined as*

$$D_t^{\beta}(u(t)) = \frac{1}{\Gamma(n-\beta)} \int_0^t (t-\zeta)^{n-\beta-1} \frac{d^n}{dt^n} u(\zeta) d\zeta, \tag{2.1}$$

*where $n-1 \leq \beta < n$.*

While Riemann−Liouville definition of derivative is given as:

$$D_t^{\beta}(u(t)) = \frac{1}{\Gamma(n-\beta)} \frac{d^n}{dt^n} \int_0^t (t-\zeta)^{n-\beta-1} u(\zeta) d\zeta, \tag{2.2}$$

where $n-1 \leq \beta < n, \quad n \in N \cup \{0\}$.

Recently, G. Jumarie [19] suggested an alternate definition to the Riemann-Liouville derivative which is known as modified Riemann-Liouville derivative. It has advantages over previously defined operators and is denoted by the expression.

$$D_t^{\beta}(u(t)) = \frac{1}{\Gamma(n-\beta)} \frac{d^n}{d\zeta^n} \int_0^t (t-\zeta)^{n-\beta-1} [u(\zeta) - u(0)] d\zeta, \tag{2.3}$$

it is defined over continuous but not necessarily differentiable functions.

## 2.2 Fractional complex transform

Fractional complex transform which is suggested by Li and He [20] is highly reliable method to transform the differential equations in non integer form into ordinary differential equations. Hence, analytical techniques dedicated to the advanced calculus

can be effectively applied to the fractional calculus.
Here we begin with the fractional differential equation given by

$$f(u, u_t^{(\alpha)}, u_t^{(2\alpha)}, \cdots) = 0 \tag{2.4}$$

where $u_t^{(\alpha)} = \frac{d^\alpha u(t)}{dt^\alpha}$, $0 < \alpha \leq 1$ denotes modified Riemann−Liouville derivatives.

Introducing the fractional complex transform given as

$$T = \frac{qt^\alpha}{\Gamma(1+\alpha)}$$

where q is unknown constant. Using the basic properties of the fractional derivative and the above transforms, we can convert fractional derivatives into ordinary derivatives as:

$$\frac{d^\alpha u}{dt^\alpha} = q\frac{du}{dT} \tag{2.5}$$

Therefore, the system of fractional differential equations are effectively transforms into system of ordinary differential equations. This system further solved by new iterative method.

## 2.3 New Iterative Method for a System of Equations

In recent years, Daftardar-Gejji and Jafari [13] introduced a very simple and efficient method to solve linear and nonlinear differential equation known as New iterative method (NIM). This technique is a improvements of terms of Adomian Decomposition Method so that it is easily implemented on computer with the help of symbolic computational packages like Mathematica.
Consider a system of equation

$$u_i(t) = f_i + L_i(u_1(t), u_2(t), \cdots, u_n(t)) + N_i(u_1(t), u_2(t), \cdots, u_n(t)), \quad i = 1, 2, \cdots, n. \tag{2.6}$$

where $f_i$ is a known function, $L_i$ is linear and $N_i$ non-linear operator.

Let $u = (u_1(t), u_2(t), \cdots, u_n(t))$ be a solution of system Eq 2.6 where $u_i(t)$ is of the series form given as:

$$u_i(t) = \sum_{j=0}^{\infty} u_{i,j}(t), \quad i = 1, 2, \cdots, n. \tag{2.7}$$

Since L is linear,

$$L_i\left(\sum_{j=0}^{\infty} u_{i,j}(t)\right) = \sum_{j=0}^{\infty} L_i\big(u_{i,j}(t)\big). \tag{2.8}$$

The operator $N_i$ decomposed as :

$$N_i(u) = N_i\left(\sum_{j=0}^{\infty} u_{i,j}(t)\right) = N_i\left(\sum_{j=0}^{\infty} u_{1,j}(t), \cdots, \sum_{j=0}^{\infty} u_{n,j}(t)\right)$$

$$= N_i(u_{1,0}(t), \cdots, u_{n,0}(t))$$
$$+\sum_{k=1}^{\infty}\left\{N_i\left(\sum_{j=0}^{k}u_{1,j}(x,t),\cdots,\sum_{j=0}^{k}u_{n,j}(t)\right)-N_i\left(\sum_{j=0}^{k-1}u_{1,j}(t),\cdots,\sum_{j=0}^{k-1}u_{n,j}(t)\right)\right\} \quad (2.9)$$

In view of Eq 2.7, 2.8 and 2.9, the Eq 2.6 is equivalent to

$$\sum_{j=0}^{\infty}u_{i,j}(t) = f_i+\sum_{j=0}^{\infty}L_i(u_{i,j}(t))+N_i(u_{1,0}(t),\cdots,u_{n,0}(t))$$
$$+\sum_{k=1}^{\infty}\left\{N_i\left(\sum_{j=0}^{k}u_{1,j}(t),\cdots,\sum_{j=0}^{k}u_{n,j}(t)\right)-N_i\left(\sum_{j=0}^{k-1}u_{1,j}(t),\cdots,\sum_{j=0}^{k-1}u_{n,j}(t)\right)\right\} \quad (2.10)$$

where $i = 1, 2, \cdots, n$.
Further consider the recurrence relation as given below for $i = 1, 2, \cdots, n$

$$u_{i,0} = f_i$$
$$u_{i,1} = L_i(u_{1,0}(t),\cdots,u_{n,0}(t)) + N_i(u_{1,0}(t),\cdots,u_{n,0}(t))$$
$$u_{i,m+1} = \sum_{j=1}^{m}L_i(u_{i,j}(t))+N_i\left(\sum_{j=0}^{m}u_{1,j}(t),\cdots,\sum_{j=0}^{m}u_{n,j}(t)\right)-$$
$$-N_i\left(\sum_{j=0}^{m-1}u_{1,j}(t),\cdots,\sum_{j=0}^{m-1}u_{n,j}(t)\right) \qquad m = 1, 2, \cdots. \quad (2.11)$$

The k−term series solution is given as

$$u_i = u_{i,0} + u_{i,1} + u_{i,2} + \cdots + u_{i,k-1} \quad (2.12)$$

In [21] the detail criteria of convergence of the series $\sum u_{i,j}$ is given.

## 3 Simulations and Forecast of the COVID-19 pandemic in INDIA

In this section, we have presented data fitting, numerical simulations and graphical demonstration of the Caputo COVID-19 model (1.1) for the population of India and some states in it which contributes highest infected cases to total infected cases of India. These states includes Maharashtra Gujrat and Capital Delhi with several important parameters which will be best fitted or estimated based on a variety of factors such as timing of the first contamination (earlier states were caught unprepared), to population density and social dynamics, to timing and efficiency of state-wide mandated directives for travel bans and social distancing, to timing and availability of testing. The parameters were estimated based on the some assumptions and facts such as the Mean incubation period ($\tau$) is set to 5.2 days, Quarantined rate of the

infectious people is ($\phi = 0.0952$), we set death rate for the quarantined and infectious population as $\rho = 0.00161$ and death rate for the not quarantined and infectious population as $\sigma = 0.00392$ induced because of COVID-19. Further, as per the from $30^th$ March to $24^th$ April 2020 available on websites of public health authorities of respective states [2, 22, 23, 24] the removal or recovery rate of the infected as well as quarantined ($\kappa$) and infected but not quarantined ($\delta$) is estimated as 0.08 and 0.066 respectively. The period of quarntined (home or institutional or hospital) is 14 days, hence we set Release rate traced and uninfected population as $\psi = 0.0714$. The other parameters plays significant role in estimating $R_0$ (basic reproductive number) for different states or cities depend upon a various factors is given in tables 1 and 2. Using the concepts of next generation matrix and calculation about reproduction number presented in [25] the basic reproduction number ( $R_0$) for model 1.1 is defined by $R_0 = (1-\eta)\alpha\mu\left(\frac{\gamma}{\tau}+\frac{1}{\delta}\right)$. The epidemiology, $R_0$ is expected number of cases directly generated by one individual in a population. When $R_0 > 1$ the infection will be able to start spreading in a population, but if $R_0 < 1$ the disease will die out.

| Parameters | Value | | | |
|---|---|---|---|---|
| | India | Maharashtra | Gujrat | Delhi |
| Contact rate $\mu$ | 0.000000022 | 0.000000030 | 0.00000017 | 0.00000031 |
| Traced rate $\eta$ | 0.381 | 0.0181 | 0.0181 | 0.0581 |
| Transmission rate $\alpha$ | 0.0123 | 0.0523 | 0.021 | 0.023 |
| Infectious rate of latent $\gamma$ | 0.0914 | 0.914 | 0.0914 | 0.0914 |
| $R_0$ | 3.59854 | 3.73882 | 3.77176 | 3.37776 |

Table 1: Estimated value of parameters for COVID-19 model (1.1) with high $R_0$

| Parameters | Value | | | |
|---|---|---|---|---|
| | India | Maharashtra | Gujrat | Delhi |
| Contact rate $\mu$ | 0.000000012 | 0.000000040 | 0.00000011 | 0.00000029 |
| Traced rate $\eta$ | 0.681 | 0.0281 | 0.020 | 0.181 |
| Transmission rate $\alpha$ | 0.0123 | 0.023 | 0.012 | 0.013 |
| Infectious rate of latent $\gamma$ | 0.0914 | 0.914 | 0.0914 | 0.0914 |
| $R_0$ | 1.01155 | 2.16997 | 1.30996 | 1.46153 |

Table 2: Estimated value of parameters for COVID-19 model (1.1) with low $R_0$

Next, we calculate and demonstrate the number of infectious cases using various plots for different parts of India. We have analyse and simulated only those regions which contributes maximum number of infected cases in total number of cases in India as on $12^th$ April 2020 [2, 26].

We start our model from initial time ($t = t_0$) as per data reported on $30^{th}$ March 2020. Hence, the required initial values are

$S(0) = 1376420550$, $E(0) = 171520$, $I(0) = 200$, $R(0) = 50$, $S_p(0) = 25000$, $E_p(0) = 1200$, $I_p(0) = 645$, $Q(0) = 10$.

We have not considered the birth and death rate for the total population. By applying iterative fractional complex transform using (2.5) and (2.11) successively upto four

terms we get series form approximate solution of the fractional COVID-19 model (1.1) as given below

$$S(t) = 1376420550 - \frac{171814.t^{2\beta}}{\Gamma(\beta+1)^2} + \frac{17043.2t^{3\beta}}{\Gamma(\beta+1)^3} + \frac{9.61362t^{4\beta}}{\Gamma(\beta+1)^4} - \frac{0.979314t^{5\beta}}{\Gamma(\beta+1)^5} + \frac{0.0006688057t^{6\beta}}{\Gamma(\beta+1)^6} + \frac{5.580619712441739^{*\wedge}\text{-}10t^{7\beta}}{\Gamma(\beta+1)^7} - \frac{185050.t^{\beta}}{\Gamma(\beta+1)}$$

$$E(t) = 171520 + \frac{6310.86t^{2\beta}}{\Gamma(\beta+1)^2} - \frac{660.95t^{3\beta}}{\Gamma(\beta+1)^3} - \frac{0.178714t^{4\beta}}{\Gamma(\beta+1)^4} + \frac{0.0191867t^{5\beta}}{\Gamma(\beta+1)^5} - \frac{1.34804\times10^{-6}t^{6\beta}}{\Gamma(\beta+1)^6} - \frac{1.09335\times10^{-11}t^{7\beta}}{\Gamma(\beta+1)^7} - \frac{29322.8t^{\beta}}{\Gamma(\beta+1)}$$

$$I(t) = 200 - \frac{3907.4t^{2\beta}}{\Gamma(\beta+1)^2} + \frac{490.489t^{3\beta}}{\Gamma(\beta+1)^3} - \frac{0.0150454t^{4\beta}}{\Gamma(\beta+1)^4} + \frac{32970.1t^{\beta}}{\Gamma(\beta+1)}$$

$$R(t) = 50 + \frac{970.065t^{2\beta}}{\Gamma(\beta+1)^2} - \frac{67.9354t^{3\beta}}{\Gamma(\beta+1)^3} + \frac{54.398t^{\beta}}{\Gamma(\beta+1)}$$

$$S_p(t) = 25000 + \frac{16674.t^{2\beta}}{\Gamma(\beta+1)^2} - \frac{16628.9t^{3\beta}}{\Gamma(\beta+1)^3} - \frac{9.3006t^{4\beta}}{\Gamma(\beta+1)^4} + \frac{0.948318t^{5\beta}}{\Gamma(\beta+1)^5} - \frac{0.0000666279t^{6\beta}}{\Gamma(\beta+1)^6} - \frac{5.40398769\times10^{-10}t^{7\beta}}{\Gamma(\beta+1)^7} + \frac{179137.t^{\beta}}{\Gamma(\beta+1)}$$

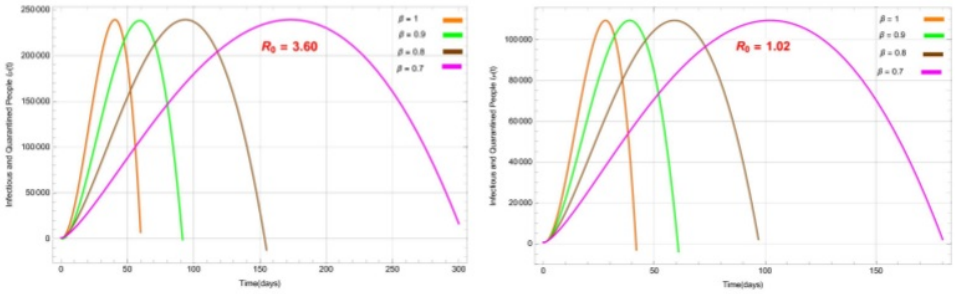
$$E_p(t) = 1200 + \frac{2554.59t^{2\beta}}{\Gamma(\beta+1)^2} - \frac{283.12t^{3\beta}}{\Gamma(\beta+1)^3} - \frac{0.11t^{4\beta}}{\Gamma(\beta+1)^4} + \frac{0.0118096t^{5\beta}}{\Gamma(\beta+1)^5} - \frac{8.2972939\times10^{-7}t^{6\beta}}{\Gamma(\beta+1)^6} - \frac{6.729679\times10^{-12}t^{7\beta}}{\Gamma(\beta+1)^7} + \frac{2022.29t^{\beta}}{\Gamma(\beta+1)}$$

$$I_p(t) = 645 - \frac{429.008t^{\beta}}{\Gamma(\beta+1)} + \frac{434.286t^{2\beta}}{\Gamma(\beta+1)^2} - \frac{6.56525t^{3\beta}}{\Gamma(\beta+1)^3} - \frac{0.0092606t^{4\beta}}{\Gamma(\beta+1)^4}$$

$$Q(t) = 10 + \frac{2.6396t^{2\beta}}{\Gamma(\beta+1)^2} - \frac{0.105785t^{3\beta}}{\Gamma(\beta+1)^3} + \frac{0.933968t^{\beta}}{\Gamma(\beta+1)}$$

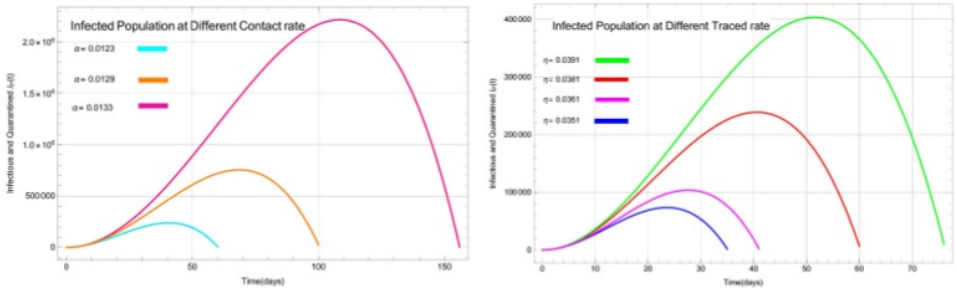
Figures 2a and 2b shows dynamical behavior of infected and quarntined population $I_p(t)$ with $R_0 = 3.60$ and $R_0 = 1.02$ respectively for various values of $\beta = 1,\ 0.9,\ 0.8,\ 0.7$ with respect to time(days). We clearly see the major diiference in both plots when value of fractional parameter $\beta$ decreases the number of infected cases also decraeses after reaching to its peak in less time. Also lowering the value of $R_0$ near to one reduces the number of infected cases significantly. Also in figures 3a and 3b we examine the possible impact of enhanced interventions on COVID-19 infection at varying disease transmission rate per contact ($\alpha = 0.0123,\ 0.0129,\ 0.0133$) and traced rate ($\eta = 0.0351,\ 0.0361,\ 0.0381,\ 0.0391$) respectively for $\beta = 1$. It is observed that reducing contact rate persistently decreases the peak value of the infected population and further enforce delay in the peak value. We also observes that this flattens the curve of infection.

Meanwhile, increasing the trace rate of susceptible people leads to increase in the peak value and also further delay in the peak, as shown in Figure 3b. Next, Increasing



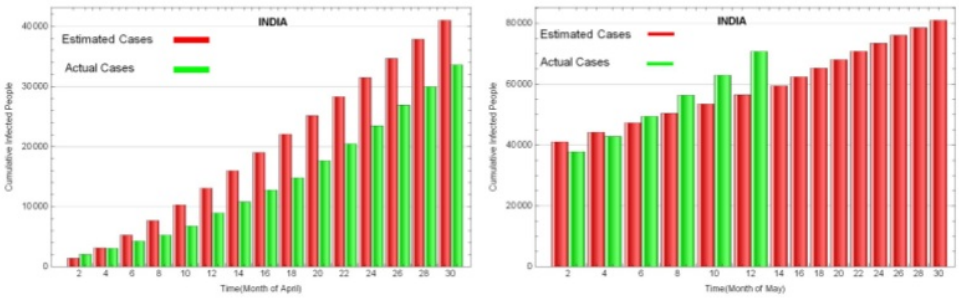

(a) (b)

Figure 2: Dynamical behavior of infected and quarntined population $I_p(t)$ with different $R_0$ for various values of $\beta$ with respect to time(days)




(a) (b)

Figure 3: Dynamical behavior of infected and quarntined population $I_p(t)$ at various values of a)contact rate ($\alpha$) and b) traced rate ($\eta$) with respect to time(days)




(a) (b)

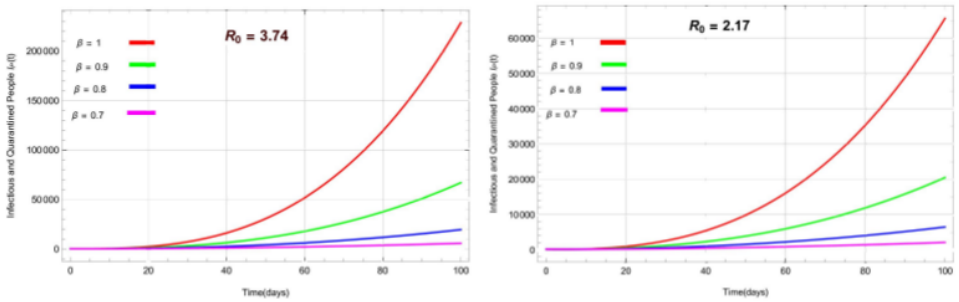
Figure 4: Cumulative number of cases of infected and quarntined population $I_p(t)$ with respect to time(days)

trace rate the infected cases also increases continuously. Figures 3a and 3b shows estimated and actual cumulative cases starting from $30^{th}$ March 2020 till $12^{th}$ May

2020. Moreover we have estimated cases for the month of May 2020.

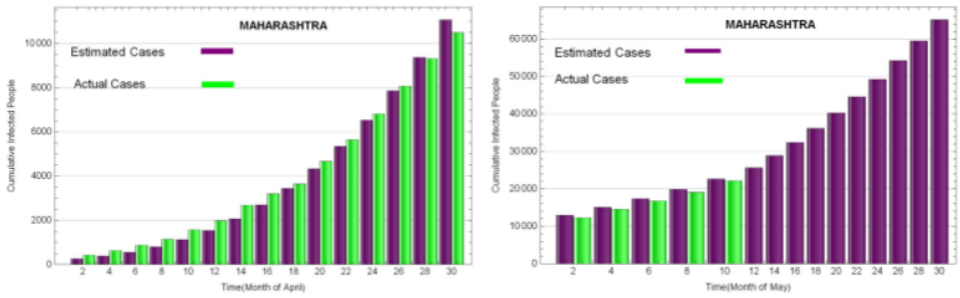
### 3.1 Forecast of the COVID-19 pandemic in MAHARASHTRA

We consider the data reported on $30^{th}$ March 2020 as initial time ($t = t_0$). Hence, the required initial values are
$S(0) = 121924973$, $E(0) = 11520$, $I(0) = 400$, $R(0) = 39$, $S_p(0) = 10000$, $E_p(0) = 800$, $I_p(0) = 200$, $Q(0) = 10$. By applying iterative fractional complex transform using (2.5) and (2.11) successively upto four terms we get series form approximate solution of the fractional COVID-19 model (1.1) and we get the following graphical results




(a) (b)

Figure 5: Dynamical behavior of a) recovered population R(t) and b) reservoir population Q(t) for various values of $\tau$ with respect to time(days)

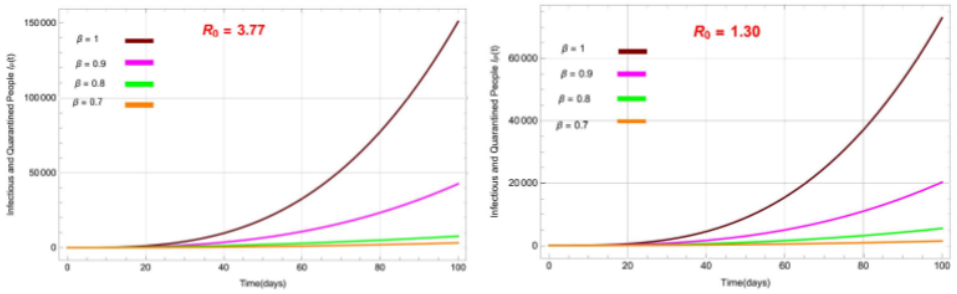



(a) (b)

Figure 6: Cumulative number of cases of infected and quarntined population $I_p(t)$ with respect to time(days)

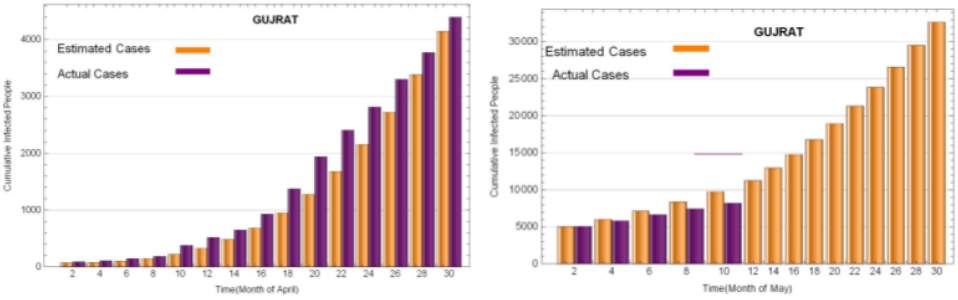
### 3.2 Forecast of the COVID-19 pandemic in GUJRAT

As per the above discussion and the data reported on $30^{th}$ March 2020 at initial time $(t = t_0)$ the required initial values are
$S(0) = 64801901$, $E(0) = 9100$, $I(0) = 100$, $R(0) = 6$, $S_p(0) = 10000$, $E_p(0) = 306$, $I_p(0) = 70$, $Q(0) = 2$. Also, we get the following graphical results by applying iterative fractional complex transform successively




(a) (b)

Figure 7: Dynamical behavior of infected and quarntined population $I_p(t)$ with different $R_0$ for various values of $\beta$ with respect to time(days)

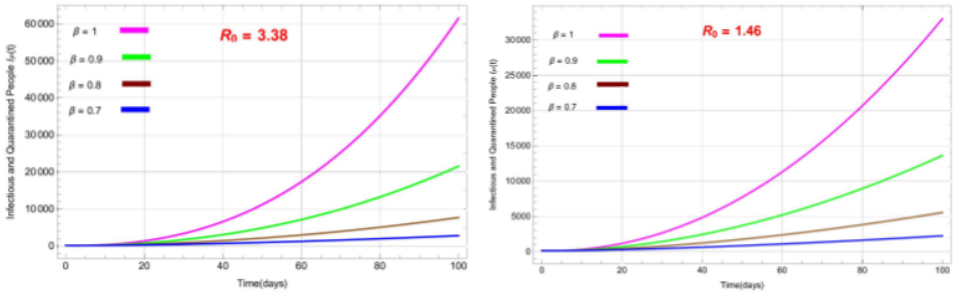



(a) (b)

Figure 8: Cumulative number of cases of infected and quarntined population $I_p(t)$ with respect to time(days)

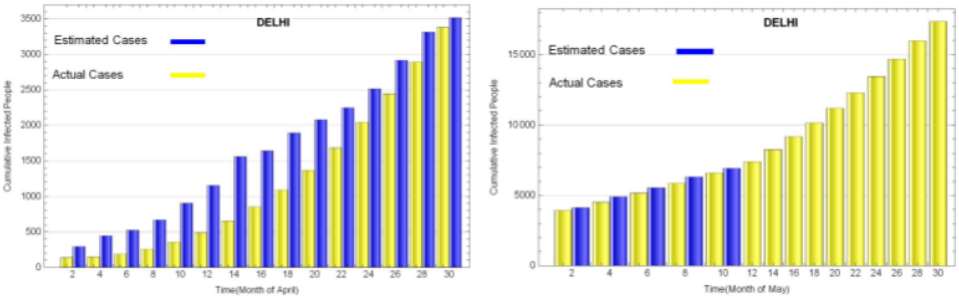
### 3.3 Forecast of the COVID-19 pandemic in DELHI

As per the above discussion and the data reported on $30^{th}$ March 2020 at initial time $(t = t_0)$ the required initial values are
$S(0) = 30290936$, $E(0) = 12100$, $I(0) = 100$, $R(0) = 6$, $S_p(0) = 10000$, $E_p(0) = 600$, $I_p(0) = 152$, $Q(0) = 2$. Also, we get the following graphical results by applying iterative fractional complex transform successively




(a) (b)

Figure 9: Dynamical behavior of infected and quarntined population $I_p(t)$ with different $R_0$ for various values of $\beta$ with respect to time(days)




(a) (b)

Figure 10: Cumulative number of cases of infected and quarntined population $I_p(t)$ with respect to time(days)

# 4 Discussion

This model of the COVID-19 pandemic for India incorporates some key features of this pandemic which includes 1) the planning of execution of the significant government policies about restrictions intended to mitigate the seriousness of the pandemic. 2) the importance of quarnatined, infectitous but not traced and latent but not traced population in estimating the number of cumulative reported cases. In this model the various parameters are estimated by considering effects of several control measures like complete nationwide lockdown from $25^{th}$ March 2020 and further extension of it, social distancing and restricting population movement implemented by government of India. Since the daily reported cases could contain more commotion during the beginning time, we utilize the total cumulative as compared to the daily frequency to make the simulations which is the limitation of our estimation in this work. In tables 1 and 2 we have estimated some important parameter values like contact rate $\mu$, traced rate $\eta$, transmission rate $\alpha$ and infectious rate of latent $\gamma$ are estimated with different $R_0$ for various regions. From figures 5a, 5b, 7a , 7b , 9a and 9b it

is observed that if $R_0 > 3$ the number infected population increases very rapidely whereas for $1 < R_0 < 2$ rate of increase is quite low. The basic reproduction number $R_0$ is depends upon most sensitive parameters like contact rate $\mu$, transmission rate $\alpha$ and traced rate $\eta$. Estimating or fitting these parameters to appropriate values reduces rate of infection significantly.
Figures 6a, 6b, 8a, 8b, 10a and 10b shows the comparison between actual and estimated number of cumulative cases of infected and quarntined population for Maharashtra state, Gujrat state and Delhi respectively. These figures also includes The bars in plots shows that there estimated cases are very nera to actual cases on a particular day. As per our estimation from this model total number of cumulative cases of infected population might go upto 100000 in India, 60000 in Maharshtra, 30000 in Gujrat and 15000 in Delhi till the end of May 2020. It is noted that there is the non-integer order time derivative affects the dynamics of the pandemic, moreover there is a striking difference at various values of time fractional parameter $\beta$ on which the present COVID-19 model depend persistently. Moreover, these figures indicates that interventions to reduce transmission rate come first in control of the outbreak followed by traced rate.

## 5 Conclusions

In this manuscript, we have investigated the appropriate fractional-order COVID-19 model which demonstrate the current scenario and future estimate of infected cases by using iterative fractional complex transform method. The effectiveness of this technique can be drastically enhanced by reducing steps and computing more components. The control measures such as quarantine startergies at home or institutional level or at hospitals, tracing infected individuals at early stage and treatment along with the policy of reducing the transmission rate can help to minimize the growth of daily infected cases of the virus. In the future to forecast conceivable behaviors of the present dynamical system, simulations with several possible fitting of parameter values can be implemented. We have analysed and estimated COVID-19 outbreak in India using this model, but it is applicable to predict and analyse transmission dynamics of any part of the world affected by COVID-19 pandemic.

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# Analysis And Dynamics of fractional order Mathematical Model of Covid 19 using Atangana Baleanue operator in Nigeria

*By* Nisar K S

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# Analysis And Dynamics of fractional order Mathematical Model of Covid 19 using Atangana Baleanue operator in Nigeria

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**Abstract**

We propose a mathematical model to investigate the current outbreak of the coronavirus disease 2019 (COVID-19). The model is studied qualitatively using stability theory of differential equations and the basic reproductive number that represents the epidemic indicator is obtained from the largest eigenvalue of the next-generation matrix. Both local and global asymptotic stability conditions for the disease free and endemic equilibrium are obtained. Further we examined this model by using Atangana-Baleanu fractional derivative operator. The uniqueness and existence criteria of solution for operator is established. We consider the data of available infection cases from April 1, 2020, till April 30, 2020 and parameterized the model. We have used iterative Laplace transform to obtain numerical simulations. These results are based on different values of fractional parameter and serves as a control parameter, which demonstrated graphically to justify our theoretical findings.

**Keywords:** Mathematical model, Covid-19, Atangana-Baleanu fractional operator, existence and uniqueness of solutions, stability analysis, numerical simulation.

## Introduction

The ongoing ravaging COVID-19 is a contagious disease instigated by SARS-CoV-2. The first case of the disease was reported in December 2019 in Wuhan, China, and has, within few weeks, spread across the globe, leading to the present 2020 COVID-19 pandemic [1]. The coronavirus disease 2019 has been regarded as the largest global health crisis in human history as a result of the magnitude of confirmed cases, accompanied with the degree of fatalities across the continents [2]. Reliable data had it that by April 2020, COVID-19 pandemic had led to over 3 million confirmed cases and 230 000 deaths and the disease has spread to over 210 nations globally [3]. As at now, the figures have skyrocketed to (5,329,444) reported cases with

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(340,524) fatalities, based on the information by the World Health Organization (WHO) on May 20, 2020.

The symptoms and signs of COVID-19 develop within 2 to 14 days [4]. When the disease is fully incubated, the infected individuals may exhibit fever, fatigue, cough and breathing disorder that is similar to those infections instigated by SARS-CoV and MERS-CoV [5-6]. However, many COVID-19 acute cases and fatalities come from the elderly people (from the age of 65 upward) and individuals with severe health challenges (such as people with kidney disease, hypertension, diabetes, obesity and other health issues that deteriorate the immune system) [3]. The first confirmed case in Nigeria was reported on 27 February 2020, when a citizen from Italy is tested positive for the virus [42]. The disease transmission raised gradually over the month of April 2020, after a substantial number of cases were noted for in the country. Since then, Nigeria is focused on spotting and referring identified infectious patients for treatment to devoted COVID-19 centres. As of 18 June 2020, Nigeria had reported 17,735 confirmed cases out of which 11,299 are active cases, 5,967 recovered peoples and 469 deaths due to COVID-19 infection [43].

The global scourge of COVID-19 pandemic has elicited the attention of scholars in different disciplines, prompting several proposals to examine and envisage the development of the pandemic [7-8]. Ndairov et al. [9] propose a model for the transmissibility of COVID-19 in the presence of super-spreaders individuals. They perform the stability and sensitivity analyses of the model and discovered that daily reduction in the number of confirmed cases of COVID-19 is a function of the number of hospitalisations. Yang and Wang [10] proposed a model to study the transmission pathways of COVID-19 in terms of human-to-human and environment-to-human spread. Their analysis confirms the tendency of COVID-19 to remain endemic even with prevention and intervention measures.

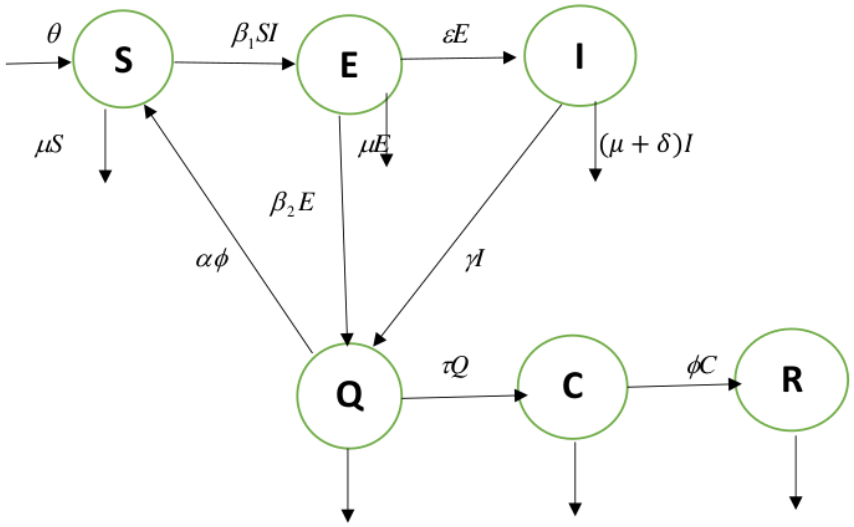
A model for the dynamics of COVID-19 with parameter estimations, sensitivity analysis and data fitting is investigated in [11] while a model for COVID-19 infection that describes the impact of slow diagnosis on the dynamics of COVID-19 is also studied in [12]. In [13], the researchers employ a statistical study of coronavirus disease 19 data to calculate time-regulated risk for fatality from the COVID-19 in Wuhan. Their results indicate that movement restrictions and adequate social distancing procedures are capable of reducing the spread of the disease. Furthermore, a data-oriented model that includes behavioural impacts of humans and governmental efforts on the dynamics of COVID-19 in Wuhan is proposed in [14]. A good number of mathematics and non-mathematics studies have also been conducted on COVID-19 [15-23].

In recent times, the integer order differential systems are generalize and improved in order to formulate several mathematical models using fractional differential operators. Since demonstration of some real world phenomena with the help of fractional derivative operator is more appropriate and useful for improving performance of numerous engineering and applied sciences systems [36-40]. In this paper, initially we formulate the mathematical model in terms of integer order derivative and then apply the Atangana-Baleanu fractional derivative operator. The motivation behind utilizing the Atangana-Baleanu operator is that it has nonlocal and nonsingular kernel in the form of Mittag-Leffler function. Moreover, the complex behavior in the model must be ideal portrayed utilizing this operator. Literature pertaining to Atangana-Baleanu derivative and their applications to several systems arising in the field of applied sciences and engineering can be cited in [29-35].

**Formulation of the Model**

The population of human under consideration is divided into six compartments which are susceptible S(t), since the incubation period of COVID-19 is between two to fourteen days there are those who are infected without exhibiting any sign of symptoms and are undetected E(t). Individuals who are infected or suspected case of COVID-19 need to go through an incubation period before the suspected symptom can noticeable these categories are quarantined Q(t), there are those certain proportion of the population have been infected with sign and symptoms of COVID-19 and is highly infectious but not yet quarantined or isolated I(t). C(t) represent confirmed case of COVID-19 from Quarantine category. R(t) represent recovery after treatment. The susceptible population is increased by immigration or by birth at the rate $\theta$, in each of the class, individuals can die a natural death and the rate $\theta$, there is a force of infection between the susceptible population and exposed population this is represented by $\beta_1$, $\varepsilon$ represent the progression from exposed class to highly infected class, the disease induced death rate for highly infected class, quarantine class and Confirmed case of COVID-19 class is represented by $\delta$, proportion of people identified as suspected case of COVID-19 are represented by $\beta_2$, after medical diagnosis, some of the suspected cases were confirmed, others that are not detected can return back to the susceptible population at the rate $\alpha$. In the meantime, some highly infectious individuals will be moved to quarantine class at the rate $\gamma$. The progression rate from quarantine to confirm case after diagnosis is denoted by $\tau$. The pictorial diagram illustrating the model is shown in figure 1 while the system of equations governing the model is given as

$$\frac{dS}{dt} = \theta - \beta_1 SI - \mu S + \alpha Q$$
$$\frac{dE}{dt} = \beta_1 SI - (\mu + \beta_2 + \varepsilon)E$$
$$\frac{dI}{dt} = \varepsilon E - (\gamma + \mu + \delta)I$$
$$\frac{dQ}{dt} = \gamma I + \beta_2 E - (\alpha + \mu + \delta + \tau)Q$$
$$\frac{dC}{dt} = \tau Q - (\mu + \delta + \varphi)C$$
$$\frac{dR}{dt} = \varphi C - \mu R \qquad (1)$$



$(\mu+\delta)Q$ $(\mu+\delta)Q$ $\mu R$

Figure 1. The model's flow diagram

The rest of the sections are organized as follows: Some valuable preliminaries dependent on the Atangana-Baleanu fractional operator is given in Section 2. In section 3, we present stability analysis of the equilibria (drug-free equilibrium state and endemic equilibrium state ). Analysis of fractional coronavirus model using the Atangana-Baleanu Operator Section 4. The Approximation technique and Numerical Simulation are given to reveal the behavior of dynamics components is accounted for in Section 5. The conclusion is finally drawn in the last section 6.

## 2 Preliminaries

This section of the paper will convert some basic definitions and properties related to Fractional calculus. During the paper process, we are going to refer to the following given specific definitions and properties of the Atangana-Baleanu fractional derivatives of Caputo type [32] that are peculiar to our study.

**Definition 2.1** *The left and right sided Caputo fractional derivative for order* $\kappa > 0$ *is defined as*

$$ {}_a^c D_t^\kappa f(t) = \frac{1}{\Gamma(n-\kappa)} \int_a^t (t-\xi)^{n-\kappa-1} f^{(n)}(\xi) d\xi , \quad (left) $$

$$ {}_a^c D_t^\kappa f(t) = \frac{(-1)}{\Gamma(n-\kappa)} \int_t^b (t-\xi)^{n-\kappa-1} f^{(n)}(\xi) d\xi \quad (right) $$

where $n-1 < \kappa \leq n,\ n \in N, f \in C^{n-1}[0,t]$.

**Definition 2.2** *The left and right Atangana-Baleanu fractional derivative for a given function for order* $\kappa$ *in Caputo sense are defined as*

$$ {}^{ABC}_a D_t^\kappa f(t) = \frac{B(\kappa)}{1-\kappa} \int_a^t \frac{df(\xi)}{d\xi} E_\kappa \left[ -\frac{\kappa}{1-\kappa} (t-\xi)^\kappa \right] d\xi , \quad (left) $$

$$ {}^{ABC}_a D_t^\kappa f(t) = -\frac{B(\kappa)}{1-\kappa} \int_t^b \frac{df(\xi)}{d\xi} E_\kappa \left[ -\frac{\kappa}{1-\kappa} (t-\xi)^\kappa \right] d\xi , \quad (right) $$

where $B(\kappa) = (1-\kappa) + \frac{\kappa}{\Gamma(\kappa)}$ is a normalization function and $E_\alpha(\cdot)$ is the Mittag-Leffler function.

**Definition 2.3** *Atangana-Baleanu fractional integral order* $\alpha$ *is defined as*

$$ {}^{AB}_0 I_t^\kappa \left( f(t) \right) = \frac{1-\kappa}{B(\kappa)} f(t) + \frac{\kappa}{B(\kappa)\Gamma(\kappa)} \int_a^t f(\xi)(t-\xi)^{\kappa-1} d\xi $$

if $f(t)$ is a constant, integral will be resulted with zero.

**Definition 2.4** The Laplace transforms for the *Atangana-Baleanu* fractional operator of order $\kappa$, where $0 < \kappa \leq 1$ is given as

$$L\{{}_{a}^{ABC}D^{\kappa}f(t)\}(s) = \frac{B(\kappa)}{1-\kappa}\frac{s^{\kappa}L\{f(t)\}(s) - s^{\kappa-1}f(a)}{s^{\kappa}+\frac{\kappa}{1-\kappa}}.$$

**Theorem 2.1** The following time fractional ordinary differential equation

$$ {}_{0}^{ABC}D^{\kappa}f(t) = \vartheta(t)$$

has a unique solution considering the inverse Laplace transform and the convolution property below:

$$f(t) = \frac{1-\kappa}{B(\kappa)}\vartheta(t) + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_{0}^{t}\vartheta(\xi)(t-\xi)^{\kappa-1}d\xi.$$

## 3. Basic Properties of the Model

### 3.1. The Invariant Region

The invariant region sets out the domain where the model's solutions are both biologically and mathematically meaningful. Since the model deals with human population, all of the model's variables and parameters are assumed to be positive. To achieve this, we consider first the total human population $N_h$, where $N_h$=$S$+$E$+$I$+$Q$+$C$+$R$

By differentiating with respect to $t$ both side of the total population $N$

$$\frac{dN_h}{dt} = \frac{dE}{dt} + \frac{dI}{dt} + \frac{dQ}{dt} + \frac{dC}{dt} + \frac{dR}{dt}$$

Then

$$\frac{N_h}{dt} = \theta - \mu(S + E + I + Q + C + R) - \delta I - \delta C - \delta Q$$

Therefore,

$$\frac{dN}{dt} = \theta - \mu N - \delta I - \delta C - \delta Q \qquad (2)$$

In the absence of the disease induced death due to COVID-19 ($\delta = 0$)

Therefore, (2) becomes

$$\frac{N_h}{dt} = \theta - \mu N_h \qquad (3)$$

Integrating on both side

$$\int \frac{dN_h}{\theta - \mu N_h} \leq \int dt \Rightarrow \frac{-1}{\mu} ln(\theta - \mu N_h) \leq t + k \qquad (4)$$

This simplifies into

$$\theta - \mu N_h \geq Ae^{-\mu t}, \qquad (5)$$

With the initial condition $N_h(0) = N_{h0}$ where $A$ is constant. Applying the initial condition in (5). Therefore,

$$N_h \leq \frac{\theta}{\mu} - \left[\frac{\theta - \mu N_h}{\mu}\right] e^{-\mu t} \qquad (6)$$

As $t \to \infty$in (6), the total human population reduces to $N_h \leq \frac{\theta}{\mu}$.

In this regards, all the feasible solution sets for human population in (1) enters and remains in the region

$$Z = \left\{(S, E, I, Q, C, R) \in \Re_+^6 : N_h \leq \frac{\theta}{\mu}\right\}. \qquad (7)$$

We therefore conclude that the proposed model is well posed and are both biologically and mathematically meaningful in the domain $Z$

### 3.2 Positivity of Solution

For the COVID-19 model dynamics in (1) to be epidemiologically meaningful it is important to prove that all its state variables are positive for all time

**Theorem 3.1**

Let the $Z = \left\{(S, E, I, Q, C, R) \in \Re_+^6 : S_0 \geq 0, E_0, I_0, Q_0, C_0, R_0\right\}$: Then the solutions $\{S, E, I, Q, C, R\}$ are non-negative for $t \geq 0$.

**Proof:**

First, we consider the susceptible compartment in equation (1)

$$\frac{dS}{dt} = \theta - \beta_1 SE - \mu S + \alpha Q$$

$$\frac{dS(t)}{dt} \geq -(\beta_1 E + \mu)S(t) \Rightarrow \frac{dS(t)}{S(t)} \geq -(\beta_1 E + \mu)dt \Rightarrow \int \frac{dS(t)}{S(t)} \geq -\int (\beta_1 E + \mu)dt.$$

By applying the initial condition $S_0$ and solving the above, we have

$$S(t) \geq S_0 e^{(\beta_1 E + \mu)t} \geq 0$$

By repeating the same procedure for $E, I, Q, C, R$ respectively in the system (1), the following we obtained the following results

$$E(t) \geq S_0 e^{(\mu + \beta_2 + \varepsilon)t} \geq 0$$

$$I(t) \geq I_0 e^{(\gamma + \delta + \mu)t} \geq 0$$

$$Q(t) \geq Q_0 e^{(\alpha + \mu + \delta + \tau)t} \geq 0 \qquad (8)$$

$$C(t) \geq C_0 e^{(\mu + \delta + \varphi)t} \geq 0$$

$$R(t) \geq R_0 e^{-\mu t} \geq 0$$

This shows that the solutions of the model are positive. Hence the proof.

### 3.3. Disease- Free Equilibrium state (DFE)

The COVID-19 model in (1) has a disease-free equilibrium DFE obtain by setting the right hand side of (1) to zero. Therefore,

$$\Omega_{DFE} = (S, E, I, Q, C, R) = \left(\frac{\theta}{\mu}, 0,0,0,0,0\right)$$

### 3.4 Existence of Endemic Equilibrium Point (EE)

We present the existence of the COVID-19 endemic equilibrium states. It is a positive equilibrium state where the COVID-19 disease is persisting in the population.

**Theorem 3.2**

Let there be a unique endemic equilibrium state when the basic reproduction number $R_0 > 1$ in the COVID-19 periodically forced model in (1)

**Proof.** Suppose $\Omega_{EE} = (S^*, E^*, I^*, Q^*, C^*, R^*)$ is a nontrivial equilibrium state of system (1) which then connote that all the compartment of $\Omega_{EE}$ are non-negative. By equating the left hand side of (1) to zero we get the following endemic equilibrium states

$$S^* = \frac{k_1 k_2}{\beta_1 \varepsilon}$$

$$E^* = -\frac{k_2 k_3(\beta_1 \varepsilon\theta - k_1 k_2 \mu)}{\varepsilon\beta_1(\alpha\beta_2 k_2 + \alpha\varepsilon\gamma - k_1 k_2 k_3)}$$

$$I^* = -\frac{k_3(\beta_1 \varepsilon\theta - k_1 k_2 \mu)}{\beta_1(\alpha\beta_2 k_2 + \alpha\varepsilon\gamma - k_1 k_2 k_3)}$$

$$Q^* = -\frac{(\beta_2 k_2 + \varepsilon\gamma)(\beta_1 \varepsilon\theta - k_1 k_2 \mu)}{\beta_1(\alpha\beta_2 k_2 + \alpha\varepsilon\gamma - k_1 k_2 k_3)} \quad (9)$$

$$C^* = -\frac{\tau\varphi(\beta_2 k_2 + \varepsilon\gamma)(\beta_1 \varepsilon\theta - k_1 k_2 \mu)}{\beta_1 k_4(\alpha\beta_2 k_2 + \alpha\varepsilon\gamma - k_1 k_2 k_3)k_4}$$

$$R^* = -\frac{\tau\varphi(\beta_2 k_2 + \varepsilon\gamma)(\beta_1 \theta - k_1 \mu)}{\beta_1 \mu\varepsilon k_4(\alpha\beta_2 k_2 + \alpha\varepsilon\gamma - k_1 k_2 k_3)}$$

Where

$$k_1 = (\mu + \beta_2 + \varepsilon), \quad k_2 = (\gamma + \mu + \delta), \quad k_3 = (\alpha + \mu + \beta), \; k_4 = (\mu + \delta + \varphi) \quad (10)$$

### 3.5 Basic Reproduction Number $R_0$

The basic reproductive ratio is a threshold quantity that represents the overall number of secondary diseases caused by a single infected individual created into a fully susceptible population throughout its infectious period. F and V are the matrices for the new infections generated and the terms of transition. Following the same approach as [24], we have

$$f = \begin{pmatrix} \beta_1 SI \\ \varepsilon E \\ \gamma I + \beta_1 E \\ \tau Q \end{pmatrix}, v = \begin{pmatrix} (\mu + \beta_2 + \varepsilon)E \\ (\gamma + \mu + \delta)I \\ (\alpha + \mu + \delta + \tau)Q \\ (\mu + \delta + \varphi)C \end{pmatrix}$$

The Jacobian matrix of $f$ and $v$ computed at the Disease Free Equilibrium is given as $F$ and $V$ such that

$$F = \begin{pmatrix} 0 & \beta_1 S & 0 & 0 \\ \varepsilon & 0 & 0 & 0 \\ \beta_2 & \gamma & 0 & 0 \\ 0 & 0 & \tau & 0 \end{pmatrix},$$

$$V = \begin{pmatrix} (\mu + \beta_2 + \varepsilon) & 0 & 0 & 0 \\ 0 & (\gamma + \mu + \delta) & 0 & 0 \\ 0 & 0 & (\alpha + \mu + \delta + \tau) & 0 \\ 0 & 0 & 0 & (\mu + \delta + \varphi) \end{pmatrix},$$

$$V^{-1} = \begin{pmatrix} \frac{1}{k_1} & 0 & 0 & 0 \\ 0 & \frac{1}{k_2} & 0 & 0 \\ 0 & 0 & \frac{1}{k_3} & 0 \\ 0 & 0 & \tau & \frac{1}{k_4} \end{pmatrix}.$$

Therefore,

$$FV^{-1} = \begin{bmatrix} \beta_1 S & 0 & 0 & 0 \\ \frac{\varepsilon}{k_1} & 0 & 0 & 0 \\ \frac{\beta_2}{k_1} & \frac{\gamma}{k_2} & 0 & 0 \\ 0 & 0 & \frac{\tau}{k_3} & 0 \end{bmatrix}$$

By substituting $k_1$ and $k_2$ from (10), we therefore obtain the basic reproduction number which is the spectral radius of the matrix $FV^{-1}$ as

$$R_0 = \frac{\theta \varepsilon \beta_1}{\mu(\mu+\beta_2+\varepsilon)(\gamma+\mu+\delta)} \qquad (11)$$

**Global Stability of the Disease-Free Equilibrium**

**Theorem 3.3.** If $R_0 \leq 1$, then the disease free equilibrium $\Omega_{DFE} = \left(\frac{\theta}{\mu}, 0,0,0,0,0\right)$ is globally asymptotically stable otherwise it is unstable.

**Proof.** We consider the Lyapunov function of the type

$L = x_1 E + x_2 I$ and $L' = x_1 E' + x_2 I'$

Where,

$$x_1 = \frac{\varepsilon}{k_1 k_2}, \quad x_2 = \frac{1}{k_2}$$

$$L' = \frac{\varepsilon}{k_1 k_2}(\beta_1 SI - k_1 E) + \frac{1}{k_2}(\varepsilon E - k_2 I)$$
$$= \frac{\varepsilon\beta_1 SI}{k_1 k_2} - \frac{\varepsilon E}{k_2} + \frac{\varepsilon E}{k_2} - I = \frac{\varepsilon\beta_1 SI}{k_1 k_2} - I$$
$$= \left(\frac{\varepsilon\beta_1 SI}{k_1 k_2} - 1\right) \leq \left(\frac{\varepsilon\beta_1 \theta}{\mu k_1 k_2} - 1\right) I$$

$$\therefore \; L = I(R_0 - 1) \tag{12}$$

From the result in (12), we can conclude that $L' \leq 0$ provided that $R_0 \leq 1$. In addition, $L' = 0$ provided that $R_0 = 1$ or $I = 0$.

## 4. Analysis of fractional coronavirus model using the Atangana-Baleanu Operator.

Let us consider the mathematical model given by an ordinary differential equation system (1) using Atangana–Baleanu fractional derivative operator as below

$$\begin{aligned}
{}^{ABC}_{0}D^{\kappa} S(t) &= \phi_1(t, S(t)) = \theta - \beta_1 SI - \mu S + \alpha Q \\
{}^{ABC}_{0}D^{\kappa} E(t) &= \phi_2(t, E(t)) = \beta_1 SI - (\mu + \beta_2 + \varepsilon)E \\
{}^{ABC}_{0}D^{\kappa} I(t) &= \phi_3(t, I(t)) = \varepsilon E - (\gamma + \mu + \delta)I \\
{}^{ABC}_{0}D^{\kappa} Q(t) &= \phi_4(t, Q(t)) = \gamma I + \beta_2 E - (\alpha + \mu + \delta + \tau)Q \\
{}^{ABC}_{0}D^{\kappa} C(t) &= \phi_5(t, C(t)) = \tau Q - (\mu + \delta + \varphi)C \\
{}^{ABC}_{0}D^{\kappa} R(t) &= \phi_6(t, R(t)) = \varphi C - \mu R.
\end{aligned} \tag{13}$$

where ${}^{ABC}_{0}D^{\kappa}$ represents the fractional operator of type Atangana-Baleanu-Caputo (ABC) having fractional order $\kappa$, where $0 < \kappa \leq 1$, subject to initial conditions

$$S_0(t) = S(0), \; E_0(t) = E(0), \; I_0(t) = I(0), \; Q_0(t) = Q(0),$$
$$C_0(t) = C(0), \; R_0(t) = R(0). \tag{14}$$

The system in equation (13) can be converted to the Volterra-type integral equation by using the ABC fractional integral. The model can be written by using Theorem 2.1 as below:

$$S(t) - S(0) = \frac{1-\kappa}{B(\kappa)}\{\theta - \beta_1 S(t)I(t) - \mu S(t) + \alpha Q(t)\} + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t \{\theta - \beta_1 S(\xi)I(\xi) - \mu S(\xi) + \alpha Q(\xi)\}(t-\xi)^{\kappa-1} d\xi.$$

$$E(t) - E(0) = \frac{1-\kappa}{B(\kappa)}\{\beta_1 S(t)I(t) - (\mu + \beta_2 + \varepsilon)E(t)\} + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t \{\beta_1 S(\xi)I(\xi) - (\mu + \beta_2 + \varepsilon)E(\xi)\}(t-\xi)^{\kappa-1} d\xi.$$

$$I(t) - I(0) = \frac{1-\kappa}{B(\kappa)}\{\varepsilon E(t) - (\gamma + \mu + \delta)I(t)\} + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t \{\varepsilon E(\xi) - (\gamma + \mu + \delta)I(\xi)\}(t-\xi)^{\kappa-1} d\xi.$$

$$Q(t) - Q(0) = \frac{1-\kappa}{B(\kappa)}\{\gamma I(t) + \beta_2 E(t) - (\alpha + \mu + \delta + \tau)Q(t)\} + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t \{\gamma I(\xi) + \beta_2 E(\xi) - (\alpha + \mu + \delta + \tau)Q(\xi)\}(t-\xi)^{\kappa-1} d\xi.$$

$$C(t)-C(0)=\frac{1-\kappa}{B(\kappa)}\{\tau Q(t)-(\mu+\delta+\varphi)C(t)\}$$
$$+\frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t\{\tau Q(\xi)-(\mu+\delta+\varphi)C(\xi)\}(t-\xi)^{\kappa-1}d\xi.$$
$$R(t)-R(0)=\frac{1-\kappa}{B(\kappa)}\{\varphi C(t)-\mu R(t)\}+\frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t\{\varphi C(\xi)-\mu R(\xi)\}(t-\xi)^{\kappa-1}d\xi. \quad (15)$$

**Theorem 4.1** The kernels $\phi_1,\phi_2,\phi_3,\phi_4,\phi_5$ and $\phi_6$ given in (13) satisfy the Lipschitz condition and contraction if the following inequality holds:

$$0\le \pi_1,\pi_2,\pi_3,\pi_4,\pi_5,\pi_6 < 1. \quad (16)$$

**Proof**: Let the kernel $\phi_1(t,S(t))=\theta-\beta_1 SI-\mu S+\alpha Q$.

Let $S_1$ and $S_2$ be two functions; then we obtain the following:

$$\begin{aligned}\left\|\phi_1(t,S_1(t))-\phi_1(t,S_2(t))\right\| &= \|(\theta-\beta_1 S_1 I-\mu S_1+\alpha Q)-(\theta-\beta_1 S_2 I-\mu S_2+\alpha Q)\|\\ &= \|-(\beta_1 I+\mu)(S_1(t)-S_2(t))\|\le(\beta_1\|I(t)\|+\mu)\|S_1(t)-S_2(t)\|\\ &\le(\beta_1 M_1+\mu)\|S_1(t)-S_2(t)\|\\ &\le(\beta_1 M_1+\mu)\|S_1(t)-S_2(t)\|\le\pi_1\|S_1(t)-S_2(t)\| \quad (17)\end{aligned}$$

Where $\pi_1=\beta_1 M_1+\mu$, $M_1=\max_{t\in J}\|I(t)\|$.

Similarly we get,

$$\begin{aligned}\left\|\phi_2(t,E_1(t))-\phi_2(t,E_2(t))\right\| &\le \pi_2\|E_1(t)-E_2(t)\|\\ \left\|\phi_3(t,I_1(t))-\phi_3(t,I_2(t))\right\| &\le \pi_3\|I_1(t)-I_2(t)\|\\ \left\|\phi_4(t,Q_1(t))-\phi_4(t,Q_2(t))\right\| &\le \pi_4\|Q_1(t)-Q_2(t)\| \quad (18)\\ \left\|\phi_5(t,C_1(t))-\phi_5(t,C_2(t))\right\| &\le \pi_5\|C_1(t)-C_2(t)\|\\ \left\|\phi_6(t,R_1(t))-\phi_6(t,R_2(t))\right\| &\le \pi_6\|R_1(t)-R_2(t)\|\end{aligned}$$

where

$\pi_2=(\mu+\beta_2+\varepsilon)$, $\pi_3=\gamma+\mu+\delta$, $\pi_4=\alpha+\mu+\delta+\tau$, $\pi_5=\mu+\delta+\varphi$, and $\pi_6=\mu$.

Considering the kernels of the model, equation (15) can be rewritten as

$$S(t)=S(0)+\frac{1-\kappa}{B(\kappa)}\{\phi_1(t,S(t))\}+\frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t\{\phi_1(\xi,S(\xi))\}(t-\xi)^{\kappa-1}d\xi.$$
$$E(t)=E(0)+\frac{1-\kappa}{B(\kappa)}\{\phi_2(t,E(t))\}+\frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t\{\phi_2(\xi,E(\xi))\}(t-\xi)^{\kappa-1}d\xi.$$
$$I(t)=I(0)+\frac{1-\kappa}{B(\kappa)}\{\phi_3(t,I(t))\}+\frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t\{\phi_3(\xi,I(\xi))\}(t-\xi)^{\kappa-1}d\xi.$$
$$Q(t)=Q(0)+\frac{1-\kappa}{B(\kappa)}\{\phi_4(t,Q(t))\}+\frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t\{\phi_4(\xi,Q(\xi))\}(t-\xi)^{\kappa-1}d\xi.$$
$$C(t)=C(0)+\frac{1-\kappa}{B(\kappa)}\{\phi_5(t,C(t))\}+\frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t\{\phi_5(\xi,C(\xi))\}(t-\xi)^{\kappa-1}d\xi.$$
$$R(t)=R(0)+\frac{1-\kappa}{B(\kappa)}\{\phi_6(t,R(t))\}+\frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t\{\phi_6(\xi,R(\xi))\}(t-\xi)^{\kappa-1}d\xi. \quad (19)$$

Therefore we get the following recursive formula.

$$S_n(t)=S(0)+\frac{1-\kappa}{B(\kappa)}\{\phi_1(t,S_{n-1}(t))\}+\frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t\{\phi_1(\xi,S_{n-1}(\xi))\}(t-\xi)^{\kappa-1}d\xi.$$

$$E_n(t) = E(0) + \frac{1-\kappa}{B(\kappa)}\{\phi_2(t, E_{n-1}(t))\} + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t \{\phi_2(\xi, E_{n-1}(\xi))\}(t-\xi)^{\kappa-1}d\xi.$$

$$I_n(t) = I(0) + \frac{1-\kappa}{B(\kappa)}\{\phi_3(t, I_{n-1}(t))\} + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t \{\phi_3(\xi, I_{n-1}(\xi))\}(t-\xi)^{\kappa-1}d\xi.$$

$$Q_n(t) = Q(0) + \frac{1-\kappa}{B(\kappa)}\{\phi_4(t, Q_{n-1}(t))\} + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t \{\phi_4(\xi, Q_{n-1}(\xi))\}(t-\xi)^{\kappa-1}d\xi.$$

$$C_n(t) = C(0) + \frac{1-\kappa}{B(\kappa)}\{\phi_5(t, C_{n-1}(t))\} + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t \{\phi_5(\xi, C_{n-1}(\xi))\}(t-\xi)^{\kappa-1}d\xi.$$

$$R_n(t) = R(0) + \frac{1-\kappa}{B(\kappa)}\{\phi_6(t, R_{n-1}(t))\} + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t \{\phi_6(\xi, R_{n-1}(\xi))\}(t-\xi)^{\kappa-1}d\xi. \quad (20)$$

We next get the difference between the iterative terms in the expression

$$\Theta_{1_n}(t) = S_n(t) - S_{(n-1)}(t) = \frac{1-\kappa}{B(\kappa)}\{\phi_1(t, S_{n-1}(t)) - \phi_1(t, S_{n-2}(t))\}$$
$$+ \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t \{\phi_1(\xi, S_{n-1}(\xi)) - \phi_1(\xi, S_{n-2}(\xi))\}(t-\xi)^{\kappa-1}d\xi.$$

$$\Theta_{2_n}(t) = E_n(t) - E_{(n-1)}(t) = \frac{1-\kappa}{B(\kappa)}\{\phi_2(t, E_{n-1}(t)) - \phi_2(t, E_{n-2}(t))\}$$
$$+ \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t \{\phi_2(\xi, E_{n-1}(\xi)) - \phi_2(\xi, E_{n-2}(\xi))\}(t-\xi)^{\kappa-1}d\xi.$$

$$\Theta_{3_n}(t) = I_n(t) - I_{(n-1)}(t) = \frac{1-\kappa}{B(\kappa)}\{\phi_3(t, I_{n-1}(t)) - \phi_3(t, I_{n-2}(t))\}$$
$$+ \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t \{\phi_3(\xi, I_{n-1}(\xi)) - \phi_3(\xi, I_{n-2}(\xi))\}(t-\xi)^{\kappa-1}d\xi\,.$$

$$\Theta_{4_n}(t) = Q_n(t) - Q_{(n-1)}(t) = \frac{1-\kappa}{B(\kappa)}\{\phi_4(t, Q_{n-1}(t)) - \phi_4(t, Q_{n-2}(t))\}$$
$$+ \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t \{\phi_4(\xi, Q_{n-1}(\xi)) - \phi_4(\xi, Q_{n-2}(\xi))\}(t-\xi)^{\kappa-1}d\xi.$$

$$\Theta_{5_n}(t) = C_n(t) - C_{(n-1)}(t) = \frac{1-\kappa}{B(\kappa)}\{\phi_5(t, C_{n-1}(t)) - \phi_5(t, C_{n-2}(t))\}$$
$$+ \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t \{\phi_5(\xi, C_{n-1}(\xi)) - \phi_5(\xi, C_{n-2}(\xi))\}(t-\xi)^{\kappa-1}d\xi.$$

$$\Theta_{6_n}(t) = R_n(t) - R_{(n-1)}(t) = \frac{1-\kappa}{B(\kappa)}\{\phi_6(t, R_{n-1}(t)) - \phi_6(t, R_{n-2}(t))\}$$
$$+ \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t \{\phi_6(\xi, R_{n-1}(\xi)) - \phi_6(\xi, R_{n-2}(\xi))\}(t-\xi)^{\kappa-1}d\xi\,. \quad (21)$$

where

$$S_n = \sum_{m=0}^{\infty}\Theta_{1_m}, \quad E_n = \sum_{m=0}^{\infty}\Theta_{2_m}, \quad I_n = \sum_{m=0}^{\infty}\Theta_{3_m}, \quad Q_n = \sum_{m=0}^{\infty}\Theta_{4_m},$$

$$C_n = \sum_{m=0}^{\infty}\Theta_{5_m}, \quad R_n = \sum_{m=0}^{\infty}\Theta_{6_m}.$$

Applying the norm of both sides to equation (21) and considering triangular inequality, the equation becomes as the following equation:

$$\|\Theta_{1_n}(t)\| = \|S_n(t) - S_{(n-1)}(t)\| \leq \frac{1-\kappa}{B(\kappa)}\|\phi_1(t, S_{n-1}(t)) - \phi_1(t, S_{n-2}(t))\| + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\left\|\int_0^t \{\phi_1(\xi, S_{n-1}(\xi)) - \phi_1(\xi, S_{n-2}(\xi))\}(t-\xi)^{\kappa-1}d\xi\right\|,$$

$$\|\Theta_{2_n}(t)\| = \|E_n(t) - E_{(n-1)}(t)\| \leq \frac{1-\kappa}{B(\kappa)}\|\phi_2(t, E_{n-1}(t)) - \phi_2(t, E_{n-2}(t))\| + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\left\|\int_0^t \{\phi_2(\xi, E_{n-1}(\xi)) - \phi_2(\xi, E_{n-2}(\xi))\}(t-\xi)^{\kappa-1}d\xi\right\|,$$

$$\|\Theta_{3_n}(t)\| = \|I_n(t) - I_{(n-1)}(t)\| \leq \frac{1-\kappa}{B(\kappa)}\|\phi_3(t, I_{n-1}(t)) - \phi_3(t, I_{n-2}(t))\| + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\left\|\int_0^t \{\phi_3(\xi, I_{n-1}(\xi)) - \phi_3(\xi, I_{n-2}(\xi))\}(t-\xi)^{\kappa-1}d\xi\right\|,$$

$$\|\Theta_{4_n}(t)\| = \|Q_n(t) - Q_{(n-1)}(t)\| \leq \frac{1-\kappa}{B(\kappa)}\|\phi_4(t, Q_{n-1}(t)) - \phi_4(t, Q_{n-2}(t))\| + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\left\|\int_0^t \{\phi_4(\xi, Q_{n-1}(\xi)) - \phi_4(\xi, Q_{n-2}(\xi))\}(t-\xi)^{\kappa-1}d\xi\right\|,$$

$$\|\Theta_{5_n}(t)\| = \|C_n(t) - C_{(n-1)}(t)\| \leq \frac{1-\kappa}{B(\kappa)}\|\phi_5(t, C_{n-1}(t)) - \phi_5(t, C_{n-2}(t))\| + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\left\|\int_0^t \{\phi_5(\xi, C_{n-1}(\xi)) - \phi_5(\xi, C_{n-2}(\xi))\}(t-\xi)^{\kappa-1}d\xi\right\|,$$

$$\|\Theta_{6_n}(t)\| = \|R_n(t) - R_{(n-1)}(t)\| \leq \frac{1-\kappa}{B(\kappa)}\|\phi_6(t, R_{n-1}(t)) - \phi_6(t, R_{n-2}(t))\| + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\left\|\int_0^t \{\phi_6(\xi, R_{n-1}(\xi)) - \phi_6(\xi, R_{n-2}(\xi))\}(t-\xi)^{\kappa-1}d\xi\right\|, \quad (22)$$

Since the kernels satisfy the Lipschitz condition, we get the following

$$\|\Theta_{1_n}(t)\| \leq \frac{1-\kappa}{B(\kappa)}\pi_1\left\|\Theta_{1_{(n-1)}}(t)\right\| + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\pi_1\int_0^t (t-\xi)^{\kappa-1}\left\|\Theta_{1_{(n-1)}}(\xi)\right\|d\xi,$$

$$\|\Theta_{2_n}(t)\| \leq \frac{1-\kappa}{B(\kappa)}\pi_2\left\|\Theta_{2_{(n-1)}}(t)\right\| + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\pi_2\int_0^t (t-\xi)^{\kappa-1}\left\|\Theta_{2_{(n-1)}}(\xi)\right\|d\xi,$$

$$\|\Theta_{3_n}(t)\| \leq \frac{1-\kappa}{B(\kappa)}\pi_3\left\|\Theta_{3_{(n-1)}}(t)\right\| + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\pi_3\int_0^t (t-\xi)^{\kappa-1}\left\|\Theta_{3_{(n-1)}}(\xi)\right\|d\xi,$$

$$\|\Theta_{4_n}(t)\| \leq \frac{1-\kappa}{B(\kappa)}\pi_4\left\|\Theta_{4_{(n-1)}}(t)\right\| + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\pi_4\int_0^t (t-\xi)^{\kappa-1}\left\|\Theta_{4_{(n-1)}}(\xi)\right\|d\xi,$$

$$\|\Theta_{5_n}(t)\| \leq \frac{1-\kappa}{B(\kappa)}\pi_5\left\|\Theta_{5_{(n-1)}}(t)\right\| + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\pi_5\int_0^t (t-\xi)^{\kappa-1}\left\|\Theta_{5_{(n-1)}}(\xi)\right\|d\xi,$$

$$\|\Theta_{6_n}(t)\| \leq \frac{1-\kappa}{B(\kappa)}\pi_6\left\|\Theta_{6_{(n-1)}}(t)\right\| + \frac{\kappa}{B(\kappa)\Gamma(\kappa)}\pi_6\int_0^t (t-\xi)^{\kappa-1}\left\|\Theta_{6_{(n-1)}}(\xi)\right\|d\xi. \quad (23)$$

This completes the proof of the theorem.

**Theorem 4.2 (Existence of the Solution).** The system given by equation (13) has a solution under the conditions that we can find $t_{max}$ satisfying

$$\frac{\pi_j}{B(\kappa)}\left(1-\kappa+\frac{t_{max}^{\kappa}}{\Gamma(\kappa)}\right) < 1, \qquad \text{for } j \in \{1,2,\ldots 6\}.$$

**Proof:** Let the functions S(t), E(t), I(t), Q(t), C(t) and R(t) are bounded. From equation (23) we get the following relations.

$$\|\Theta_{1_n}(t)\| \leq \|S(0)\|\left\{\frac{\pi_1}{B(\kappa)}\left(1-\kappa+\frac{t_{max}^{\kappa}}{\Gamma(\kappa)}\right)\right\}^n,$$
$$\|\Theta_{2_n}(t)\| \leq \|E(0)\|\left\{\frac{\pi_2}{B(\kappa)}\left(1-\kappa+\frac{t_{max}^{\kappa}}{\Gamma(\kappa)}\right)\right\}^n,$$
$$\|\Theta_{3_n}(t)\| \leq \|I(0)\|\left\{\frac{\pi_3}{B(\kappa)}\left(1-\kappa+\frac{t_{max}^{\kappa}}{\Gamma(\kappa)}\right)\right\}^n,$$
$$\|\Theta_{4_n}(t)\| \leq \|Q(0)\|\left\{\frac{\pi_4}{B(\kappa)}\left(1-\kappa+\frac{t_{max}^{\kappa}}{\Gamma(\kappa)}\right)\right\}^n,$$
$$\|\Theta_{5_n}(t)\| \leq \|C(0)\|\left\{\frac{\pi_5}{B(\kappa)}\left(1-\kappa+\frac{t_{max}^{\kappa}}{\Gamma(\kappa)}\right)\right\}^n,$$
$$\|\Theta_{6_n}(t)\| \leq \|R(0)\|\left\{\frac{\pi_6}{B(\kappa)}\left(1-\kappa+\frac{t_{max}^{\kappa}}{\Gamma(\kappa)}\right)\right\}^n. \qquad (24)$$

Hence, the functions $\Theta_{1_n}(t)$, $\Theta_{2_n}(t)$, $\Theta_{3_n}(t)$, $\Theta_{4_n}(t)$, $\Theta_{5_n}(t)$ and $\Theta_{6_n}(t)$ given in equations (24) exist and are smooth. Moreover, to show that the functions in equations (24) are the solutions of equations (13), we assume that

$$\begin{aligned} S(t)-S(0) &= S_n(t)-\Delta_{1(n)}(t),\\ E(t)-E(0) &= E_n(t)-\Delta_{2(n)}(t),\\ I(t)-I(0) &= I_n(t)-\Delta_{3(n)}(t),\\ Q(t)-Q(0) &= Q_n(t)-\Delta_{4(n)}(t),\\ C(t)-C(0) &= C_n(t)-\Delta_{5(n)}(t),\\ R(t)-R(0) &= R_n(t)-\Delta_{6(n)}(t). \end{aligned} \qquad (25)$$

where $\Delta_{1(n)}(t)$, $\Delta_{2(n)}(t)$, $\Delta_{3(n)}(t)$, $\Delta_{4(n)}(t)$, $\Delta_{5(n)}(t)$, and $\Delta_{6(n)}(t)$, are reminder terms of series solution. Then, we must show that these terms approach to zero at infinity, that is, $\|\Delta_{1(\infty)}(t)\| \to 0$, $\|\Delta_{2(\infty)}(t)\| \to 0$, $\|\Delta_{3(\infty)}(t)\| \to 0$, $\|\Delta_{4(\infty)}(t)\| \to 0$, $\|\Delta_{5(\infty)}(t)\| \to 0$ and $\|\Delta_{6(\infty)}(t)\| \to 0$. Thus, for the term $\Delta_{1(n)}(t)$

$$\begin{aligned} \|\Delta_{1(n)}(t)\| &\leq \tfrac{1-\kappa}{B(\kappa)}\|\phi_1(t,S(t))-\phi_1(t,S_{n-1}(t))\|\\ &\quad+\frac{\kappa}{B(\kappa)\Gamma(\kappa)}\int_0^t (t-\xi)^{\kappa-1}\|\phi_1(\xi,S(\xi))-\phi_1(\xi,S_{n-1}(\xi))\|\,d\xi\\ &\leq \tfrac{\pi_1}{B(\kappa)}\left(1-\kappa+\tfrac{t_{max}^{\kappa}}{\Gamma(\kappa)}\right)\|S(t)-S_{n-1}(t)\|. \end{aligned} \qquad (26)$$

Continuing this way recursively, we get

$$\|\Delta_{1(n)}(t)\| \leq B\,{\pi_1}^n\left\{\tfrac{1}{B(\kappa)}\left(1-\kappa+\tfrac{t_{max}^{\kappa}}{\Gamma(\kappa)}\right)\right\}^{n+1} \qquad (27)$$

Where $B = \|S(t)-S_{n-1}(t)\|$.

When we take the limit of both sides as n tends to infinity, we get

$$\|\Delta_{j(\infty)}(t)\| \to 0, \qquad j \in \{1,2,3,4,5,6\}.$$

## 5. The Approximation technique and Numerical Simulation

### 5.1 Approximation technique

Consider the coronavirus model (13) along with initial conditions (14). The terms SI in this model is nonlinear. Implementing the Laplace transform on both sides of system (13), we obtain,

$$\frac{B(\kappa)}{1-\kappa}\frac{s^{\kappa}L\{S(t)\}-s^{\kappa-1}S(0)}{s^{\kappa}+\frac{\kappa}{1-\kappa}} = L\{\theta-\beta_1 SI-\mu S+\alpha Q\}$$

$$\frac{B(\kappa)}{1-\kappa}\frac{s^{\kappa}L\{E(t)\}-s^{\kappa-1}E(0)}{s^{\kappa}+\frac{\kappa}{1-\kappa}} = L\{\beta_1 SI-(\mu+\beta_2+\varepsilon)E\}$$

$$\frac{B(\kappa)}{1-\kappa}\frac{s^{\kappa}L\{I(t)\}-s^{\kappa-1}I(0)}{s^{\kappa}+\frac{\kappa}{1-\kappa}} = L\{\varepsilon E-(\gamma+\mu+\delta)I\}$$

$$\frac{B(\kappa)}{1-\kappa}\frac{s^{\kappa}L\{Q(t)\}-s^{\kappa-1}Q(0)}{s^{\kappa}+\frac{\kappa}{1-\kappa}} = L\{\gamma I+\beta_2 E-(\alpha+\mu+\delta+\tau)Q\}$$

$$\frac{B(\kappa)}{1-\kappa}\frac{s^{\kappa}L\{C(t)\}-s^{\kappa-1}C(0)}{s^{\kappa}+\frac{\kappa}{1-\kappa}} = L\{\tau Q-(\mu+\delta+\varphi)C\}$$

$$\frac{B(\kappa)}{1-\kappa}\frac{s^{\kappa}L\{R(t)\}-s^{\kappa-1}R(0)}{s^{\kappa}+\frac{\kappa}{1-\kappa}} = L\{\varphi C-\mu R\} \qquad (28)$$

Rearranging, we get

$$L\{S(t)\} = \frac{S(0)}{s}+\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}L\{\theta-\beta_1 SI-\mu S+\alpha Q\},$$

$$L\{E(t)\} = \frac{E(0)}{s}+\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}L\{\beta_1 SI-(\mu+\beta_2+\varepsilon)E\},$$

$$L\{I(t)\} = \frac{I(0)}{s}+\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}L\{\varepsilon E-(\gamma+\mu+\delta)I\},$$

$$L\{Q(t)\} = \frac{Q(0)}{s}+\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}L\{\gamma I+\beta_2 E-(\alpha+\mu+\delta+\tau)Q\},$$

$$L\{C(t)\} = \frac{C(0)}{s}+\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}L\{\tau Q-(\mu+\delta+\varphi)C\},$$

$$L\{R(t)\} = \frac{R(0)}{s}+\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}L\{\varphi C-\mu R\}. \qquad (29)$$

Further, the inverse Laplace transform on equations (29), yields

$$S(t) = S(0)+L^{-1}\left[\left(\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}\right)L\{\theta-\beta_1 SI-\mu S+\alpha Q\}\right],$$

$$E(t) = E(0)+L^{-1}\left[\left(\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}\right)L\{\beta_1 SI-(\mu+\beta_2+\varepsilon)E\}\right],$$

$$I(t) = I(0)+L^{-1}\left[\left(\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}\right)L\{\varepsilon E-(\gamma+\mu+\delta)I\}\right],$$

$$Q(t) = Q(0) + L^{-1}\left[\left(\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}\right)L\{\gamma I + \beta_2 E - (\alpha+\mu+\delta+\tau)Q\}\right],$$

$$C(t) = C(0) + L^{-1}\left[\left(\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}\right)L\{\tau Q - (\mu+\delta+\varphi)C\}\right],$$

$$R(t) = R(0) + L^{-1}\left[\left(\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}\right)L\{\varphi C - \mu R\}\right]. \quad (30)$$

The series solutions achieved by the method are given by,

$$S = \sum_{n=0}^{\infty} S_n, \quad E = \sum_{n=0}^{\infty} E_n, \quad I = \sum_{n=0}^{\infty} I_n, \quad Q = \sum_{n=0}^{\infty} Q_n, \quad C = \sum_{n=0}^{\infty} C_n, \quad R = \sum_{n=0}^{\infty} R_n.$$

The nonlinearity of SI is written as $SI = \sum_{n=0}^{\infty} G_n$,

whereas $G_n$ is further decomposed as follows [37]

$$G_n = \sum_{j=0}^{n} S_j \sum_{j=0}^{n} I_j - \sum_{j=0}^{n-1} S_j \sum_{j=0}^{n-1} I_j.$$

Using initial conditions, we get the recursive formula given by

$$S_{n+1}(t) = S_n(0) + L^{-1}\left[\left(\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}\right)L\{\theta - \beta_1 S_n I_n - \mu S_n + \alpha Q_n\}\right],$$

$$E_{n+1}(t) = E_n(0) + L^{-1}\left[\left(\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}\right)L\{\beta_1 S_n I_n - (\mu+\beta_2+\varepsilon)E_n\}\right],$$

$$I_{n+1}(t) = I_n(0) + L^{-1}\left[\left(\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}\right)L\{\{\varepsilon E_n - (\gamma+\mu+\delta)I_n\}\}\right],$$

$$Q_{n+1}(t) = Q_n(0) + L^{-1}\left[\left(\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}\right)L\{\gamma I_n + \beta_2 E_n - (\alpha+\mu+\delta+\tau)Q_n\}\right],$$

$$C_{n+1}(t) = C_n(0) + L^{-1}\left[\left(\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}\right)L\{\tau Q_n - (\mu+\delta+\varphi)C_n\}\right],$$

$$R_{n+1}(t) = R_n(0) + L^{-1}\left[\left(\frac{s^{\kappa}(1-\kappa)+\kappa}{s^{\kappa}(B(\kappa))}\right)L\{\varphi C_n - \mu R_n\}\right]. \quad (31)$$

Where

$S_0(t) = S(0), \quad E_0(t) = E(0), \quad I_0(t) = I(0), \quad Q_0(t) = Q(0), \quad C_0(t) = C(0), \quad R_0(t) = R(0).$

The approximate solution is assumed to obtain as a limit when n tends to infinity.

$$S(t) = \lim_{n\to\infty} S_n(t), \quad E(t) = \lim_{n\to\infty} E_n(t), \quad I(t) = \lim_{n\to\infty} I_n(t), \quad Q(t) = \lim_{n\to\infty} Q_n(t),$$

$$C(t) = \lim_{n\to\infty} C_n(t), \quad R(t) = \lim_{n\to\infty} R_n(t).$$

### 5.2 Numerical simulations

In this section, we have presented data fitting, numerical simulations and graphical demonstration of the Atangana Baleanu COVID-19 model (13) for the population of Nigeria. We consider the available cumulative infection cases for April 1, 2020, till April 30, 2020 and parameterized the model [41, 43]. The parameters were estimated based on the some assumptions and facts given in table 1 which plays significant role in estimating $R_0$ (basic reproductive number). $R_0$ is expected number of cases directly generated by one individual in a population. When $R_0 > 1$ the infection will be able to start spreading in a population, but if $R_0 < 1$ the disease will die out.

**Table 1.** Details Defination of Variables and Parameters

| Parameter | Description | Value | Source |
|---|---|---|---|
| $\theta$ | recruitment rate into susceptible class | 1.3 | [25] |
| $\mu$ | natural death rate | $4.317 \times 10{-}5$ | [26] |
| $\delta$ | covid-19 infection death rate | 0.00618 | Fitted |
| $\beta_1$ | force of infection | $2.51 \times 10^{-7}$ | Fitted |
| $\beta_2$ | proportion of people identified as suspected cases | 0.04 | Fitted |
| $\varepsilon$ | progression rate from exposed class to highly infected class | 0.00916 | Fitted |
| $\alpha$ | Rate of returning to susceptible class after diagnosis | 0.068 | [28] |
| $\gamma$ | Progression rate from highly infectious class to quarantine class | 0.001 | Fitted |
| $\tau$ | progression rate from quarantine to confirm case after diagnosis | 0.002 | [28] |
| $\boldsymbol{\varphi}$ | rate of recovery from infection | 0.0714 | [27] |

Next, we evaluate and present the number of cumulative infectious cases in different compartments with respect to time in days using various plots for population of Nigeria. We begin estimation of our model from initial time ($t = t_0$) as per data reported on April 1, 2020 [42]. Hence, the required initial values are
S(0) = 205773342; E(0) = 15,000; I(0) = 100; Q(0) = 100; C(0) =175; R(0) = 31.

By applying iterative Laplace transform using equation (31) successively up to four terms we get series form approximate solution of the fractional COVID-19 model (13) as given below

$$S(t) = 205773342 - \frac{0.0000382421}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^2} + \frac{0.0000764842\kappa}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^2} - \frac{0.0000382421\kappa^2}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^2} + \frac{2.6}{1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]}} - \frac{2.6\kappa}{1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]}} + \frac{0.00001291281439502035 9t^{\kappa}}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^3(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \frac{0.00003873844318506108t^{\kappa}\kappa}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^3(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \ldots$$

$$E(t) = 15000 + \frac{0.000032630000000000004}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^2} - \frac{0.00006526\kappa}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^2} + \frac{0.000032630000000000004\kappa^2}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^2} - \frac{0.00001291281439502036 2t^{\kappa}}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^3(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \frac{0.00003873844318506108t^{\kappa}\kappa}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^3(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} - \frac{0.00003873844318506108t^{\kappa}\kappa^2}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^3(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \frac{0.00001291281439502035 9t^{\kappa}\kappa^3}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^3(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \ldots$$

$$I(t) = 100 + \frac{0.28430815806309984t^{\kappa}}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^2(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} - \frac{0.5686163161261999t^{\kappa}\kappa}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^2(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \frac{0.28430815806309984t^{\kappa}\kappa^2}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^2(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} - \frac{39.573442828747645t^{\kappa}}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \frac{39.57344282874765t^{\kappa}\kappa}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \frac{0.28430815806309984\text{Gamma}[\kappa]}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^2(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} - \ldots$$

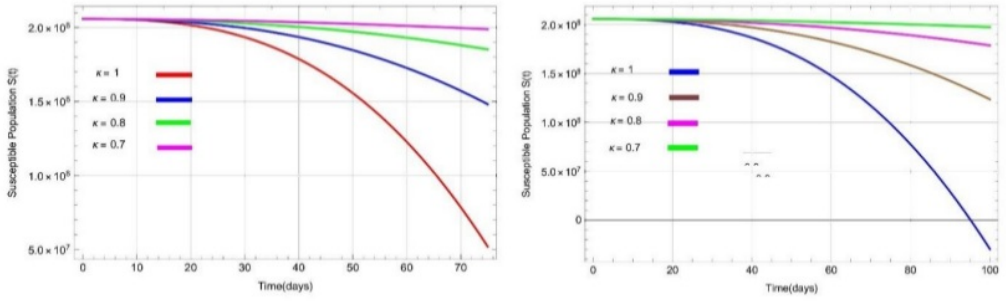
$$Q(t) = 100 + \frac{10.024125186027561t^{\kappa}}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^2(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} - \frac{20.04825037205514t^{\kappa}\kappa}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^2(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \frac{10.024125186027561t^{\kappa}\kappa^2}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^2(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} - \frac{132.0967231202757t^{\kappa}}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \frac{132.0967231202756t^{\kappa}\kappa}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \frac{10.024125186027561\text{Gamma}[\kappa]}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})^2(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} - \ldots$$

$$C(t) = 175 - \frac{2.2228283659623 86t^{\kappa}}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \frac{2.2228283659623855t^{\kappa}\kappa}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} - \frac{2.222828365962386\text{Gamma}[\kappa]}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \frac{4.445656731924771\kappa\text{Gamma}[\kappa]}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} - \frac{2.222828365962386\kappa^2\text{Gamma}[\kappa]}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \frac{0.09173682565913349t^{\kappa}\text{Gamma}[\kappa]}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(\kappa+\text{Gamma}[\kappa]-\kappa\text{Gamma}[\kappa])^2} - \ldots$$

$$R(t) = 31 + \frac{0.9551899812522688t^{\kappa}}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} - \frac{0.9551899812522688t^{\kappa}\kappa}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \frac{0.9551899812522688\text{Gamma}[\kappa]}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} - \frac{1.9103799625045377\kappa\text{Gamma}[\kappa]}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \frac{0.9551899812522688\kappa^2\text{Gamma}[\kappa]}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(-\kappa+(-1+\kappa)\text{Gamma}[\kappa])} + \frac{0.15871406888486345t^{\kappa}\text{Gamma}[\kappa]}{(1-\kappa+\frac{\kappa}{\text{Gamma}[\kappa]})(\kappa+\text{Gamma}[\kappa]-\kappa\text{Gamma}[\kappa])^2} - \ldots$$

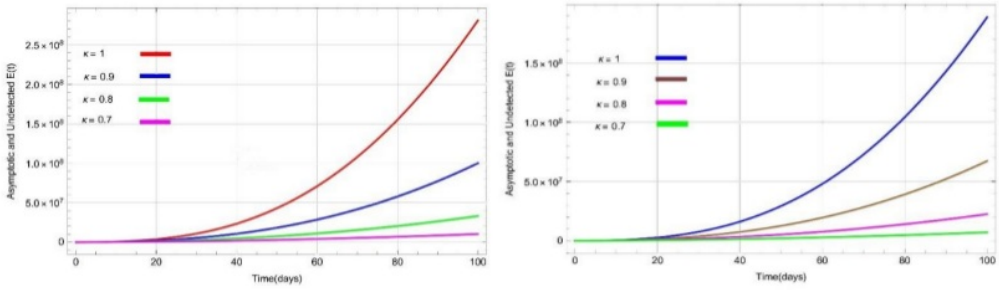
In table 1 we have estimated some needed biological parameter values related with basic reproduction number $R_0$ corresponds to model (1) like, covid-19 infection death rate ($\delta$), force of infection ($\beta_1$), proportion of people identified as suspected cases ($\beta_2$), progression rate from exposed class to highly infected class ($\varepsilon$) and other parameters are fitted from previous literature. Estimating these parameters to suitable values decreases rate of infection meaningfully. It is examined and noted that if $R_0$ is near to 2 the number of cumulative infected population rises very quickly. Also reducing the value of $R_0$ near to one lowers the number of infected cases rapidly.

Figures 2 to 7 shows the dynamical behaviour of various classes of mathematical model like susceptible population S(t), symptomatic and undetected population E(t), highly infectious but not yet quarantined or isolated I(t), individuals who are infected or suspected and quarantined Q(t), confirmed and quarantine population C(t), recovered population R(t) with $R_0 = 1.96$ and $R_0 = 1{:}16$ respectively for various values of $\kappa = 1, 0.9, 0.8, 0.7$ verses time in days. We clearly observe the significant variance in both type of plots (a) and (b) in each figure when value of fractional parameter κ changes. The number of cumulative cases of infections in every class is continuously depends upon the values of fractional order.
Also, Figures 8(a) shows the comparison between estimated and actual number of cumulative cases of confirmed and quarantine population C(t) for data of available infection cases from April 1, 2020, till April 30, 2020 of Nigeria. This clearly shows that estimated and actual cases of infections are very near to each other. Figure 8(b) shows the plots of total infected population in various compartments of model (1) versus time (days).



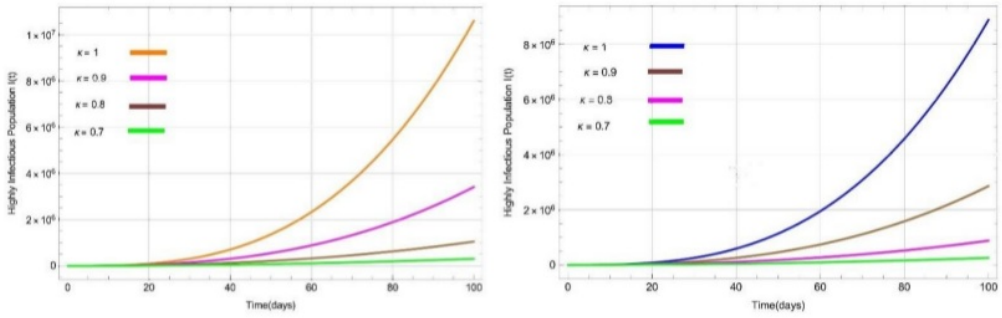

**(a)** **(b)**

**Figure 2:** Plots of susceptible population for various values of $\boldsymbol{\kappa}$ with respect to time t in days and different $R_0$ [fig.2(a) $R_0$=1.96, fig.2(b) $R_0$=1.16].



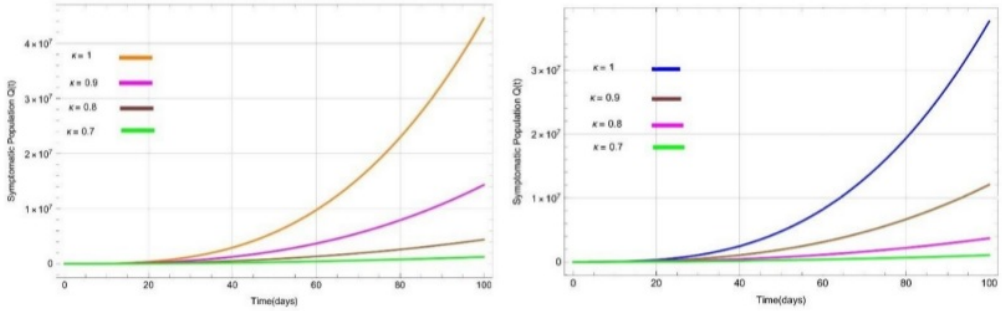

**(a)** **(b)**

**Figure 3:** Plots of asymptotic and undected population for various values of $\boldsymbol{\kappa}$ with respect to time t in days and different $R_0$ [fig. 3(a) $R_0$=1.96, fig. 3(b) $R_0$=1.16].



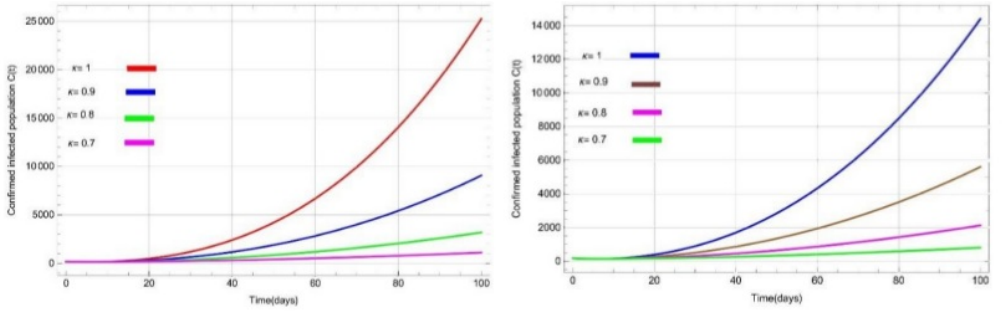

**(a)** **(b)**

**Figure 4:** Plots of highly infectitious population for various values of $\kappa$ with respect to time t in days and different $R_0$ [fig. 4(a) $R_0$=1.96, fig. 4(b) $R_0$=1.16].



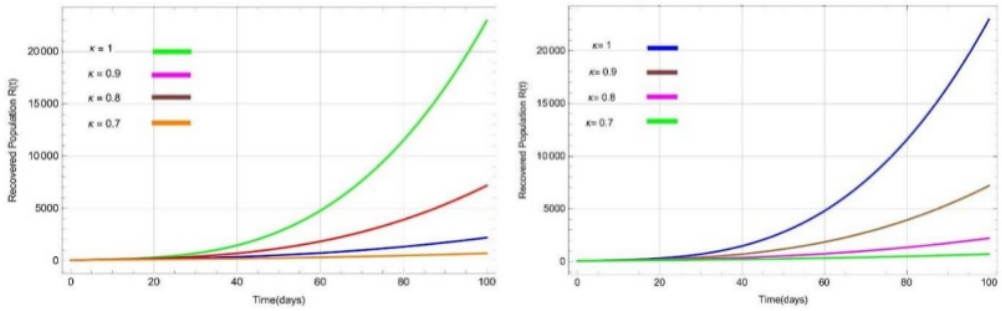

**(a)** **(b)**

**Figure 5:** Plots of symptomatics population for various values of $\kappa$ with respect to time t in days and different $R_0$ [fig. 5(a) $R_0$=1.96, fig. 5(b) $R_0$=1.16].



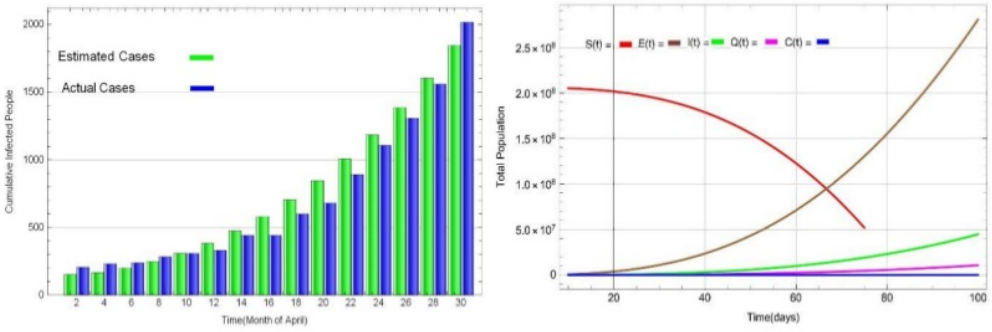

**(a)** **(b)**

**Figure 6:** Plots of confirmed infected population for various values of $\kappa$ with respect to time t in days and different $R_0$ [fig. 6(a) $R_0$=1.96, fig. 6(b) $R_0$=1.16].




**(a)** **(b)**

**Figure 7:** Plots of recovered population for various values of $\kappa$ with respect to time t in days and different $R_0$ [fig. 7(a) $R_0$=1.96, fig. 7(b) $R_0$=1.16].




**(a)** **(b)**

**Figure 8**: (a) Cumulative number of cases of infected population C(t) with respect to time(days) (b) Plot of total population in various classes of model versus time (days).

**Conclusions:**

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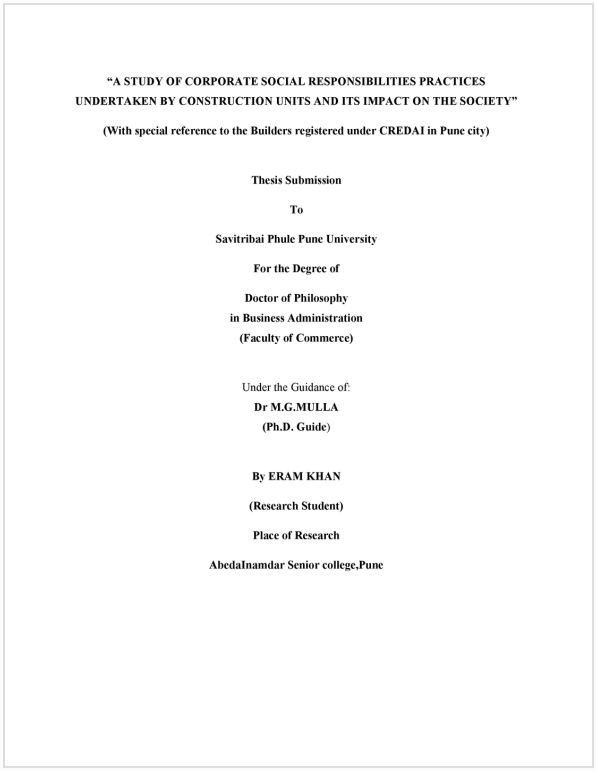

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(With special reference to the Builders registered under CREDAI in Pune city)

Thesis Submission

To

Savitribai Phule Pune University

For the Degree of

Doctor of Philosophy
in Business Administration
(Faculty of Commerce)

Under the Guidance of:
Dr M.G.MULLA
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Page | 2 Chapter 1 INTRODUCTION 1.1 Introduction 1.2 Changing Trends 1.3 Software Project Management 1.4 Quality of Learning 1.5 Market Expectation 1.6 Employability of Learner 1.7 Savitribai Phule Pune University 1.8 Alumni 1.9 Project Domains 1.10 Role of Project Guide 1.11 Choice of Project 1.12 Project Standards 1.13 Technical Skills required 1.14 Project Evaluation and Grading System 1.15 Report Writing 1.16 Research Methodology 1.17 Concluding Remark References

Page | 3 Chapter 1 INTRODUCTION 1.1 Introduction Students highly value the experience of a good final year design and implementation of project. Student learns both by managing the process and delivering a product. An ideal project will succeed in both but there can be many obstacles to complete success. From students point of view there are variety of well-defined expectations. Often these expectations concern the learning process and are independent of the final technical outcome. Supervisors often have a stronger expectation of technical success as a proof of competence but make greater allowance when failure to deliver is for legitimate reasons. Clear definition of expected project outcome both in terms of learning objectives and project deliverables will maximise the likelihood of a satisfactory outcome. The candidate is expected to select the project, do the required analysis, carry out the necessary design procedure and complete the implementation. The dissertation will consist of the work on the topic selected for the project. Selecting the topic is one of the major difficulties faced by students. Our experience as dissertation and enterprise project supervisors reveals that students who work during their studies usually write about their companies. They first select the industry focus of their project and after that the functional field. Nonworking students seem to follow the other pattern – they first select what they want to write for and after that they determine the company to investigate. Both approaches are acceptable and have their own advantages. When students select the company first, it is usually because they have access to it, which facilitates the research process. In the other case, students choose the functional field they feel comfortable with which allows them to delve deep into the theoretical issues of the field. In any case, a good graduation project requires a good topic [1] . As a significant component of the curriculum, student research as an assessment tool has been studied and evaluated by reflective higher education practitioners. Concern with

Page | 4 reliability and consistency of standards is particularly significant in climate of increased pressures on staff due to high student numbers and tight marking deadlines. These concerns are further intensified when combined with a large assessment team and when the assessed work forms a large proportion of the student's overall degree classification, both

characteristics of the undergraduate project. Staff in School of Sciences at colleges and University, examined the creation, communication and application of assessment criteria for the project, raising important issues concerning the extent, and desirability, of criteria standardisation. On balance, the authors supported the need for equity, consistency and transparency that agreed assessment criteria can supply, whilst recognising the need to be flexible and reward innovation in approach and execution; factors that are surely to be encouraged given the individuality and independence of each student's research project. In order to understand these challenges, it is necessary to revisit some of the basic processes and tenets of research that the experienced researcher may take for granted, but which the novice student researcher may be exploring for the first time. This includes the standard convention of representing the research process as a series of steps or stages that fit together in a linear arrangement. 1. Identification of the problem 2. Assessment of value of the research process 3. Development of the research proposal 4. Development of the research design 5. Determination of data collection methods and procedures 6. Determination of analytical procedures 7. Evaluation of results 8. Final report including results, evaluation and recommendations

Page | 5 The research process and particularly the intellectual or _thinking' part of it is inherently _messy'. This is because however well planned a research process is, there will always be an element of creative uncertainty. The recognition of movement, both advancing and retreating, within the research process model is important as it suggests that the researcher will be presented with situations where decisions have to be made regarding the direction of the research. This may involve re- directing the research from the original research plan. Triggers for this redirection may be positive, if for example unforeseen opportunities arise, but may also be negative, e.g. barriers to access. The need for re-directional strategies presents the researcher, particularly a novice student, with challenging decisions concerning the development and completion of their research project. As the first major piece of independent research undertaken by students, the undergraduate project confers _responsibility for taking a research project all the way from conception to completion'. Students often feel they are _working in the dark', with common concerns over getting started, getting stuck on data collection and problems with the writing- up. Thus, even the first stage of the process, getting underway and particularly choosing a topic, presents the student researcher with a major challenge and one that has significant implications for the project as a whole. 1.2 Changing Trends Many first time researchers want to proceed as soon as a topic has been selected, but are advised that if insufficient attention is given to access issues, problems may occur and the research may get stuck up. Within a research project, access may be required to documents, people and/or institutions refer to both physical and cognitive access. Access challenges for the student may include the status of the researcher, ethical implications, and gaining access to respondents or an organisation. Undergraduate research is commonly carried out over one or two semesters alongside other taught courses which must be fitted in with the external demands on a student's time, including the financial pressures of undertaking higher education. Anecdotal evidence suggests that many students underestimate the amount of time and effort that negotiating access can take. Access may be particularly challenging when the research subject is of a sensitive nature. Problems of access usually start at the data collection

Page | 6 stage. Any reasons for choosing a particular research method will, to some extent, depend on how easy the method is to implement, how easy it is gain access to the desired quality and quantity of respondents [2] , and once identified, how easy it is to gain co-operation. Gatekeepers are often crucial players in gaining access and permission to carry out research; however students are often unclear about how to identify and interact with these key figures. However, they do go on to suggest a number of possible response strategies if access is refused: approaching other, similar participants; trying another organisation; trying to find another route into the original organisation; or waiting and re-approaching the same gatekeeper at a later date. Once these avenues have been explored, if access is still blocked, the student may need to consider changing their research strategy completely. The important thing is to try and salvage what work you have done and to fully explain what went wrong and why. 1.3 Software Project Management Conceiving a plan and going for execution is a discipline of project management in which software projects are planned, implemented, monitored, and controlled. Analysis of software project management failures has shown that the following are the most common causes: 1. Insufficient end-user involvement 2. Poor communication among customers, developers, users & project evaluators 3. Unrealistic or unarticulated project goals 4. Inaccurate estimates of needed resources 5. Badly defined or incomplete system requirements and specifications 6. Poor reporting of the project's status 7. Poorly managed risks 8. Use of immature technology 9. Inability to handle the project's complexity 10. Sloppy development practices Top half items in the list above show the difficulties articulating the needs of the client in such a way that proper resources can deliver the proper project goals.

Page | 7 Specific software project management tools are useful and often necessary, but the true art in software project management is applying the correct method and then using tools to support the method. Without a method, tools are worthless. Since the 1960s, several proprietary software project management methods have been developed by software manufacturers for their own use, while computer consulting firms have also developed similar methods for their clients. Today software project management methods are still evolving, but the current trend leads away from the waterfall model to a more cyclic project delivery model that imitates a software development process. A software development process is concerned primarily with the production aspect of software development, as opposed to the technical aspect, such as software tools. These processes exist primarily for supporting the management of software development, and are generally skewed toward addressing business concerns. [3] . Examples are: ? Interpersonal communication and conflict management and resolution. Software developers, users, project managers, customers and project sponsors need to communicate regularly and frequently. The information gained from these discussions allows the project team to analyze the strengths, weaknesses, opportunities and threats (SWOT) and to act on that information to benefit from opportunities and to minimize threats. Effective interpersonal communication and conflict management and resolution are the key to software project management. ? Requirements management is the process of identifying, eliciting, documenting, analyzing, tracing, prioritizing and agreeing on requirements and then controlling change and communicating to relevant stakeholders. ? Software configuration management is the process of identifying, and documenting the scope itself, which is the software product underway, including all sub-products and changes and

enabling communication of these to relevant stakeholders. In general, the processes employed include version control, naming convention (programming), and software archival agreements. The purpose of project planning is to identify the scope of the project, estimate the work involved, and create a project schedule. Project planning begins with requirements that define the software to be developed. The project plan is then developed to describe the tasks that will lead to completion.

Page | 8 1.4 Quality of Learning Projects evaluated were undertaken on marketing strategies, quality management, human resource development, and crisis management. Students' motivations for choosing a research topic, as reported through the interviews and where is survey only project evaluation, varied considerably and three main drivers were identified: personal interest in the subject area, a link to career aspirations, and perceived ease of access to primary or secondary data or the literature. Personal interest in the subject area was motivated by a desire to learn more about a subject. This was the most common motivation for choosing a research topic. Less significant, although linked with personal interest, was choosing a topic related to career aspirations, including planning to use the dissertation as evidence of understanding of a topic or issue; for example: —Doing a project on low cost airlines is a subject that interests me and I also would like to work in the airline industry so knowledge gained may help me later‖ [4] . 1.5 Market Expectations Software development is unlike most professions, because developers have to both design and build. Increasingly, coders are getting involved further and further down the technology stack to get their wonderful code into a user's hands. The so-called adoption of —full stack‖ development means they have to master, at least to some degree, a wide ranging of skills beyond Ruby or JavaScript. It's like asking construction architects to also be skilled at brick-laying, plastering and welding [5] . In today's market requirements following skills are required Problem-solving skills – this is one of the biggest challenges facing most people entering the world of work and that includes software developers. During their education, their coding experience is probably based around assignments focused on teaching a single lesson or skill. Picking up an existing body of code, forensically identifying and fixing bugs, validating the changes and running through integration and deployment stages could more accurately simulate the kinds of challenges students will face later.

Page | 9 Collaboration and Communication – developing software is like being part of a sports team, with multiple contributors who together have the skills and roles to deliver a final product. Software development courses often include some group working where people get experience of coding alongside other students, but anecdotally, we hear that too often the bulk of the work is carried out by one or two individuals. The exception to this observation is curricula that focus on games development, because learning how to be a team player is so fundamental to that environment. Graduates from these educational establishments are frequently well-versed in basic agile development principles and task-tracking, making it easy to slot them into development teams. However, students who end up working in more mainstream enterprises or the public sector will equally benefit from learning to be team players. Also, developers need to learn how to communicate what they are doing, not just with each other, but to customers, who may be colleagues in other, non-technical departments. Being able to articulate their work, what they need from the customer or what roadblocks

need to be overcome is an essential part of software developers‘ roles. So courses need to focus on three further elements: one, encourage _team player‘ mentality; two, task every individual to contribute to a project in a definable, transparent way; and three, communication skills, which is most definitely not something that can be learned in isolation. Understanding Someone Else’s Code: - The Way to decipher other people‘s code is an important skill to acquire, since much of a developer‘s typical daily role is about modifying existing code that was written by someone else. The problem is that course homework is usually focused on an individual composing their own code. This isolated approach can encourage evolution of coding behaviours that are not conducive to working with other team members. For instance, unnecessarily creative indenting strategies could be obtrusive and downright annoying for future peers. Motivating the students chasing the limited places available. This is a call out to employers as well – placement students are not an expensive drag on your time (nor are they cheap labour) they are an investment. They‘re also a chance to bring modern, up-to-date thinking into a team that may be long out of university. Many of the most talented programmers started their careers at the company as students on placements. Long-term group projects will help students to learn how to interpret someone else‘s work, especially when involving pre-existing, —legacy‖ code. Another option for this is to encourage students to use or modify open source libraries that expose them to other coding styles, to explore other development tools outside the curriculum. Playing with APIs will to not only expand

Page | 10 students‘ overall knowledge, but also teach the process of learning and working with new technologies. This is a useful skill that will pay dividends for years to come. There is no substitute for real-world experience, but the educational process can go a long way to helping prepare software development students to be ready for the world of work, looking beyond technical expertise to more _soft‘ skills, such as project management, team-playing and communications 1.6 Employability of Learners While designing assessment, the outcome, process and mode are equivalent to those currently being used in graduate destinations. For example, if most of the assessment items are paper-based multiple-choice exams, it is important that employees in industries where graduates are commonly employed typically work off-line and are required to recall fact- based information on a regular basis. If assessment requires students to write a series of long, referenced research essays, it is important to ask whether the emphasis on this skill is adequately developing their possible industry-based skills such as creating press releases and short social media posts. While essays can be a necessary academic skill to prepare some students for future post-graduate work, is assessment adequately balanced such that multiple types of graduate outcomes are supported? Know the typical, common and/or range of destinations of your graduates [6] . Analyse what types of work these graduates do and align your assessment accordingly. When choosing a degree pathway, students and parents want to know about career outcomes, graduate pathways and success stories. It is important to stay in contact with graduates in order to inform students. However, this information is not only relevant to prospective or future students on a marketing basis, but to current students. It is important to align lessons and assessment with industry trends and practices. Know what is happening in the field to ease the transition and properly prepare students for these outcomes. Employment is constantly changing and new opportunities emerging. In order to adjust curriculum and learning experiences accordingly, it is vital to stay connected to industry. Remember to

regularly share this information with students and engage them in reflective conversation about graduate employability.

Page | 11 1.7 Savitribai Phule Pune University After Mumbai Pune has become main educational hub of Maharashtra. Numerous students from every corner of India and the world come to Pune. It is quite safe and peaceful city as compared to other educational centres in India. The climate of Pune is pleasant and good for health. The city of Pune houses many well-known, established institutes and colleges. Savitribai Phule Pune University is one of the finest and most popular educational centres in the city. It offers excellent programs in various areas including Science, Commerce, Arts, Languages and Management Studies. Savitribai Phule Pune University is one of the premier universities in India; it is positioned in the North-western part of Pune city. It was established on 10th February, 1949 under the Poona University Act. The university houses 46 academic departments. It is popularly known as the 'Oxford of the East'. It has about 307 recognized research institutes and 612 affiliated colleges offering graduate and under-graduate courses. The university attracts many foreign students due to its excellent facilities. It offers good accommodation facility. There is a provision of hostel for the students. There is a well-stocked library containing plenty of books regarding various subjects. The university offers different scholarships to the students. The university conducts seminars and conferences for the students. Mission ? Becoming a vibrant Knowledge Centre and a Centre of Excellence in teaching, research and extension activities; ? Bringing about conservation, creation, advancement and dissemination of knowledge. ? Creating technologically equipped thought and action leaders in a wide range of spheres by providing value based and high quality education, generating cutting- edge research and innovations, and enabling empowerment through social and regional inclusion; ? Increasing global linkages by attracting international students and establishing collaborative Programmes with educational institutions of repute.

Page | 12 Vision ? Becoming a vibrant knowledge Centre and a Centre of Excellence in teaching, research and extension activities. ? Bringing about conservation, creation advancement and dissemination of knowledge; ? Creating technologically equipped thought and action leaders in a wide range of spheres by providing value-based and high quality education; ? Generating cutting edge research and innovations and enabling empowerment through social and regional inclusion; ? Increasing global linkages by attracting international students and establishing collaborative programmes with educational institution of repute 1.8 Alumni The mission of the Alumni Association is to serve all alumni, present students by networking with one another intellectually and emotionally connected between the university and its graduates. The association serves the need of alumni for support and communications such as :- ? Provide Scholarships for poor and deserving students and Research Work. ? Alumni Association helps Technical Incubation Centre for promoting and encouraging our students to develop their technical skills. ? Support Lecture Series on varied topics can be arranged by Alumni to supplement the curriculum and help the research. ? Association can arrange special short term programmes as per needs of teaching faculty and students in context with latest trends and need of the market. ? Alumni Association provide support to many student centered activities by way of expertise and sponsorships. ? The mentors to the

project can be senior alumni technical personnel to attach 2-3 students according to their disciplines so as to establish rapport with them and have future guidance etc.

Page | 13 1.9 Project Domain

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While the curriculum may scaffold development of students' capacity to undertake projects through project based learning and work integrated learning, the

students projects

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represents a major extension of expectations regarding a student's capacity to conduct a project. Some guidance for students is appropriate, but too much support will hamper the student's capacity to deal with complex, real-life professional projects. In identifying resources that can be made available to help students manage their projects, questions about the appropriate balance between support and exposure to real-life complexity need to be addressed. Student guidelines and resources will be produced and tested [7] . 1.10

Role of Project Guide

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Final year project assessment is particularly vulnerable to variation in the quality of supervision because a large number of projects need supervision each year requiring many academics, each of whom may advise students differently about project expectations. Identification and description of good practice would provide academic supervisors with resources for induction and staff development. Guidelines are required to ensure appropriate, consistent support. Students should also be provided with clear expectations about appropriate supervision so they can respond more constructively when expected support is not provided. 1.11

Choice of Project Choosing a research topic is the first and one of the most important stages of the research process, as it will have a bearing on all the other stages of the research project. The independent nature of the research and the responsibilities and expectations this puts on students is a major pressure. —All research projects emerge from an interest in a particular topic||, however, even with research methods teaching and support through a

supervisor, it can be overwhelming for a student when the onus is on them to develop and execute research independently. Up until this point, the focus of their assessment has largely been predetermined and directed by teaching staff. It is pointed out that: —it's very rare for students to have a clear focus from the outset of their research, and yet many find the lack of a clear

Page | 14 focus is a major impediment to getting started‖ [8] . Given these conditions, what are the determining factors or motivations for a student's choice of research topic? Evaluating academic research conducted within organisations, it is suggested that significant research is successfully produced when the researcher has intrinsic motivation for initiating it; for example, where there are psychological rewards such as the opportunity to demonstrate one's ability or there is a sense of challenge and achievement. Motivation can take the form of personal interest: a desire to learn more about a subject that enthuses researchers into a more in-depth examination of a particular area. This interest may be generated by personal circumstances and interests, as well as previous courses and assessments. It is appropriate for students that: A dissertation topic should sustain interest over the necessary period of time. People can come to hate the whole dissertation process and as a consequence lose motivation, but, if a topic is chosen that retains the interest of the writer, there is a good chance of successful completion. Undergraduates are sometimes motivated to choose a research topic which links future aspirations. It suggests that —research should have a beneficial influence, not only on body of knowledge, but also on the personal development and career paths of those undertaking research‖. Although preparatory research methods courses are common for project and dissertation students, many, at both undergraduate and postgraduate level, find the transfer from learning about research to actually doing their own research. The linear research process model suggests that when faced with a problem or barrier, the researcher returns to the previous stage in the research process, revisiting ways of developing and designing the project. However, many students find difficulties in first recognising a problem, and then responding constructively. Whilst this literature clearly contains pertinent advice and guidance for the novice researcher, it does not give an understanding of how the novice student researcher experiences and responds to these challenges. In the end

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project assessment is particularly vulnerable to variation in the quality of supervision because a large number of projects need supervision each year requiring many academics, each of whom may advise students differently about project expectations. Identification and description of good practice would provide academic supervisors with resources for induction and staff development. Guidelines are required to ensure appropriate,

Page | 15 consistent support. Students should also be provided with clear expectations about appropriate supervision so they can respond more constructively when expected support is not provided [9] .

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Many involve industry-based projects in which the industry client's expectations about project outcomes may not align well with the requirements for education and assessment. Industry projects may also involve intellectual property and confidentiality issues that require sound guidelines. Authoritative explanatory guidelines would assist industry partners to understand the educational context and expectations of student's projects. The kind of project a student selects can influence a student's grade. Routine projects may not provide scope for students to demonstrate high levels of professional capability and obtain a high grade. There is debate about what kinds of

student's projects are acceptable. 1.12 Project Standards Results of final year project

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is an extended report or portfolio. It is important that students receive clear advice about requirements, and receive an appropriate level of support in preparing their reports because the

project

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report will usually be the first extended report students have prepared. If project assessment is based on report moderation, supervisors and moderators also need shared expectations for assessment, and supervisors must advise students of these expectations. 1.13

Technical Skills Required Technical skills required for the students of computer science to be competent enough to develop their project as per market requirements [10] . ? Good Programming skills in any one language - preferably object oriented. ? Strong Data Structures and Algorithms skills. ? Basic web development - hosting your own site with a database (mySQL) on a server. ? Write Neat, Simple and Modular code. ? Contribute to Open source Projects - Learn how to use github, fork projects, contribute patches and maintain code. ? Basics of Machine Learning. ? Learn to make a very basic operating system.

Page | 16 ? Open and assemble the components of a computer - know what each component does and how they fit in together. ? Learn how computer networks work; create a basic usable chat application. ? Basics of security, vulnerabilities and cryptography. 1.14 Project Evaluation and Grading A project evaluator needs to know how to manage the entire project lifecycle

from start to finish. There are a total of 5 process groups that a project evaluator will need experience in when managing an organizational project. This includes Initiating (starting), planning (documenting), Executing (acting), Monitoring (controlling), and formally closing the project. In order to do this effectively, project evaluators need to have solid knowledge and experience in managing things like cost, risk, quality, procurement, human resource, project scope and scheduling. Project evaluators also need to have great people skills and leadership qualities. 90% of their job is communication, working closely with stakeholders and integrating project information from various places [11] . That is a great question. Science and art degrees do allow some specialization. But, they are often required to take some general education courses or electives outside the project management disciplined. Depending on the college, they may have to take courses in economic, statistics, finance and even liberal arts to fulfil the degree requirements. At University level, curriculum focuses heavily in project management, balancing theory and practice, and helping students to develop both their hard skills and soft skills equally. This means topics like leadership, communication, critical thinking, emotional intelligence and problem solving are not overlooked. The increased presence of assessment tools in the classroom is redefining how education is delivered. Assessment tools are giving educators a better view of their students' learning needs, allowing them to close learning gaps and engage the classroom with innovative teaching styles. Formative feedback tools help instructors focus on daily improvement by capturing student comments about their learning experience in real-time. Mid-term evaluations give educators enough time to make instructional changes that will impact the overall learning experience. End-of-term evaluations provide valuable data that can help educators identify areas where improvement is needed for the following semester. Assessment can take into account different elements such as

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supervisor's report, technical report, design portfolio, journal, poster, oral presentations, weightings for technical quality

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and communication, etc. The criteria for grading projects use various rubrics that influence assessment and benchmarking processes. A particular issue in assessment is the relative emphasis placed on the product or outcome of the project on the one hand, and on each student's thinking, decision-making, management and investigation processes that guided the project on the other. 1.15

Report Writing Most students employ survey as a research methodology and questionnaires as a data collection tool. Students easily determine the size of samples they need in order to obtain statistically significant results. However, having enough completed questionnaires is a difficult task – from the analysed graduation projects only those they employ census in a small company produce statistically significant results. The rest of the projects produce results that are not generalized because of the low number of completed questionnaires. They are frightened that their privacy and anonymity will not be protected, or that data collected could be used for purposes other than the stated. This scepticism hinders data collection and diminishes the response rate in students' research. Additional challenges related to data collection are related to the questionnaires and include the length of questionnaires, omission of possible answers in the closed questions, inclusion of questions that do not have obvious connection with the aims of the project, etc. The reason might be in the greater difficulty in the subsequent analysis of the qualitative data from the interview compared to the quantifiable data from the questionnaires. Other reasons might be the unwillingness of potential interviewees to participate or students' inability to motivate them to participate in the research. Most students prepare summary tables of interviewees' responses on each question. They also easily identify the obvious correlations between the answers to different questions, although this is not always result of the application of correlation and regression analysis or other complicated statistical methodologies. Sometimes students focus too much on details that do not relate directly to the topic and the aim of their graduation project and do not devote much attention to major issues arising from the primary data they have collected. On the positive side, students prepare many tables, figures and graphs to illustrate their findings, although sometimes they are a bit too many.

Page | 18 Writing a research project requires persistence. However, our experience shows that many students leave it to the last weeks before the deadline. Of course, the final outcomes, in terms of project quality and mark, are strongly correlated to the time devoted to the project and the number of meetings a student had with the supervisor. Dissertation is an independently conceived and executed research project; this contrasts with the sciences where students work independently on projects that are generally derived from staff members' research interests undergraduates are often collaborating with staff and graduate students as part of wider research projects or themes. Whilst this presents different challenges for both students and academics, there are commonalities in terms of the significance of the project to undergraduate curricula, and issues of supervision and assessment. Subsequent development and introduction of a criterion-reference approach to project assessment, led further curriculum developments in the University's Departments. A three year pilot study resulted in a voluntary scheme allowing students to submit three research progress reports, thus gaining formal feedback from lecturers and encouraging student reflection on their learning styles and research methodology. 1.16 Research Methodology i. Type of study In the work both quantitative and qualitative research methods is used to address the research questions and objectives. In the first stage of the work data from different colleges/Institutes and secondary data from researches is used to build the whole picture of Changing Trends in Adoption of Software Project Management Principles in Computer Science Course, Based on the data collected, analysis will be made, in order to shed a light for several research questions. In the second stage Answers to questionnaire analysing

project reports of final year projects of MSc passed students from selected colleges under Savitribai Phule Pune University (Earlier known as Pune University).

Page | 19 Table 1.1 List of Colleges Sr.No. Puncode College Started 1 CAAA016160 Ahmadnagar Jilha Maratha Vidya Prasarak Samaj New Arts Commerce And Science College Addr: Lal Taki Road Ta: Ahmednagar Dist: Ahmednagar 1991-1992 2 CAAA016720 Ahmadnagar Jilha Maratha Vidya Prasarak Samaj Rajarshi Shahu Mahavidyalay Addr: Devlali Parvara Ta: Rahuri Dist: Ahmednagar 2010-2011 3 CAAP010100 Anekant Education Society Tuljaram Chaturchand College Addr: Baramati Ta: Baramati Dist: Pune 2001-2002 4 CAAP010210 Anjuman Khairul Islam Poona College Addr: 1647, Camp, New Modikhana, Ta: Pune (corporation Area) Dist: Pune 1997-1998 5 CAAP013030 ARIHANT EDUCATION FOUNDATION Arihant College of Arts Commerce and Science Addr: Apolo Tower,Next to Vijaya Bank,Solapur Bazzar,Near Mahatma Ganadhi Bus Stand,Camp,Pune-411001 Ta: Pune (corporation Area) Dist: Pune 2009-2010 6 CAAP011640 Audyogik Shikshan Mandal College of Commerce Science and Information Technolgy Addr: C Wing survey No 29/1 2A CTS No 4695 old mumbai pune highway back to sterling honda showroom pimpri pune 411018 Ta: Haweli (excluding Corporation Area) Dist: Pune 2007-2008 7 CAAP012270 Camp Education Society Dr.Arvind B.Telang Sr. College of Arts, Commerce, Science Addr: Sector No 27/ A,Nigdi,Pradhikaran Ta: Haweli(excluding Corporation Area) Dist: Pune 2006-2007 8 CAAP011660 Chanakya Education Society Indira College of Commerce and Science Pune Addr: Dhruv, 89/2 A, New Pune Mumbai Highway, Wakad Police Chowki, Pune -411033 Ta: Mulashi Dist: Pune 2005-2006 9 CAAP010010 Deccan Education Society Fergusson College Addr: FC Road Ta: Pune (corporation Area) Dist: Pune 1995-1996 10 CAAP012910 Dnyanvardhini Prathishthan Dnyanvardhini Pratishthan's Dnyanvardhini College, Arts, Commerce,Science, BBA & BCA, Addr: Chikhali, Pimpri Chinchwad, Pune - 411 019 Ta: Pimpari Chinchwad (corporation Area) Dist: Pune 2009-2010 11 CAAP011470 Dr. D.Y. Patil Vidya Pratishthan Society Pune Pad.Dr.D.Y.Patil Science and Computer Science College Addr: Sect.-27 A Near Lokmanya Hospital, Nigadi Pradhikaran, Akurdi Ta: Pimpari Chinchwad (corporation Area) Dist: Pune 2002-2003

Page | 20 12 CAAA016040 Dr.Bhaskar Pandurang Hivalee Education Ahmednagar College Addr: Station Road Ta: Ahmednagar Dist: Ahmednagar 2000-2001 13 CAAN018010 Gargi Education Institute GARGI AGRICULTURE RESEARCH AND TRAINING INSTITUTE Addr: CIDCO Ta: Nashik Dist: Nashik 2010-2011 14 CAAN017570 Gokhale Education Society H.A.L. College of Science & Commerce Addr: Ozar Township Taluka Niphad District NASHIK 422207 Ta: Niphad Dist: Nashik 2000-2001 15 CAAN017340 Gokhale Education Society H.P.T. Arts and R.Y.K. Science College Addr: Prin TA Kulkarni Vidya Nagar Ta: Nashik Dist: Nashik 2008-2009 16 CAAN017370 Gokhale Education Society RNC, JDB Commerce College and NSC Science Addr: RNC Arts JDB Commerce and NSC Science College Nashik Road, Nashik Ta: Nashik Dist: Nashik 2009-2010 17 CAAN017850 K.K. Wagh Shikshan Sanstha K.K. Wagh Arts, Commerce, Science and Computer Science College Addr: Adgaon Road Nashik Ta: Nashik Dist: Nashik 2010-2011 18 CAAP013000 Kamala Education Society Pratibha College Of Commerce And Computer Studies Addr: Block No D III,Plot No 3, Off Mumbai Pune Road, Behind Mehta Hospital,Chinchwad Ta: Pimpari Chinchwad (corporation Area) Dist: Pune 2009-2010 19 CAAP010430 Khadki Shikshan Sanstha Tikaram Jagannath Arts, Commerce & Science College

Addr: Elphiston Road Khadki Ta: Pune (corporation Area) Dist: Pune 2001-2002 20 CAAN017600 Madhyavarti Hindu Sainik Shikshan Mandal Bhonsala Military College Addr: Dr Moonje Marg Rambhumi Nashik Ta: Nashik Dist: Nashik 2006-2007 21 CAAP012970 Maharashtra Academy Of Engineering And Educational Research MIT Arts,Commerce And Science College Addr: Dehu Phata ,Alandi Devachi Ta: Haweli(excluding Corporation Area) Dist: Pune 2009-2010 22 CAAP010040 Maharashtra Education Society Abasaheb Garware Mahavidyalay Addr: Karve Road Ta: Pune (corporation Area) Dist: Pune 1996-1997 23 CAAN017360 Mahatma Gandhi Vidyamandir M.S.G. College Addr: Loknete Vynaktrao Hire road Malegao camp Ta: Malegaon Dist: Nashik 2007-2008 24 CAAN017820 Mahatma Gandhi Vidyamandir Panchvati College of Management and Computer Science Addr: Mumbai- Agra Road, Highway Number 3 Panchvati Nashik Ta: Nashik Dist: Nashik 2008-2009

Page | 21 25 CAAN017440 Maratha Vidya Prasarak Samaj KRT Arts BH Commerce and AM Science College (KTHM) Nashik Addr: Shivajinagar, Gangapur Road, Nashik Ta: Nashik Dist: Nashik 1994-1995 26 CAAP010790 MCE Society Abeda Inamdar Senior College Of Arts,Science and Commerce Addr: 2390 BKB Hidaytullah road Azam Campus Ta: Pune (corporation Area) Dist: Pune 2001-2002 27 CAAA016170 Pravara Rural Education Society's Padmashri Vikhe Patil College Of Arts,Scienece and Commerce,Pravaranagar Addr: A/P-Loni KD,Tal- Rahata,Dist-Ahmednagar,413713 Ta: Rahta Dist: Ahmednagar 2001-2002 28 CAAP010870 Progressive Education Society Modern Arts Commerce & Science College Addr: Ganeshkhind, Pune 411053 Ta: Pune (corporation Area) Dist: Pune 2000-2001 29 CAAP010230 Progressive Education Society Modern College Shivajinagar Addr: Shivajinagar, Pune - 411 005 Ta: Pune (corporation Area) Dist: Pune 1994-1995 30 CAAP010860 Pune Jilha Shikshan Mandal Prof. Ramkrishna More Arts Commerce and Science College Addr: Sec No 28 Ganganagar Akurdi Pradhikaran pune Ta: Pimpari Chinchwad (corporation Area) Dist: Pune 2001-2002 31 CAAP011690 Pune Vidyarthi Gruh P.V.G's College of Science Addr: 44, Vidyanagari, Shivdarshan, Parvati Pune 411009 Ta: Pune (corporation Area) Dist: Pune 2005-2006 32 CAAP011480 Raja Shri Shivray Pratishthan Maharashtra College of Science and Commerce Addr: Baburav Sutar Road Rambag Colony Paud Road Kothrud Ta: Pune (corporation Area) Dist: Pune 2006-2007 33 CAAP011670 Rajmata Jijau Shikshan Pasarak Mandal Arts, Commerce and Science College Addr: Landewadi,Bhosari Ta: Pimpari Chinchwad (corporation Area) Dist: Pune 2005-2006 34 CAAA016050 Rayat Shikshan Sanstha, Satara R.B. Narayanrao Borawake College Addr: Taluka Shrirampur Dist Ahmednagar Ta: Shrirampur Dist: Ahmednagar 2009-2010 35 CAAP010150 S.S. Prasark Mandal C.T. Bora College Addr: Shirur Ta: Shirur Dist: Pune 2004-2005 36 CAAP013640 Sarhad sarhad college Addr: 76/4 near katraj deari,katraj,pune Ta: Pune (corporation Area) Dist: Pune 2009-2010 37 CAAP010070 Shikshan Prasarak Mandali S.P.college Addr: Tilak Rd,Sadashiv Peth ,Pune Ta: Pune (corporation Area) Dist: Pune 2009-2010

Page | 22 38 CAAP013370 Sinhgad Technical Education Society Sinhgad College of Science Addr: Survey No 44-1 Off- Sinhgad Road, Ambegaon Pune -411041 Ta: Haweli(excluding Corporation Area) Dist: Pune 2009-2010 39 CAAP011030 Vidya Pratishthan Arts Commerce and Science College Addr: Vidyanagari Baramati Ta: Baramati Dist: Pune 2000-2001 (Source: SPPU, Pune) The table 1.1 consist of names of colleges affiliated to Savitribai Phule Pune University, with their year of establishments and university code. These are the colleges those are

running Master's Degree programme in Computer Science. ii. Objectives of the Research 1. To find out the changing trends in adoption of Software Project Management Principles of Computer Science Course. 2. To study the Employability of Learners with respect to Software Project Management for MSc Programs of Computer Science. 3. To understand the role of Project Guide in completing Project. 4. To examine the Student's Project work as per Project Domain, Technology changes over period of research. 5. To know the project evaluation process used by the Projects Guide and how the Grade system used by the examiners. 6. To know the present technology used in the market and challenges for students using technology for their projects. 7. To study the role of Alumni and effort with respect to employability of Learner.

Page | 23 iii. Hypothesis (a) Employment Status of Learners with Respect to Software Project Management of M.Sc. Program of Computer Science. Ho: The Proportion of employability of Learner is 80%. H1: The Proportion of employability of Learner is greater than 80%. (b) No college/Institute is using agile/RAD development methodology for Software Project Development work. Ho: There is no significant difference between using agile and RAD methodology for software Project Development. H2: There is significant difference between using agile and RAD methodology for software Project Development. iv. Universe and Sample The Universe of this study is Savitribai Phule Pune University, Pune. The colleges under Savitribai Phule Pune University, Project Reports of different colleges are considered for study and data was collected from these reports using a formatted questionnaire. Few projects guides are interviewed on same questionnaire meant for project reports. Table 1.2 Number of Students Passed MSc from colleges in SPPU, Pune Sr. No. College 2012- 13 2013- 14 2014- 15 2015- 16 2016- 17 1 Ahmadnagar Jilha Maratha Vidya Prasarak Samaj New Arts Commerce And Science College Ahmednagar 54 68 72 72 59 2 Ahmadnagar Jilha Maratha Vidya Prasarak Samaj Rajarshi Shahu Mahavidyalay Ahmednagar 27 34 36 35 29 3 Anekant Education Society Tuljaram Chaturchand College Pune 54 68 71 70 58

Page | 24 4 Anjuman Khairul Islam Poona College Pune 27 34 36 35 29 5 Arihant College of Arts Commerce and Science Pune 81 102 108 105 87 6 Audyogik Shikshan Mandal College of Commerce Science and Information Technology Pune 54 68 70 70 58 7 Camp Education Society Dr. Arvind B.Telang Sr. College of Arts, Commerce, Science Pune 29 34 36 35 29 8 Chanakya Education Society Indira College of Commerce and Science Pune 54 69 72 70 59 9 Deccan Education Society Fergusson College Pune 52 68 71 74 58 10 Dnyanvardhini College, Arts, Commerce, Science, BBA & BCA, Pune 27 34 36 35 29 11 Dr. D. Y. Patil Science and Computer Science College Pune 54 69 72 70 58 12 Dr. Bhaskar Pandurang Hivalee Education Ahmednagar College Ahmednagar 53 68 70 71 62 13 Gargi Agriculture Research And Training Institute Nashik 29 34 36 35 29 14 H.A.L. College of Science & Commerce Nashik 26 32 35 36 32 15 H.P.T. Arts and R.Y.K. Science College Nashik 27 34 34 35 29 16 RNC, JDB Commerce College and NSC Science Nashik 29 35 36 37 31 17 K.K. Wagh Arts, Commerce, Science and Computer Science College Nashik 28 34 33 35 29 18 Pratibha College Of Commerce And Computer Studies Pune 81 102 108 105 87 19 Tikaram Jagannath Arts, Commerce & Science College Pune 55 68 72 70 58 20 Bhonsala Military College Nashik 27 34 36 35 29 21 MIT Arts, Commerce And Science College Pune 59 70 72 70 60 22 Abasaheb Garware Mahavidyalay Pune 54 68 70 72 58 23 Mahatma Gandhi Vidyamandir M.S.G. College Nashik 27 35 36 35 30 24

Panchvati College of Management and Computer Science Nashik 29 34 35 37 29 25 KRT Arts BH Commerce and AM Science College (KTHM) Nashik 56 68 72 69 58 26 Abeda Inamdar Senior College Of Arts, Science and Commerce Pune 55 71 69 71 59 27 Padmashri Vikhe Patil College Of Arts, Science and Commerce, Ahmednagar 54 68 72 70 58 28 Modern Arts Commerce & Science College Pune 53 70 68 73 61 29 Modern College Shivajinagar Pune 0 0 0 0 0 30 Prof. Ramkrishna More Arts Commerce and Science College Pune 55 69 72 69 58 31 P.V.G's College of Science Pune 56 68 71 70 59

Page | 25 32 Maharashtra College of Science and Commerce Pune 55 65 70 71 58 33 Rajmata Jijau Shikshan Pasarak Mandal Arts, Commerce and Science College Pune 27 34 36 35 29 34 R.B. Narayanrao Borawake College Ahmednagar 28 35 35 36 30 35 C.T. Bora College Pune 28 34 36 35 29 36 Sarhad college Pune 55 69 72 70 62 37 S. P. college Pune 54 67 71 71 58 38 Sinhgad College of Science Pune 55 68 73 72 60 39 Vidya Pratishthan Arts Commerce and Science College Pune 28 34 36 35 29 Total University Result 1697 2115 2206 2190 1824 (Source: SPPU, Pune) Table 1.2 shows there are in all 39 colleges offering M.Sc. Computer Science Course in Savitribai Phule Pune University, Pune. The period of study in Universe is project completed from 2012-13 to 2016-17. Hence in this period a total 10032 projects have been completed in the colleges covered under universe of SPPU, Pune. Since the number of projects is too large amounting to 10032 projects it was practically impossible to collect and evaluate these projects hence a Convenience Sample of 500 projects were selected with 100 projects each from the period of study from 2012-13 to 2016- 17 by applying Convenience Sampling Method. The projects are selected randomly from the total available projects of each year. v. Data Collection Secondary Data Data collection was from selected colleges of SPPU, where student‘s profile and his/her completed final year project report is considered. Technology Parameter and Quality parameter were defined in the student Projects report analysis. Overall data of computer science course projects is taken from depository as secondary data source. vi. Tools and Techniques of Analysis

Page | 26 Data analysis was done using statistical tools such as averages and graphical representation techniques. Statistical data Tables and different types of charts and graphs are used. Percentages, Averages, etc. techniques are used for the analysis. Hypothesis testing is done by using Z test. vii. Scope of Research Scope of the research is limited to the project reports of Masters in Computer Science students of Savitribai Phule Pune University. Here the reports are selected from colleges of the said university using convenience sampling by randomly selecting the projects. All other courses and even computer courses except MSc are not considered and are beyond the scope of study. The study is undertaken for projects of passed students of all colleges running Master‘s Degree programme in computer science affiliated with Savitribai Phule Pune University. The data is collected for the period from year 2012 to 2017.This can be applied to all strategic project preparation in different courses of the Savitribai Phule Pune University and other universities of Maharashtra. viii. Limitations of Research:- The scope is limited to projects of SPPU, Pune University however it would have been convenient if the scope of study was widened and other universities could have been accommodated. It was done due to Researcher being alone and could not undertake extensive work, hence a Micro Study approach was considered. ix. Chapter Scheme Chapter 1

Introduction and Research Methodology Chapter 2 Literature Review Chapter 3 Software Project Management Principles

Page | 27 Chapter 4 Data Analysis and Interpretation Chapter 5 Conclusion and Suggestions Bibliography & Annexure 1.17 Concluding Remark While summarizing the chapter basic details about software project management was discussed. The points regarding selection of project and choice of project are also discussed in brief. The chapter emphasises on changing trends, technology used and market expectation from the projects of the students. Quality of learning and learner's employability is also dealt by considering the students of MSc computers science. Role of guide has been stressed in the chapter with domain selection, project standards and project evaluation. Special care was taken in report writing part of the students. Chapter also covers details of research like methodology used for research, defining the objectives and hypothesis, scope and limitations of the research, etc.

Page | 28 Chapter 2 Literature Review 2.1 Introduction 2.2 Review References

Page | 29 Chapter 2 Literature Review 1.18 Introduction Students pursuing higher education in terms of their Master's degree, needed to concentrate on practical performance in the form of project. In the field of computer science any project related with those subjects the student has learned during the theoretical sessions needed to implement in practical for a real world problem. This is a final test to judge overall abilities of student who had gained knowledge in one and half years. To know this ability of project development in terms of software of system, students are required to develop their own prototype. This chapter throws light on different articles published, books written and other material on student project management. This is review in short of the selected literature for this study. 1.19 Reviews Stanislav Ivanov and Miroslava Dimitrova 1 in their work, they clearly demonstrated that student projects research provide an excellent opportunity of linkage between research community and company representatives. In their paper, they suggested that there has been seen significant potential in graduation project work, but it has not been fully utilized. They have also observed that most of the graduation research work had no specific business orientation. It needed communication between educational institutions and professionals, government organizations and companies to get better results. They proposed a solution that research proposals shall be collected and each research student shall be made to choose an option between designing own study and taking a _Tailor Applied Research' assignment. According to them, this approach shall provide better access to companies to get a closer collaboration with company representatives that may lead to future employment and closer team work with project supervisors which could affect positively the quality of the research and the final outcome.

Page | 30 Rachel A. I'Anson and Karen A. Smith (2004) 2 in their work discussed different roles of student project like problem solving skills, learning through problem identification, research skills development and application of knowledge. They emphasized on issues like independence of research, responsibilities and expectations exerts pressure on students. They observed that few students are focussed in their research. According to their research students interest played an important role in selecting dissertation topic. Research had

beneficial influence, on topic knowledge and on personal development of the researcher. They also observed that, despite all the planning, things go wrong, but they need to try and salve the work. In their research paper, they tried to highlight negative experiences in data collection, sensitivity of topic, uncooperative respondents, etc. They suggested on research training to students before start of activity in topic selection, planning of project, staff development, supervisory skills, coping with larger groups of students, plagiarism and need of technological advances. Finally they thought to provide opportunities in technical content of project, process of doing research and self-learning. Rasul Mohammad, Nouwens Fons, Martin Fae, Greensill Colin, Singh D, Kestell Colin & Hadgraft Roger. (2009) 3 In their paper discusses work of

0: https://www.researchgate.net/publication/228477355_Good_practice_guidelines_for_managing_supervising_and_assessing_final_year_engineering_projects 73%

project course coordinators and project supervisors as they are under time pressures, and in isolation from practice at other universities.

As per their work projects

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are important vehicles for assessing the capabilities of graduating students and for evaluating program standards. It is critical that teaching and assessment practices are efficient, fair, reliable and valid.

Their

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intention was to begin to develop good practice guidelines and resources to assist students, supervisors, coordinators and industry partners, and to make these available to the community. They intended to stimulate interest in the issues already identified, and to inform the education community of the developments.

Tero Ahtee and Timo Poranen (2009) 4 in their paper they suggested that every project course should have a written final report, and a final conclusive meeting with the project group that finalizes the learning process. Their analysis showed that the teachers and project work team members should pay a lot of attention to support and training on using development tools and project planning. Risk item list given in this work should be discussed with the course

students and clients to make all stakeholders aware of common project risks. They says that account severities of risks are not taken into consideration with analysis on

Page | 31 correlations of the team's working language, different nationalities in the team, project's topic, and client's organization. They further say to recognize causalities between risk items. Dr Ziene Mottiar and Geraldine Gorham 5 In their research provided a good insight into the dissertation experience for students and supervisors. Encouraging students to see the dissertation as something bigger than just a hurdle they have to overcome in order to complete a programme, but instead as something which will enhance their key skills would be beneficial. Students at the end of the process see the value in terms of key skills that they have developed. Again enlightening participants of this advantage early on may encourage a greater sense of commitment and eagerness about the process while it is ongoing rather than just on reflection at the end. They claim that from practical point of view the findings of research shall influences development of support materials for students who are beginning a dissertation next year. These materials will include interviews with students who have completed the process and supervisors who have seen the benefits and advantages of dedicated and interested students. It simply sets the ball rolling as there are many other issues of concern that need to be investigated. These include, examining different methods of supervision, analysing the student supervisor relationship, investigating the perception of the importance of the dissertation among industry members, assessing the students' perceived impact in terms of how acquiring these key skills has aided them in gaining employment and in doing their job, comparing the undergraduate and postgraduate experience. Kacy Lundstrom and Flora Shrode (2013) 6 declared that librarians should help students during their research topic selection process. It would be useful to some students. However, upon more reflection, it seems that recognizing and engaging in the "process" aspect of the topic selection is more significant. Librarians could seek additional opportunities to introduce themselves to students and begin explaining that our purpose is to assist them and to describe ways they can interact. The librarian can then discuss after brain storming the students, how librarians can assist in each of those processes, including in the topic selection and redefining stages. Emphasizing topic selection as a process might be equally, if not more, beneficial to students than focusing on the final choice. Here librarians in an already strategic place for helping students consider their topics during the time that they are finding information. Students can allow the information they find to shape their topic and their perspective. This iterative approach is central to learning how to use information effectively. Students still struggle with various tensions that exist because of their perception of which topic will be successful. The focus group discussions indicated that most students perceive success based on a

Page | 32 grade and what they are most interested in researching and writing about, which could lead to genuine personal benefit resulting from completing the assignment. Roger Ottewill and Bruce Macfarlane 7 said that there is a generic stance on pedagogy in higher education. They emphasized need for reflection and research to identify the challenges faced by business and management educators. They observed that special attention is required for comprising a unique mix for business and management education. J. Emi Retna, Greeshma Varghese, Merlin Soosaiya and Sumy Joseph (2010) 8 Concluded in their research paper that

good engineering methods can largely improve software reliability. They forced to perform testing, verification and validation before deployment of software. Software testing removes defects of product. As per their observations various analysis tools such as trend analysis, fault-tree analysis, Orthogonal Defect classification and formal methods, etc, can also be used to minimize the possibility of defect occurrence after release and therefore improve software reliability. After deployment of the software product, field data is required to be gathered and analyzed to study the behaviour of software defects. Fault tolerance or fault/failure forecasting techniques will be helpful techniques and guide rules to minimize fault occurrence or impact of the fault on the system. C. K. Chang, C. Chao, T. T. Nguyen and M. Christensen (1998) 9 in their paper proposed a formal model to facilitate management activities during the software life cycle. The model assists software managers in obtaining understanding on progress of project. They said that there were some limitations in their work like probability of success rate was assigned on the basis of software manager's experience. They didn't incorporated risk management, software quality and reliability in their algorithm. Nandkishor Patil, Kedar Sawant, Pratik Warade and Yogesh Shinde (2014) 10 in their research observed that software development involves time, talent, and money. They emphasized that cost associated with the employees need to be optimized, selection of employees should be on the basis of multiple skills, methodology to build solution in iterative way enables use of problem-based heuristics for search direction and review of various techniques will be helpful for better study and inventing new ideas for even better scheduling techniques.

Page | 33 Tommy Wedlund (2007) 11 in his research paper, he presented a learning cycle for project- based course. His learning cycle progresses as per the project. He thinks that teacher should switch focus between macro and micro levels. He interprets that individual learning, team process, environment, management knowledge and application areas are some knowledge areas. He emphasizes teacher to identify strengths and weaknesses of the course to get macro picture of course. Mihai Liviu (2014) 12 emphasizes in his research that heavyweight methodologies are suitable for projects where requirements are unlikely to change. These methodologies are easy to implement. Solid documentation is provided in these methodologies. Here project manager can easily perform tracking, evaluation and reporting. Lightweight methodologies are suitable for projects were specifications are unclear. These methodologies are based on incremental approach were software is delivered in multiple consecutive iterations. Lightweight methodologies provide great flexibility and can easily adapt to change. He says that when choosing a software development methodology project owner profile, developer's technical expertise, project complexity, budget and deadlines must be taken into account. Nicholas G. Hall (2012) 13 identified trends those make project management harder, those increased competition, shortens product and service life cycles, tightens budgets, unfamiliar and more complex applications, globally distributed and multicultural project teams. He also discussed underestimation of value of project management as a planning methodology. He concludes that a confluence of factors resulted in numerous interesting research opportunities in project management. Mohammad Khalid Shaikh and Kamran Ahsan (2015) 14 Emphasized success of India and Brazil as major software exporting nations and mentioned the shift of focus on outsourcing towards the DC. They concluded that the growth in software development industry can only be guaranteed through achieving maturity in SPM practices in DC therefore more research in this regard is the need

of time. They said that researchers have to play an active role in ensuring maturity of SPM practices in those DC that have just started to acquire larger share of outsourced projects compared to what they have been receiving in the past. Nidhi Sehrawat, Neha Munsi and Mahak Jain (2014) 15 said that disasters of incomplete projects would have been avoided or strongly reduced if there had been an explicit early

Page | 34 concern with risk management. In their paper they dealt with risk management, risk identification approaches, risk impact definition. They also discussed about four types of risk management approaches. One approach is suitable for small projects or projects with high structure outcomes while other approach works better for projects with less people involved. After the study, they found that risk-strategy analysis approach for a complex project among those four approaches. It can be combined or used in different stages of software development as all are interlinked with each other. They said that software risk management is a continuous process rather than sequential activity. It emphasizes that there is a communication between different stakeholders. However, because risk management is a continuous process, each stage of development needs to consider risk management. Srikrishnan Sundararajan, Bhasi M. and Pramod K.V. (2013) 16 in their research said that software risks, risk rankings, and risk management, in the context of off-shored or outsourced software projects differ from firm owned, or in-sourced software development. They said that risk factors and risk management factors emerged from study were clearly distinct, in comparison with the existing literature on software risk. The model proposes key focus areas for software development risk management in off-shored and outsourced projects, to achieve the best outcome. Lazaros Sarigiannidis and Prodromos D. Chatzoglou (2011) 17 in their research recorded and examined

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parameters of risk management in software development projects that induce and motivate managers or project team members.

Their

0: https://www.scirp.org/html/5068.html 87%

study provided many visions of software project risk that project managers should utilize in order to manage the potential risks related with a particular project and to evaluate effectively the possible alternatives.

Their research model suggested that there has to be a validating real life data. Claude Y. Laporte and Alain April (2013) 18 in their research said that many changes made to the SQA course was initially set up. The challenge was to ensure that all improvements met the objectives of the course. Adding practical content and tools has made the most significant difference in the scores. The authors think that the current SQA course lectures and laboratory sessions provide a solid foundation for future software engineers, even though SQA is still perceived as a low priority by most SMEs and VSEs.

Page | 35 Elaine Wenderholm (2004) 19 in their paper discussed tat faculty members are often hesitant to undertake undergraduate research projects since they often ask themselves whether undergraduates have sufficient training and knowledge to conduct research. Additionally faculty researchers may not have experience in project planning and management. In their paper they suggested that effective strategies for success are based upon experience directing a four-year research project. Sukhpal Singh and Harinder Singh (2013) 20 in their research observed that the case teaching method has been used effectively in many professions to teach about how to solve problems and make decisions, while dealing with genuine circumstances, working with real- world restrictions, and engaging with both human and technical issues. Although the use of the case module in teaching software engineering has been restricted, the discipline is key candidate for such a procedure. The project described in their research paper has the objective of building a framework for using the case module for teaching software engineering. In addition, the project provides case modules, which can be used to teach various software engineering topics. Anita Singh and Lata Singh (2017) 21 in their research paper discussed that with the rapid growth of digital technology and rise in virtual learning centres offering online courses and degrees to students, E-Learning has gained a vital role to play in future as a class room teaching tool and self-study platform for skill development. They emphasised to identify prominent factors of e-learning for the development of job-specific skills. They performed step wise multiple regression analysis. The result suggests that from the student's perspective, besides other factors flexibility in E-learning is the most prominent factor for developing job specific skills. Donald William, Ashleigh Melanie and Baruch Yehuda (2018) 22 in their research findings revealed that undergraduates perceive their investment in higher education to offer a net financial gain; however, this is narrowing due to increased tuition fees, associated student debt and interest payments eroding earning premiums. As undergraduates progress, they feel more employable from a personal perspective, but less employable from a market perspective due to competition for graduate jobs and the cost/benefit conflict of resources. The authors provide nine opportunities for enhancing the employability of graduates collaborating with

Page | 36 graduate employers, providing a timely contribution to the social, political and economic debate on the funding of higher education. Helen J. Heaviside, Andrew J. Manley and Joanne Hudson (2018) 23 says that their study was to explore Postgraduate Sport and Exercise Psychology students' and their lecturer's experiences of PBL, and, its role in developing their employability skills. Inductive thematic analysis of verbatim transcripts was used as a basis for developing portrait and composite vignettes to illustrate their experiences. Their underpinning themes suggested that PBL was instrumental for developing key employability skills: team working, communication and interpersonal sensitivity; thinking critically, creatively and flexibly; for helping students translate academic knowledge into application in future employment contexts, and for increasing awareness that learning is a lifelong developmental process. Mike Smith, Mike Duncan and Kathryn Cook (2013) 24 through their paper said that the percentage of recent graduates employed in lower skilled jobs increased, while approximately one new graduate in every five available to work is unemployed. It is therefore a matter of urgency for higher educational institutions to investigate ways that can increase student opportunities to develop their employability skills

within the curriculum. They implemented a problem-based learning (PBL) approach in to the curriculum across all three levels of an undergraduate Sports Psychology program. Student perceptions of their satisfaction with and how important they felt a PBL approach was in facilitating their employability skills were investigated. Their results indicated that regardless of whether students liked, disliked or were unsure of PBL, they all reported that PBL facilitated their employability skills. Othman H. et. al. (2017) 25 in their paper summarized that PBL has helped the students to become more independent and active in their learning process. This is prove that PBL to Engineering Students can make better student employability skills. They also had that much opportunity to develop their employability skills like communication, leadership and problem solving. In their study, with one subject using PBL students performed better than the conventional group. They cannot deny the possibility that PBL is the better alternative learning process. Ajit Bansal (2018) 26 in his research said that enhancing employability skills of management students is challenge before the institutes of management education Management education is

Page | 37 not able to identify the way and out to develop employability skills also in a puzzle to select a proper approach that may have more employability alternatives to management students. Management education today has to address a wide variety of critical issues, one of survival, intense competition, serving the needs of stakeholders, delivering industry employable graduates and in the process of doing all this develop brand equity. While all of these issues are critical and important enough to generate a discussion, research and elaboration at length, his research was an attempt to know the perception of MBA student's possession of employability skills at entry level in job market. This particular study focuses on the gap between perceived skills by management students and the industry expectations from MBA post-graduate at entry level. Anna D. Rowe and Karsten E. Zegwaard (2017) 27 says that employability seems to receive considerable attention and scholarly debate in the literature, there are still notable gaps around evidence that links successful attainment of work-ready skills to the impact graduate employability and employment, including the long term career implications. There are few available longitudinal studies exploring employability. Furthermore, there is a need to consider curriculum redesign with employability foundational to the curriculum, where students can identify and explicitly link to their learning activity to a desirable graduate competency. Advancing the education provided to post-secondary students is integral to effectively preparing them for a life-long career in their chosen field. Therefore, it is likely that employability, despite the considerable discussion already in the literature, will remain a key research direction and focus of scholarly debate for some time yet. Jill Tomasson Goodwin, et. al. (2019) 28 says that this is an original contribution to research because its study design combines practical instructional design with empirical research of significant scope and participant size therefore, contributes quantitative evidence to the employability skills articulation discussion. By surveying students six months post-course, the study captures whether articulation instruction can be recalled, an ability of particular relevance for career preparedness. Likewise, our research study can help to answer other, larger calls for university accountability, such as Harvey Weingarten‘s, who laments that postsecondary institutions have —little information about whether students arrive on campus with these skills or to what degree they acquired them through their studies, because we don’t test for them||. Most broadly, our study can also help to meet the underlying rationale of

Page | 38 postsecondary education, which assumes that —knowledge, skills, and attitudes learned in this setting will be recalled accurately, and will be used in some other context at some time in the future‖ Martin Smith, Kenton Bell, Dawn Bennett, and Alan McAlpine (2018) 29 says that their research project was activated to explore trends emerging in the intersecting domains of employability, work-integrated learning, and career development learning. Attendees explored questions around employability in vocationally specific and non-vocationally specific degrees. The language and conversations highlighted the influence of global contexts on strategies and practices in transnational settings specifically, how employability is defined and supported across the breadth of university activity. Tinashe Harry, Willie T. Chinyamurindi and Themba Mjoli (2018) 30 saw many black students enrolling in higher education. Inequality in the labour market, however, continues to prevail. This has resulted in limited employment opportunities, unemployment and underemployment. This study contributes to understanding students' perceptions of employability. By understanding these perceptions and factors, policymakers can develop policies that will cater to the needs of such students. Carr Robert A., et. al. (2018) 31 in their study examines student experiences of Peer Assisted Study Sessions (PASS) at Western Sydney University (WSU), investigating attendee and facilitator perceptions of the relationship between peer-learning and employability. It defers to contemporary higher education scholarship and related sector definitions of employability as an objective criteria for evaluating outcomes which may result from student experiences with PASS. This investigation observes the extent to which such definitions are evident in the skills and attributes students have acquired via their participation in PASS through both quantitative and qualitative research. The study found that attendees and facilitators of the WSU PASS program perceive that the program contributes to student employability in a variety of ways such as improving participants' core technical skills, organisational skills, social skills, professionalism and business acumen, appreciation of mentoring, and critical thinking skills. Oliver, B. (2015) 32 discusses that employability features more prominently on the agenda of higher education institutions when the economy falters or changes the majority of students,

Page | 39 and their families, expect a degree to deliver a career pathway as well as an education. He explores some of the trends and predictions in the rapidly changing world of work and proposes a re-worked definition of employability that employability means that students and graduates can discern, acquire, adapt and continually enhance the skills, understandings and personal attributes that make them more likely to find and create meaningful paid and unpaid work that benefits themselves, the workforce, the community and the economy. He proposes that work-integrated learning includes a range of learning tasks that either resemble those expected of working graduates in their early careers, or are proximal to the workplaces or spaces, physical or digital, where professional work occurs. Determining the appropriate spread of tasks across a degree is best done by mapping assessments, ensuring there are more high level tasks in the latter years so that students are prompted to focus on the skills, understandings and personal attributes that make them more likely to find and create meaningful paid and unpaid work that benefits themselves, the workforce, the community and the economy. Daudi Lazarus and Timothy L.J. Ferris (2016) 33 said that attention was given to the different interest of individual's in accepting responsibility for their professional development. In this regard, several sources reveal the need for learners

to take their own responsibility for developing employability competencies development. However, the concern must be expressed at the incompleteness of research into the personal responsibility for competency development. Vladan Devedzic 34 in his book said that in order to organize and manage a software development project successfully, one must combine specific knowledge, skills, efforts, experience, capabilities, and even intuition. They are all necessary in order to be able answer questions on management and control during software development, organizing the development team, the indicators and measures of the product's quality, set of development practices, to create and maintain a good relationship with the customers and end-users, remedial actions in case of problem, etc. The details provided an extended overview of many important issues around which such knowledge should be structured. Mick Healey, Laura Lannin, Arran Stibbe and James Derounian (2013) 35 in their book discusses about final-year projects and dissertations. They said that the topic is of international interest. However, there is increasing pressure to rethink the form of the

Page | 40 traditional projects and dissertation in response to the growth in student numbers and diversity of motivations to study, the expansion of professional degrees, lack of relevance to some courses and future careers, and the reduction in the numbers of staff/faculty to supervise projects. Their book has sought to identify innovative and creative solutions for developing project and dissertation to meet the requirements of students from different backgrounds, aspirations, disciplines and kinds of institution in the context of diminishing resources in many countries. They emphasized that wide range of skills acquired through many forms of projects and dissertations suggested significant benefits regarding student employability. These skills support students' development by encouraging them to become empowered, confident and capable learners. Although they found wide range of different approaches in terms of the design of the projects, the way they are undertaken and assessed, and the form of the outputs, it is somewhat surprising to find, the relatively limited choice that students appear to be given. In less than 20% of the case studies we collected is there an explicit element of choice. Despite all the innovative ideas we encountered, it appears that most programmes continue to operate a one-size-fits-all policy to those taking their projects and dissertations. They think that students can be encouraged to showcase their work in a variety of ways, including undergraduate conferences, end-of-year shows, presentations to colleagues, academics and professionals, the production of documentaries and consultancy reports, as well as, or in some cases instead of, writing theses. Integrating self and peer assessment into the design of project and dissertation and explicitly assessing the development of project skills may also be beneficial to student learning. Supervising projects and dissertations can consume considerable staff/faculty time and energy. Providing information in the form of guides and question and answer sessions, using group supervisions, and facilitating ways for students to support each other can reduce the staff time required. Focused discussions between supervisors and students and greater consistency can be encouraged through the use of tools, such as the student expectations framework. Mick Healey and Alan Jenkins (2009) 36 in their book concluded, that they returned to some of earlier perspectives, affirm key connections between the sections of their work and suggest ways forward. As they stated in the first section, the key to developing undergraduate research and inquiry is to mainstream it and integrate it into the curriculum for all students. To achieve this aim they argue that it is important to make connections between different

Page | 41 levels of action and different forms of research and inquiry. This research work builds on the work of institutions and academics in different parts of the world in developing a better understanding of links between teaching and discipline based research and ways of progressing these links further. They are convinced that US-derived conceptions of undergraduate research offer ways forward for universities worldwide to hold onto the Humboldtian ideal of the university as an institution where teaching and research are interconnected. The strength of undergraduate research is that the spotlight moves from the traditional focus on individual academics, being effective as both researchers and teachers, to a focus on students and realising the Humboldtian ideal through the undergraduate curriculum. The task then for national systems, institutions and departments is to reinvent and reshape the overall curriculum and other aspects of university structures to support students engaging in research and inquiry. This perspective not only gives due value to all students, it also potentially values all staff – not only research-focused academic staff, but also teaching- focused academics, librarians, technical support staff, educational developers and so on. For a _research-active undergraduate curriculum' to be realised all these roles have to be equally respected and effectively connected. This is an important agenda if higher education is to be effectively higher. Such goals are, essential and realisable through mainstreaming research and inquiry throughout the curriculum. This aim, however, poses challenges to current and future practice and policies. This research, through its wide array of case studies, has revealed an international galaxy of interesting and effective practices from the level of the individual course to national policies. However, for undergraduate research and inquiry to be realised for all or many students, these interventions need to be interconnected. Clearly such interventions may well start in particular courses or within a specialist undergraduate programme, but the task then is to scale up and connect these interventions. We were struck by how, in particular, some of the American readers who provided us with critical support in reading an earlier draft, commented on what they saw as major difficulties in realising in US institutions, such interconnected interventions at course team, departmental, institutional and national levels. Perhaps they were picking out key strengths of the UK system with its strong institutional and national quality enhancement systems; for example, effective national requirements for institutional teaching strategies, many of which now do in part focus on linking teaching and discipline-based research and supporting undergraduate research. Or perhaps these US observers were seeing the UK through rose-tinted glasses. They point to how QAA

Page | 42 Scotland's project on _graduate research attributes' which has uncovered much innovative good practice in institutions, departments and disciplines, but has also revealed that such practices and policies are often isolated examples and not yet connected in a coherent way in the curriculum to support student understandings of research. M. Berndtsson, J. Hansson, B. Olsson and B. Lundell (2007) 37 proposed characterises of project which is the fact that it is something that is planned, has a specific purpose, lasts only for a limited time with a clear start and finish, and is undertaken with finite resources with respect to personnel, money and equipment. The project is an opportunity for studying a subject in more depth. It may view the project as preparation for working life, by practising your skills and knowledge on real world problems. The project may be used as preparation for graduate studies, by exploring a research problem and learning about the research process. In

addition, your university probably sees project as serving two further purposes. Typically, these can be captured by the following goals, shared by most projects, and which emphasise the educational motivation and the research motivation. The first goal is the ―educational‖ part of the project. This can be viewed as a test to show that you have mastered previously attained knowledge and skills, and know how they can be applied to a problem that is more realistic than those normally presented in courses. In detail, the ―educational‖ part has the following set of learning goals. The project should (1) develop your critical thinking; (2) enhance your ability to work independently; (3) increase your understanding of how to use and appreciate scientific methods as tools for problem solving; and (4) develop your presentation skills, oral as well as written. With ―critical thinking‖ we mean the ability to approach something new in a systematic and logical way, and to use creative and diverse, yet systematic ways to approach and solve a problem. Further, to support opinions with trustworthy evidence, data and logical reasoning; and also the ability to decide how a problem fits into a larger context. Those who have become comfortable with thinking in this way can often apply these acquired skills also in everyday life. The second goal is the ―research‖ part of the project, in which it will deepen understanding of the subject area, and contribute to the common knowledge and understanding of the subject area. However, to attain this goal, your project must have aspects that are original. In other words, it is generally not enough to repeat the work of others, since it is regarded as a waste of resources (time, money etc), unless, that is, your purpose is to confirm or reject previous findings. The gains from your project are based on

Page | 43 the contribution it makes, i.e. the development of knowledge and results that were not known before you started the project, and on the fact that the findings will have been disseminated. Dissemination of results is necessary in order to ensure that the knowledge is spread to other people working in the field. Even though you might learn a lot from the project, no one else will do so if the results are not disseminated. In this case, the project would fail to fulfil the first goal concerning the development of knowledge, i.e. to increase our understanding of the subject area. The non-dissemination of new and valuable knowledge may be said to be as useful as work not done at all. In universities, most research is carried out by faculty members and doctoral students. However, there are many valuable reasons for linking research and undergraduate teaching. It introduces students to the fascinating world of science, and makes the latest knowledge available to them. In fact, you should expect that university studies, wherever appropriate and possible, incorporates the findings of the latest research. It is generally considered that incorporating elements of research methodology, and giving students the opportunity to undertake their own research related project, or to be involved in a bigger research project, facilitates individual students‘ development towards becoming independent and critically thinking people. It is our opinion that thesis projects offer excellent opportunities for closing the gap between research and teaching. Not only are teachers able to pass on their knowledge and experience in the topic area, as well as research methods, but it also gives an excellent opportunity for you to become involved in leading-edge research activities. Independently of whether you do your project off campus or in the university environment, you will notice that you will be working more closely with faculty members, and very often in a more collegial and informal way than is normally the case in traditional courses. As mentioned before, the project itself gives insights into what research is

and how it is performed, and is a good preparation for doctoral studies, since it includes initial training in using research methods. When doing a project, it is important to familiarise with the criteria and expected standards defined by your university and/or department. In the process outlined in this book, the assessment of projects involves a set of criteria that has been shown to be representative of many departments. For example Relevance of chosen topic, Originality of chosen topic, Significance of findings and Degree to which the work is the student's own work Nancy Fried Foster and Susan Gibbons (2007) 38 first defined problem. Their first task was to identify one trenchant research question to guide the project. The question was developed

Page | 44 to know the research papers. Between the assignment of a research paper and the finished, submitted product was a black box that largely concealed the processes undertaken by the student. They wanted to take a peek into that box to see what we could find. They felt that this question accurately reflected our ignorance of student work habits while providing a manageable focus for our information-gathering activities. They took a general approach, avoiding presuppositions. They wanted to begin our project by exploring students' practices; they did not set out to prove a point. Their initial aim was to be able to describe in detail how students actually write their research papers. This would enable the library staff to develop new ways to help students meet faculty expectations for research papers and become adept researchers. While understanding student practices they anticipated that changes or improvements in three areas i.e. reference outreach, facilities, and Web services are required to be implemented. Timo Poranen (2012) 39 identified six skills and associated with research project and project managers, who would benefit from adopting these skills and behaviours to improve efficacy of their projects. First one is to understand the relationship between behaviours and feelings, being genuine, open and honest, showing authentic concern for others and adopting repertoire of behaviours for different situations. Next to inspire others to be more creative, applying appropriate leadership style for situations, informing others about manager's wishes. Next point is to influencing or impressing others so that they can see the benefits, selling others the benefits. Another point is in showing an open concern for others, accepting people who they are and empowering people. Understanding the needs other people have and make people feel good about the work, the project and themselves. Next is to have open and honest discussions to find root causes of the conflicts. Concentrating on work issues, being loyal, trustful and helpful, and being prepared to compromises. It was also expected to develop, display and apply an awareness of other cultures in a team. One of the main findings in the research is that knowing the skills and acquiring competences is not enough. Practitioners need to apply the skills, observe the outcomes and modify them if needed to make them work even better. It is a continuous process where behaviour and it's impacts matter. Literature suggests some people project managers are play-acting rather than showing authentic behaviours. The problem here is that people behave consistently with their. It does not matter what they say when their behaviour shows their real beliefs. According to research play-acting is acceptable behaviour only when applied time to time in situations, not continuously. These skills and

Page | 45 behaviour can be adopted by project managers anywhere in the world. Expectations of the behaviour of managers may vary in different areas of the world and there may be some

corporate cultural differences also. The behaviours are not limited for application in any specific area of the world or industries. Benjamin Mako Hill (2000) 40 wrote in his book discussed the version as the part of the third pre−release cycle. It is written to be released to developers for critique and brainstorming. Please keep in mind that this version is still in an infant stage and will continue to be revised extensively. Project has provided with a home, a place to practice free software advocacy, a place to make a difference, a place to learn from those who have been involved with the movement much longer than, and proof of a free software project that definitely, definitely works. Feedback is always and most certainly welcome for this document. Without your submissions and input, this document wouldn't exist. He wanted this document to be a product of the Free Software development process that it heralds and he believed that its ultimate success will be rooted in its ability to do this. Meri Williams (2008) 41 writes that Discovery is the process by which the organization reviews the available opportunities and decides which of them will become projects in due course. Where this process is undertaken, it's usually combined with some sort of portfolio planning through which the potential projects are matched against the resources or capabilities of the organization itself. The full range of tools and practices that can be useful in discovering projects within an organization would include idea elicitation, portfolio management, organization building & resource planning. There are three steps to choose best project opportunities and they are Identify the opportunities, Compare the opportunities and Rank them and decide which to undertake. Some other points are think about some hallmarks of good projects i.e. they deliver big benefits, with defined metrics that specify the size of those benefits, they're important to the future of the organization, sufficient resources are invested in them and they have supporters within the organization. Gary R. Heerkens (2002) 42 in their research throws light on three aspects of management viz. process context, interpersonal context and organizational context. As per the author Gary, if projects are classified into four basic levels viz. Initiation phase, Planning phase, Execution phase and Close-out phase.

Page | 46 Evan Dashevsky (2017) 43 writes about potential gold mine for GE is automating its infrastructure. The industrial internet is not nearly as well-known as its consumer counterpart, but it is far more expansive and vital. These unseen networks keep lights on, water clean and flowing, and trains running on time. Here the project management techniques used by GE is non conventional. They uses IIoT field GE which seemed most excited about was something called a Digital Twin, or virtual representations of an asset. These Twins are created by pooling data from fleet sensors. Assets can then be optimized for performance, but also proactively send an alert when a part needs to be fixed or replaced before the situation becomes critical. As these systems gain capability and ubiquity, they continue to tip-toe towards an automated world. It will be safer, cheaper, and faster all the things shall be conditioned to root for but we should not lose sight of how they will impact our world in potentially negative ways. Joab Jackson (2011) 44 discussed Project and Portfolio Management software used by Hewlett-Packard is broadening the potential scope of the software to manage all organizational projects, not just IT projects. They have sold this product to the IT groups, but they found that a lot of customers were using it as a true enterprise project and portfolio management system. They released too better serve this expanded user-base, HP PPM 9.1, which includes a number of new features and modules aimed at setting the curiosity that organizational executives and high-level managers have about the success of their projects. PPM software

helps manage a difficult task, keeping track of complex projects. Analysts have estimated that around 68 percent of most software projects fail to meet their goals, and their managers typically take the blame for this shortfall. Liane Cassavoy (2013) 45 discusses Zoho Projects, a Web-based and mobile (Android and iOS) tool, helps you manage projects by creating tasks and task lists, viewing items on a calendar, assigning them to others, and more. I like how you can quickly upload files as attachments, and the activity feed, which lets you comment and see other user's comments, much like you do on social networks like Facebook. When it comes to customization, few apps can compete with Podio. Available as an online service and a mobile (Android and iOS) app, Podio offers project management and collaboration tools that can be completely customized to meet your needs. That makes Podio incredibly useful, but it also requires a bigger time investment if you want to get the most out of it. Doing so comes with a bit of a

Page | 47 learning curve, but the time you invest will result in a truly individual tool for managing your project or task. Liquid Planner is as much a time management tool as it a project manager. And that makes a lot of sense, as you can't get your work done without managing your time. Liquid Planner can be a bit overwhelming at first, thanks in large part to its all-business, text- heavy interface. It uses a structure somewhat similar to email tools like Outlook, with columns that let you drill down into each item for more information. Liquid Planner lets you add projects, with sub-categories and task lists, as well as packages, which are items that don't necessarily fit into a project, but that you want to organize or prioritize. Helping you prioritize tasks is what Liquid Planner really is all about. Richard Morochove (2007) 46 discusses project management software aims to help organize teamwork. Microsoft Project is one of the best-known project management apps, but not every business requires its power. A new generation of simpler, Web-based services can do the job. Web-based project management services are inexpensive and easy to set up. They are well-suited for coordinating a mobile or geographically dispersed team. Each team member just needs access to the Internet to participate in project planning. These basic services may not be robust enough for every business, particularly those that handle complex, multi-year projects. You'll need to decide if they deliver enough horsepower for your business needs. List view lets you create and modify tasks. Each task has a start date, duration, and due date. You can add a detailed description and attach related documents. You can also decide how you want to be notified about tasks by e-mail. By default, the service notifies you of changes in tasks you have created and those assigned to you, but this can be changed for each group. Jill Duffy (2017) 47 says that teams that have to handle multiple projects simply can't rely on human memory to keep them all organized. And trying to keep everything together in email is a recipe for disaster. To deliver projects on time and within budget, information needs to be written down, deadlines plotted, and documents shared. Team members need to be in constant communication with one another. When your team needs to get serious about managing projects, the solution is to get project management software. Project management services are online systems for both working and collaborating on projects. These real-time workspaces let team members and outside partners keep an eye on every detail that brings a project to fruition. They typically provide an overview of all the projects in the pipeline, as well as the nitty-gritty details about the daily work being done to move the projects forward.

Page | 48 The very best project management apps help teams handle common problems, such as slipped deadlines, by automatically rescheduling tasks that are affected by them. They generate reports that give managers insight into which team members have too much or too little work on their plates. Many track time spent on projects and integrate with invoicing and billing systems. The most important thing to know about project management apps, as opposed to other kinds of work-management apps, is that they are for projects. That might sound like a tautology, but it's important. Projects are a specific type of work. Projects have a start date, an end date, and deliverables. Creating a new design for a website is a project. Maintaining that website, however, is ongoing work with no clear beginning or end date. Ashok Pandey (2017) 48 believes that there are four pillars of management. However, before discussing the workforce skill trends, first try understand how technical support is evolving at a dramatically fast pace. Functional IT framework describes four primary IT disciplines Infrastructure, Development, Security, and Data. The Infrastructure pillar is the bedrock of IT operations. With a broad reach and a long history, Infrastructure contains many of the rules most often associated with IT. The second primary pillar for IT operations is Development. While Infrastructure focuses on hardware, Development centres on software. It is important to note that companies build external customers have separate product development teams. As technology needs become more complex and digital stakes get higher, security becomes the most important pillar of any organization. Security, most often, begins as an offshoot of Infrastructure, since the traditional security approach has been heavily focused on technology. The need for further specialization is driven by new layers of technical tools, business processes that establish secure practices. Traditionally organizations have used firewall and antivirus as the means for securing their infrastructure and endpoint devices. However, for digital organizations, this security perimeter is not sufficient, as applications and data regularly travel outside the walls of the firewall. As Security is an offshoot of Infrastructure, Data is an offshoot of Development. The skills and thinking needed to translate well to Data, where there is an abstract component of dealing with bits and bytes. The recent growth in the amount, veracity, velocity, and variety of data that a company can manage has brought focus to certain specialized skills, but there is a foundation that must be built before moving to more advanced applications.

Page | 49 Bourgault, Mario, Robert, Benoît, Yan, Gabriel (2006) 49 says teaching project management to undergraduate students is undeniably more challenging than teaching it to professionals, who usually demonstrate more intrinsic motivation (and need) to acquire knowledge and skills that can help them more effectively realize their projects. They described an approach that one university believes can enhance the value of undergraduate training in project management and that its students and faculty perceive as valuable. Instead of traditional in-class lectures, the university teaches project management through concrete situations (capstone projects) occurring over a period of four years. Additionally, the university will also offer more advanced learning concepts not directly applicable to capstone projects using e-learning strategies. Considering the importance of developing a young engineer‘s project management competencies, university should develop new teaching methods to create more authentic learning conditions that prepare students for professional working conditions. Dawn Bennett, Dr Sarah Richardson and Dr Philip MacKinnon (2016) 50 proposed in their project the understanding of graduate employability in relation to the contrasting

perspectives of different stakeholders. The research confirms that to identify and develop the skills and attributes needed to navigate post-graduation pathways, higher education students need timely and informed support. Graduates assert that the lack (or under development) of these skills and attributes is one of the most critical disadvantages encountered by graduates transitioning into work. 53 Educators are central to the process of change, but higher education leaders, graduates and students report many educators to be ill equipped for the task. Whilst the team acknowledges the expert and impactful employability work undertaken by many colleagues, one reference group member reminded the team of a —fundamental disconnect‖ between the development of employability within higher education and those academics who —would say that universities are not ‗responsible' for anything, except perhaps the pursuit of truth and beauty‖. Zuleika Firdosh Homavazir (2015) 51 says that online learning education industry is divided into three major market segments Content organisations, Learning services firms and Delivery solutions companies. Growing demands for e-learning require a combination of methodologies, tools, and technologies to effectively scale by e-learning development throughout the organization. As e-learning is definitely a growing field in the educational and

Page | 50 training market and e-learning standard is a new emerging area, there are many challenges in implementation of undergoing technological changes and developments. The security of services, the encryption of messages and the common taxonomies to describe services and service xv access points in e-learning systems environments are all in need of consideration. Supporters of e-learning are always looking forward some new developments. Technology advancements will continue to reshape learning over the Internet with increasing use of advanced tools and techniques. Many business houses are now moving towards using e- learning technologies for induction and refresher trainings. Keerthi Menon (2014) 54 in her research says that human resources, in terms of quality and quantity, are India's biggest assets. A favourable demographic structure adds to this advantage. However, to capitalize fully on this opportunity and not face the possibility of a skills-shortage, it is essential to gear up the education system through innovative initiatives. The two greatest concerns of employers today are finding good workers and training them. 52 The difference between the skills needed on the job and those possessed by applicants, sometimes called the skills-gap, is of real concern to human resource managers and business owners looking to hire competent employees. While employers would prefer to hire people who are trained and ready to go to work, they are usually not willing to provide the specialized, job-specific training necessary for those lacking such skills. Finding workers who have employability or job readiness skills that help them fit into and remain in the work environment is a real problem. The term employability —signals a connection to the world of work that is dynamic and long-term in nature‖ Lee Harvey, William Locke and Dr Alistair Morey (2002) 55 in their report says that the dynamic nature and diversity of provision mean that development is uneven. Some institutions are better at embedding employability in the curriculum than others. Some institutions prioritise the role of central services. Others have excellent relations with employers and have made enormous progress in developing and acknowledging work experience opportunities. Some institutions have taken a strategic approach - which in Wales has been encouraged by the funding council. The field is also constantly changing and not all changes are incrementally forward. Some initiatives do not achieve their goals and others lose

momentum and fade away. There is a long history of funded initiatives that produce good results during the funding period, but which, despite good intentions, fail to be embedded in

Page | 51 institutions. There is a lot of information on initiatives and activities, but relatively little analysis of the impact of employability development in universities. Employability performance indicators are entirely inadequate as measures of the impact of such activities. Chapter 3 Software Project Management Principles 3.1 Introduction 3.2 Software Project Management 3.3 Student Personality 3.4 Prior Knowledge of Students 3.5 Teacher Quality 3.6 Technology Change in Recent Times 3.7 Software Tools 3. 8 Type of Study 3.9 Data Collection and Proposed Tools 3.10 Data Analysis Techniques 3.11 Report Writing Technique 3.12 Course Outcome 3.13 Learner's Employability

Page | 52 Chapter 3 Software Project Management Principles 3.1 Introduction A dissertation or final year project usually has several key characteristics which are common to disciplinary or interdisciplinary areas whether undertaken on campus, in workplace or in community. Dissertations and final year projects are likely to require an extended piece of work, research and inquiry, an element of originality, innovation or creativity, a discipline-based or interdisciplinary topic, work which is underpinned by relevant sources, critical thinking and assessment, contextualisation and recognition of the provisionality of knowledge, methodology, self-reflective commentary, a build-up to conclusions and it needs to be an extended piece of work. Dissertation or project tackles a central question or issue in depth. It needs to be research or inquiry based. There are a great variety of approaches to research, but central to all of them is a desire to find out something significant about ourselves or our world. For example, research can be qualitative, quantitative, laboratory based, design based, artistic, ethnographic, participative, action research, research _on', _for' or _with' people, first person inquiry, or any other scholarly approach. It needs an element of originality, innovation or creativity. Dissertations and final year projects need to go beyond stringing together facts from books. Mick Healey (2016) 1 The originality could come from, for example, application of a theoretical framework to new data, critical evaluation of the arguments surrounding a controversial issue, bringing together information from multiple sources and presenting it in an innovative way, or applying theory to real-life issues. It needs to be relevant to a discipline or take an interdisciplinary approach. Student is usually having the opportunity to choose their subject matter, but it should be relevant to the student's areas of interest and hence maybe disciplinary or inter- disciplinary in nature. Sometimes the project's focus may be work or community based. It needs to be underpinned by a range of relevant sources. Sources those inform students are required to consider and examine their relevance, questioning what they learn and the ideas

Page | 53 which are presented to them. They should consider a variety of ideas, leading up to their final and reasoned conclusions and implement the skills that they have accumulated throughout their degree to research, analyse, and discuss. It needs to be contextualised and show recognition of the provisionality of knowledge. It is essential that students understand and demonstrate the context of the work on which they draw and are contributing to within their fields. Dissertations and final year projects in higher education should recognise that knowledge is uncertain and provisional. It needs a clearly defined methodology and

appropriate methods. These provide a structure, purpose and rationale for the dissertation or project and should be appropriate for its aims and objectives. It needs to be supported by an element of reflective commentary. This helps to understand the student's reasoning and to place the dissertation or project in its setting. It needs to build up to its conclusions. Dissertations and final year projects should be built on all the above points to reach a coherent set of conclusions which relate to both particular topic and research process. 3.2 Software Project Management An official definition of project management, courtesy of

the Project Management Institute, defines the term as: —

0: https://www.pmi.org/learning/library/project-management-business-analysis-6410 100%

The application of knowledge, skills, tools and techniques to project activities to meet project requirements.‖(

PMBOK Guide)

Time: Time required completing the project. Cost: Amount required completing the project. Scope: It is the list of deliverables or features that have been agreed. Quality: Quality may include not only the quality of the finished product, but also the approach. These four aspects (time, budget, scope, and quality) make up what's known as the balance quadrant. Project Development Life Cycle The generic project life cycle is fairly simple—first you start the project (called Initiating), then you go on to actually do the project (through the Planning, Executing, and Controlling phases, which form a loop), and finally you finish with everyone happy, a strategy for the future in place, and a check in your hand (Closing). Source: Meri Williams (2008)]

Page | 54 Planning Traditional project planning is focused around tasks—jobs that you need to do, or actions you need to take. At first glance, this might seem sensible. A task-based plan will literally give you a list of items that you need to do, like a to-do list for the entire project. Deliverables are the actual end-products of your project, be they tangible (machines, buildings, cash) or intangible (software, a brand identity, and so on). The difference between a task and a deliverable is that the task is the job you're busy doing (building, designing, creating), while the deliverable is the product you end up with (a wall, a design, a document). For instance, the task might be —lay the foundations,‖ but the end product or deliverable is the foundations themselves. Planning a project for the first time is a six-step process: 1. Break down the project into pieces small enough to work with. 2. Identify dependencies. 3. Estimate how long each piece will take. 4. Add some contingency. 5. Consider the risks. 6. Represent the plan in a format that the team, board, and stakeholders will understand and follow. Controlling The Controlling phase of the project life cycle is all about understanding how you're doing, tracking your progress, and adapting to changing circumstances. Executing The Executing phase of the project life cycle is all about doing the work—creating the product. It's where many new project managers feel most comfortable, since they've come Initiating Closing Planning Controlling Executing Fig 3.2 Project Development Life Cycle

Page | 55 from being part of the project team. Nevertheless, there are still some key issues you'll need to look at from a project management perspective. Risks, Issues, and Bugs If you're not on track, it probably means that one of your risks has materialized. Risks are risks when they are still just potential problems that haven't arisen yet. Once a risk is realized, project management-speak deems it to be an issue. Issues exist at the project level. If you're from a technical or production background, it can be very easy to confuse issues with bugs or defects, but issues are different from bugs. Bugs are technical errors—a system failing to behave in the way you intended. Defects are product errors—an aspect that fails to meet quality standards. Issues are risks that have come to life; they're problems that mean you can't carry on with the project as planned. This doesn't necessarily mean that you have to stop the project completely; it may just be that you need to adapt your direction or your methods a little. Verification V/S Validation Throughout the Executing and Controlling processes, you'll constantly be verifying the fact that you're creating the deliverables that you planned to create. Verification is simply the process of checking that you've built what you intended. Validation is a separate matter. Validation is checking that whatever you're delivering is actually going to deliver the promised value. Validation is what brings you to change course mid-project, despite the fact that you're delivering everything on time, within budget, and to the correct scope and quality. Closing Knowing when you are ready to move out of the Planning, Controlling, and Executing cycle, and on to closing the project seems deceptively simple. You just move on to closing once you've finished the actual doing of the project. 3.3 Student Personality A well-known theory of personality is the Big Five, which describes five characteristics that together give an indication of one's personality. These five characteristics are:

Page | 56 ? Openness: This refers to openness to experience, for example if one is adventures and curious. Also creativity and longing to novelty are part of openness. ? Conscientiousness: Being organized, having self-discipline, and plan activities rather than spontaneous act on them. ? Extraversion: Being social, energetic, assertive, and reach out to other individuals. Opposed is introversion, meaning that one is more reserved. ? Agreeableness: Being cooperative and sympathetic towards others. Also, trusting others and sometimes being naïve belongs to agreeableness. ? Neuroticism: High degree of experiencing negative emotions, such as anger, anxiety, and sadness. This is also referred as emotional unstable. In terms of study success, several studies have investigated whether personality is related to study success and if so, which specific characteristics are important for better academic performances. It is expected that certain personality traits affect the way students approach their study, and hence influence their study results. A consistent predictor that is found in the majority of studies is conscientiousness. It is the strongest predictor of the Big Five: Higher scores on conscientiousness relate to study success in terms of tertiary GPA and final grades and exam scores. Some of these studies controlled for intelligence and found that even then, conscientiousness is still a predictor. There is still much discussion ongoing about whether or not the other traits are related to academic performance at all. Some studies found a positive relation between openness and study success or agreeableness and study success, but these findings are inconclusive. Besides the Big Five characteristics, narrow personality traits of these characteristics are also important for predicting study success. It was found that especially self-discipline, achievement-striving behaviour, and curiosity are positively related

to academic achievements. Additionally, impulsivity and anxiety are negatively related to academic achievements. The meta-analysis further showed a positive relation between need for cognition and study success and emotional intelligence and study success. However, these traits are likely so difficult to identify due to their abstract nature, the challenge for researchers is to adequately quantify and measure them. All in all, personality – especially being conscientious – is related to academic success. However, two remarks need to be made: First correlations that are found are generally small, and second, other factors, such as motivational factors, seem to be a stronger predictor for study success then personality. There is some discussion about whether some motivational factors, like self-efficacy, are a trait or not. Self-efficacy is one of the strongest predictors of study success

Page | 57 3.4 Prior Knowledge of Students Prior knowledge relates to the skills, procedures, and knowledge the student has already learned and is typically able to apply automatically or without much effort. Prior knowledge is a critical learner characteristic which should be taken into account to optimize instruction. A clear example of how prior knowledge affects instruction efficacy is the so- called expertise-reversal effect which is the phenomenon that the instructional design efficacy can reverse when students gain more expertise. In other words, an instructional design approach which is effective for novices can be less effective for experts, and vice versa. When starting to learn about new subject students can be considered novices, but they gradually increase in expertise through training. For example, novices who were instructed in the functioning of electrical circuits performed better when electrical circuit diagrams were presented with textual explanations than without. However, after the initial training the additional information became redundant and the students – who had acquired more knowledge during the training – performed better when they were shown diagrams without any text. This study demonstrated that the efficacy of instruction is moderated by prior knowledge. Other studies have found similar expertise reversal effects, for example that providing additional information to aid understanding is beneficial for novices but redundant and often hindering for experts. Students should receive abundant supporting information when learning a relatively new topic, but the level of support should be reduced when they become more knowledgeable. Nicholas G. Hall (2012) 2 likewise, novice students benefit from texts which are highly coherent and easy to read, while later on they typically learn more and deeper from texts which are much more difficult as well as less coherent hen students have to learn about a complex visual or schema which has many interacting elements, such as a complex diagram of human anatomy, some of the students might not be able to process and learn from all the large amount of information. Instead, it is advised to first teach the individual components in isolation, before moving on to the big picture. In contrast, students who are already familiar with the individual elements are hindered by such a thorough instruction, and learn more efficiently when directly given the complex materials.

Page | 58 Taken together, a range of active ingredients or instructional design principles are only effectively function for novice learners but are sub-optimal or even detrimental for more experienced or knowledgeable learners. Furthermore, educational courses are generally an extended process spanning days to weeks such that within each course one or multiple situation-specific expertise reversal effects may occur, thus implying that the instructional design should adapt to these changes throughout a course and not merely from course to

course. 3.5 Teacher Quality What qualities of university and college teachers positively influence learning outcome of students has been a research topic since long. The unmentioned Qualities facilitate students : ? Skill: the instructor‘s overall pedagogical adroitness. ? Rapport: the instructor‘s empathy, accessibility and friendliness to students. ? Structure: the extent to which the course is well planned and organised. ? Difficulty: the amount and difficulty of work expected of students in a course. ? Interaction: the extent to which students are encouraged to become actively engaged in class sessions. ? Feedback: the extent to which the instructor provides feedback on the quality of a student‘s work. 3.6 Technology Change in Recent Times History An outline for what would have been the first piece of software was written by Ada Lovelace in the 19 th century, for the planned Analytical Engine. However, neither the Analytical Engine nor any software for it was ever created. The first theory about software – prior to the creation of computers as we know them today – was proposed by Alan Turing in his 1935. This eventually led to the creation of the twin academic fields of computer science and software engineering, which both study software and its creation. Very quickly, commercial software started to be pirated, and commercial software producers were very

Page | 59 unhappy at this. UNIX was an early operating system which became popular and very influential, and still exists today. The most popular variant of UNIX today is macOS, while Linux is closely related to UNIX. Pre-Internet source code sharing Before the Internet – and indeed in the period after the internet was created, but before it came into widespread use by the public – computer programming enthusiasts had to find other ways to share their efforts with each other, and also with potentially-interested computer users who were not themselves programmers. Such sharing techniques included distribution of tapes, such as the DECUS tapes, and later, electronic bulletin board systems. However, a particularly popular and mainstream early technique involved computer magazines. Tiny BASIC was published as a type-in program in Dr. Dobb's Journal in 1975, and developed collaboratively (in effect, an early example of open source software, although that particular term was not to be coined until two decades later). It was an inconvenient and slow process to type in source code from a computer magazine, and a single mistyped – or worse, misprinted – character could render the program inoperable, yet people still did so. (Optical character recognition technology to scan in the listings rather than transcribe them by hand was not yet available). However, even with the widespread use of cartridges and cassette tapes in the 1980s for distribution of commercial software, free programs (such as simple educational programs for the purpose of teaching programming techniques) were still often printed, because it was cheaper than manufacturing and attaching cassette tapes to each copy of a magazine. Many of today's IT professionals who were children at the time had a lifelong interest in computing in general or programming in particular sparked by such first encounters with source code. However, eventually a combination of four factors brought this practice of printing complete source code listings of entire programs in computer magazines to an end: ? Programs started to become very large ? Floppy discs started to be used for distributing software, and then came down in price ? More and more people started to use computers – computing became a mass market phenomenon, and most ordinary people were far less likely to want to spend hours typing in listings than the earlier enthusiasts

Page | 60 ? Partly as a consequence of all of the above factors, computer magazines started to attach free cassette tapes, and free floppy discs, with free or trial versions of software on them, to their covers Recent Developments Applications for mobile devices (cell phones and tablets) have been termed "apps" in recent years. Apple chose to funnel iPhone and iPad app sales through their App Store, and thus both vet apps, and get a cut of every paid app sold. Apple does not allow apps which could be used to circumvent their app store (e.g. virtual machines such as the Java or Flash virtual machines). The Android platform, by contrast, has multiple app stores available for it, and users can generally select which to use (although Google Play requires a compatible or rooted device). Peter W.G. Morris (2009) 3 this move was replicated for desktop operating systems with GNOME Software (for Linux), the Mac App Store (for macOS), and the Windows Store (for Windows). All of these platforms remain, as they have always been, non-exclusive: they allow applications to be installed from outside the app store, and indeed from other app stores. The explosive rise in popularity of apps, for the iPhone in particular but also for Android, led to a kind of "gold rush", with some hopeful programmers dedicating a significant amount of time to creating apps in the hope of striking it rich. As in real gold rushes, not all of these hopeful entrepreneurs were successful. Savitribai Phule Pune University Guidelines Regarding Project The aim of the project as per the university is to develop in student problem solving abilities using mathematics; to apply algorithmic strategies while solving problems; to develop time and space efficient algorithms; to develop software engineering documents and testing plans; to use algorithmic solutions using distributed, Embedded, concurrent and parallel environments and to encourage and expose students for participation in National or International paper presentation activities. There were also reasons for project like exposure to Learning and knowledge access techniques using Conferences, Journal papers and participation in research activities. There are expected course outcomes viz; to write review SRS, reliability testing reports, and other software engineering documents in the project report; to write problem solution using multi-core, distributed, embedded, concurrent/Parallel environments; to write the test cases to demonstrate the results of the project; to write conference paper; to write

Page | 61 code using FOSS tools and technologies or propitiatory Tools as per requirements; and to practice presentation, communication and team-work skills. 3.7 Software Tools Latest software tools are required as per latest syllabus and guidelines from Savitribai Phule Pune University. Preferably 64-bit FOSS tools are required. Latest SAN, 3-tier architectures along with latest version of FOSS Operating systems like Fedora 21 or equivalent, LAMP tools, WEB server, Applications servers, Database servers, Mongo-DB or latest open source Big-DATA tools, FOSS Programming Tools like Gcc, G++,Eclipse, Python, Java and other tools are per requirement of the SRS. Eddie Fisher (2011) 4 the documentation tools like Open office, GIT, Latex, Latex- Presentation should be used. Project workstation selection, installations and setup along with report to the guide, Programming of the project, Test tool selection for various testing recommended by preferably external guide and generate various testing result charts, graphs etc. including reliability testing, Review of design and necessary corrective actions taking into consideration feedback and other competitions/conferences participated. Students must submit and preferably publish atleast one technical paper in the conferences held by IITs, Central Universities or SPPU Conference or International Conferences in Europe or US, Final term work submissions in the prescribed format of a

project report consisting of a detailed design with all necessary UML diagrams document, User Interface design, Laboratory assignments on test cases and test results generated by selected project testing tool, conclusions, appendix, glossary, tools used and references at the end of Term-II after checking, removing/ avoiding the plagiarism. Give an additional assignment per reporting plagiarism to be submitted in the report under the Annex heading extra-work. If the project is the replica of any other previous project or work from other unrelated persons than the student's team, such project should be rejected for the term work. Software Used Previously In case of final year projects of students who are performing a sort of new research, applying all the knowledge of software engineering for the project and then writing a dissertation report submitting it for the completion of course. When observed from previous reports it was cleared that the technology used by the students in development of projects were Visual Basic with Oracle and data reports for data base project. Even Fox-pro, Fox-

Page | 62 base, Dbase III and IV and Clipper were used as databases with C and C++ programming. To certain extent Cobol was also used i development of the project. These are in regard with database projects. In case of networking UNIX and Windows 2003 were used for net based software like websites. Use of HTML was also observed in projects developed before five years. Software Used Nowadays When observed the reports of recent years within last three years, it is seen that latest database softwares are used like DOT Net technology with internet based Python and R Language. Majority of software nowadays are net based hence using Linux Operating System, Apache server, MySQL database and PHP language (LAMP) because of all being open source. Even Active Server Pages (ASP.net) and JAVA are also used heavily. Besides database projects, huge amount of mobile computing projects are also being developed by the students using Android Operating System with all its versions like Jelly Beans, Honey Comb, Kit Kat, Lollypop, Foyo, Gingerbread, Donut, Eclair, etc. Cell phones are used by almost 90% of population. Even amongst all the cell phone users, more than 85% are using smart phones. Hence projects on smart cell phones are at high demand. The same is observed in the student's projects. 3.8 Type of Study When type of study was considered and observed previous projects belonging to about five years before, projects were based on the core concepts of software engineering like Data Structure and Algorithm. Different algorithms and data structures were used as the important theme of the project. Beside these Databases were also key concept used in the project. With the help of data structures and databases sorting and searching algorithms were designed. Artificially intelligent software projects were also observed from past projects. Web based projects were also observed to certain extent with concepts like Websites, Cryptography, Anti-viruses and Network Protocols. Data reports were used in case of data base projects. Very few system programming based projects were also observed based of industrial automatic control. Giorgio Locatelli, Giacomo Mariani, Tristano Sainati and Marco Greco (2017) 5 said when recent project reports were studied; it came to know that recent students are using most

Page | 63 advanced concepts and types for their projects. Instead of data structures and algorithms, nowadays data mining and data-ware housing concepts and worked upon. Instead of simple database, object oriented databases and distributed databases have taken their place. Instead of simple programming, object oriented programming are being used.

Instead of Artificial intelligence, neural network, machine learning and Internet of Things have occupied their seat. More number of web based projects is being observed nowadays like shopping cart, social chat site, cloud computing etc. Nowadays because of lots of data on the network, data security is also a key concern being observed in the project reports. There are projects based on Advance encryption techniques like holomorphic encryption over cloud being observed. Firewalls and anti-viruses are also being more worked on. One more section has increased its applications are Mobile computing and Microcontroller based projects. 3.9 Data Collection and Proposed Tools Data collection is process required in at least two different contexts while completion of software project. First data collection is required for requirement analysis of the software development life cycle. This data is collected by software developer from client to know the software requirements. The data is collected in the form of written texts, formats, etc. The second data collection is the analysis of software. This can be either trial data or real one to test and run the software. This data can be in the form of computer data entry form, data query or database tables. This depends on the type of software and data generated or used by the software. Some time data transcription is required if data is collected at one place and processed at different place. Web forms are sometimes used to collect to know the responses of many different people. Nowadays because huge amount of data is available, data mining is used to extract information. This requires data ware housing and data mining techniques. The data can be from social site like twitter or facebook. Even purchase data from database of a shopping mall can also be used to extract useful information from it. The data can be text, number, picture, video or sound clip. Data can be collected in any form using data acquisition system in an industrial setup. 3.10 Data Analysis Techniques Data analysis is the main part of research activity. Even the research projects at master's level course require data analysis. This analysis used to be done previously using electronic data processing software like components of Microsoft Office viz; Word, Excel,

Page | 64 etc. or open source software Open Office. The basic instruments of statistical analysis like Percentages, Averages, Mean, etc were calculated manually or using available softwares. But in case of latest development, there are many software available like SPSS (Statistical Package for the Social Sciences) software, FOSS (Free or Open Source Software), different simulation softwares like MATLAB and SCILAB. SPSS software helps in all sort of statistical analysis with advanced statistical data analysis like Co-relations, Standard Deviations, Testing of data by using T-test, Z-test or Chi-Square test. 3.11 Report Writing Technique Writing report is most important part of dissertation process. This process inculcates mode of technical writing in the students. Previously the reports were written using word processor software like MS Word, Acrobat Editor, etc. Charts and other pictorial representations were using MS Excel or MS Power point. Nowadays special documentation softwares like LATEX is used for report writing. This is specially designed software with covering every minute details of technical writing. Use of open source software like Open Office is also being used in larger extent to write reports. The students nowadays are using latest technological options in completion of their dissertation process. This improved the quality of work and efficiency of their project work and their personality. 3.12 Course Outcome ? The Master's Degree course at Pune University aims at training for professional practice in the industry. The programme is designed so that the graduate can adapt to any specific need with ease. ? It prepares the student for higher studies in Computer Science. A long project

provides an opportunity to apply the principles to a significant problem. It gives students the grounding that makes it possible to 1. Approach problems and solve them on the computer. 2. Obtain mathematical formulations of real world combinational problems 3. Solve them algorithmically

Page | 65 4. Do simple analysis of efficiency of such algorithms 5. Acquire the necessary mathematical background for doing deeper analysis of algorithms At the end of the course the student should be familiar with 1. The notion of a graph and the related concepts 2. Algorithms to solve various graph theoretic problems 3. Idea of efficiency of an algorithm and simple methods of estimating computing time of various algorithms 4. Tools of algorithm analysis such as solution of recurrence relations, asymptotic notation etc. The stress in teaching Numerical Analysis gives a mathematical discipline and not an art. It focuses on teaching unifying principles and to avoid teaching them as a bag of tricks. An Algorithm as a computational procedure depicts a differentiated from the theorem, which is a statement about what the Algorithm does. As many of the students come with a poor knowledge of complex variables, it is necessary to give an introduction to complex variable theory as part of numerical analysis course. Syllabus contains all mentioned topics needed for modelling. - To distinguish between and be able to relate the high level (mathematical) world of data structures and the low level (engineering) world of storage structures. - To develop a vocabulary for algebraic manipulation of data structures and a calculus of systematic refinement to algorithms and storage structures in the low level world of C and machines. - To round off the foundations laid in IP and MF by engineering slightly bigger software on realistic computer systems. Functional Paradigm discusses the central issue to be able to use the computer as a high level tool for problem solving. The paradigm conveyed simply expresses as a modern non-strict functional language with a polymorphic type system as the medium for this part. The currently used language is the internationally standardized language, Haskell. Important ideas that are covered include Standard Constructs, Standard Data Types Fluency, calculus, First Classiness , Polymorphism, Inference, User defined types, Concrete types, Recursion , Operational Semantics, Type Classes,

Page | 66 1. To question informal techniques in programming but inverting them into questions of programmability (computability). 2. To acquaint with (i) Complexity (ii) Semantics and in this context systematically show the increase in power of Lower power formalisms, languages, automata in the direction of its very limits the notion of computability. 3. To reformulate old, classical definitions of computability in the technologically relevant setting of modern programming languages, thus breaking the theory Vs practice divide. 4. To build conceptual glue that spans the triad automata, languages and computation. ? Modern Computer Systems have layer upon layer of s/w abstractions. These abstractions, though perhaps made with the best intentions, ultimately end up obscuring the actual workings of computers. The primary aim of the LLP course is to crack open this high level abstraction layer. ? To understand the workings of a computer at the lowest levels where h/w and s/w meet. C Programming (Basics here, advanced in Data structures and syspro). To be able to write assembly language programs (in small doses) and to integrate C and assembly (in larger doses). To be comfortable with low level system software. The above to be done with respect to a specific OS depending on availability and instructors choice. This is to describe the major

architectural styles of computer systems and the programmed abstract machine that is created over a given computer system via operating systems software. ? When students first study programming, the one style that they have learnt, they inevitably take to be THE style. The aim of the PP course is to convert that 'THE' into 'a'. ? A variety of different ways of thinking about programming are presented. The differences are investigated so that the word 'paradigm' can begin to make sense the different languages covered are vehicles, not the goal. The sense of the intellectual

Page | 67 content for computer science as being not fixed but a melting pot of new ideas. Some aspects of how these paradigms are implemented. This course focuses on fundamental techniques for the design and analysis of correct and efficient algorithms. After reviewing the applicable mathematics and introducing the basic concepts, the course presents several design techniques. First a technique is introduced in its full generality, and then it is illustrated by concrete examples drawn from several different application areas. Attention is given to the integration of the design of an algorithm with the analysis of its efficiency and correctness. The course also introduces the concepts of computational complexity. ? Concepts in DBMS are taught in depth so that students will attain the ability to design Databases and understand the ACID principles and nitty-gritty involved in any DBMS development, through the implementation exercises carried out in the course. ? General principles and concepts of computer networks and the services built on top of them are covered so as to make students attain the ability to design basic network services and implement network Systems. ? It conveys the idea that systems programs help in building an abstract machine over the raw machine, and are governed by the fundamental need of interpretation. Also attempt to demonstrate the mix of techniques from formal to heuristics that are used to write real programs. ? To equip the student with tools and techniques required for generation and manipulation of pictures/images. The device independent aspects as well as the device dependent quirks of colour and gray scale devices is expected to be appreciated by the student at the end of this course. ? To introduce the student to practical or real world systems which require understanding and defy complete (if any) analytical methods towards their analysis and hence the requirement for modelling and simulation. This includes mathematical, statistical and language tools required for specifying a model, winning the simulation and analysing the results. The course would emphasize DES while showing linkages to other types of simulation.

Page | 68 ? This course focuses on two aspects of OR, viz. deterministic (mathematical programming) and stochastic. At the end of the course the student should have developed or honed his/her skills at modelling (or at least problem formulation) and be able to choose an appropriate quantitative technique towards it's solution, or be aware that the problem on hand is *not* amenable to quantitative techniques. ? Software development is a complex process. Good quality software results by using disciplined and methodological approaches for requirement analysis, design and coding. In this course, the student is introduced to both formal and less formal techniques used for requirement and domain analysis. At the end of the course the student will Become more adapt in understanding a problem in terms of its processes and concepts and design a good solution using CASE tools. Have sound understanding of software engineering issues for large scale development through modelling

and notation and provide a foundation for the Software Engineering course (which is taught later), so as to be able to develop a piece of quality software according to sound principles and notation. ? To teach the use of formal methods in software development. Although formality should not be sacrificed too much, scaling up in software size with reduction in formality should be illustrated when possible. Software engineering is concerned with the cost effective development and evolution of software systems. This course introduces the topics through lectures and by giving the students a chance, in the form of a class project (which is a group project), to develop a software product and to manage its development process. It is a combination of the System Analysis and Design course and covers all other issues that are needed in Software Industry.

Page | 69 3.13 Learner's Employability —A learner is someone who is learning about a particular subject or how to do something‖ and employability is defined as —if a person or company employs you, they pay you to work for them‖. As per Cambridge dictionary a learner is defined as a person who is still learning whereas employability i defined as the skills and abilities that allows you to be employed. Developing learners' employability skills is a key driver for organisations who want to prepare their learners for the 21st century workplace. How Learning is related with Employability? Employability is a set of skills, knowledge and personal attributes that make an individual more employable. Institutions of higher education are examining the methods they use to enhance student employability and are exercising various measures to grow and strengthen this. Employers are demanding skills from graduates which are outside the subject area of study in Higher Education. Indeed, some employers have placed less importance on graduates' actual degree discipline in favour of the more generic skills which they have acquired. Employers generally see a graduate's achievements related to the subject discipline as necessary but not sufficient for them to be recruited. Achievements outside the boundaries of the discipline extracurricular activities such as work experience, volunteering, and involvement in clubs and societies are seen as having equal importance in this context as the knowledge and experience acquired through academic study. What is required to increase Employability? Producing employable graduate forms a part of the process of education. It encompasses the full educational spectrum of values from imparting knowledge and understanding to developing skills and attributes. Work has already been undertaken in embedding a set of graduate attributes, progressed in line with institutional developments on the previous and current Enhancement Themes: _Graduates for the 21st Century' and _Developing and Supporting the Curriculum'. Generic employability skills are important because the labour market is intensely competitive, and employers are looking for people who are flexible, take the initiative and have the ability to undertake a variety of tasks in different environments. Employability skills are not as narrowly prescribed and defined as in the past and generally, they are more _service oriented', making information and social skills increasingly important.

Page | 70 The _employability agenda' is of crucial significance to any leading university, and there is little doubt that it impinges upon student recruitment, retention, and satisfaction. Prospective students and parents carefully weigh up their future employment prospects when selecting degrees and universities. They consult university league tables and sources which publish graduate destination data and starting salaries. With the rise of tuition fees, students

will look more carefully for a return on their investment. Is the syllabus compatible with the needs of market? The world is undergoing a technological revolution that is fundamentally changing the way we live, work and relate to one another. In its scale, scope and complexity, the transformation is unlike anything we have experienced before. Termed as the "fourth revolution," it has today created a "techonomy community" that believes in the paradigm that technology is and will define the business and society. These changes are impacting all the jobs in the industry and society. We need people who are suitable to work in this fast-changing environment. With the rush of change, we also need people who can handle and adapt to this change. Jobs are changing very rapidly by adapting to automation, AI, robotics and new business architecture. The new job environment requires individuals to be at ease with technology, uncertainty and, therefore, risks, in addition to delivering in the midst of chaos and complexity. All this demands a complete new form of professionals. The prime responsibilities of developing young professional with such capabilities, rests primarily with our institutes of higher learning. Unfortunately, our present higher education system is completely incapable of even addressing to the basic elements of this responsibility, leave aside taking the lead to steer and guide the change process in industry and society. Educational institutes are not keeping up with change. We also want to see that our institutes of higher education act as centres of learning that encourage collaboration, autonomous learning and innovations; but our educational institutes are infested with redundancy, lethargy and complete lack of creativity and innovation. The major cause of this state of affairs is the culture and environment of our institutes. The responsibility of creating and maintaining the culture of creativity and of innovation rests primarily with the faculty and the students of the institutes. Most of the faculty members of the institutes of higher learning are on the permanent tenure; without any robust mechanism of monitoring their role and contribution in supporting the creativity and innovation in the institute.

Page | 71 Most of the people taking up such jobs become lethargic after some time as there is no mechanism to reward and support the creative thinking. This leads to a situation where the educational institutes get dissociated from the changes taking place in the society and industry. The rate at which the faculty members and the curriculum are reformed is much slower than the changes happening in the industry. With time, this gap between the industry and academia becomes so wide that the education process completely loses its relevance to the industry and society. This is the kind of scenario we are experiencing in current times. This state of affairs is very alarming as the present day economy and the leadership in the world entirely depends upon the technology, the institutes of higher education need to revamp them; so that they can play the apt role in building the nation and prosperity for its people. Institutes should be the agent of transform, rather the institutes are laggards, barely able to keep them aware of what happening in the industry, rather than leading the change. 1. Higher education leadership The leadership is the most important component of the higher education framework, but, unfortunately that is the unconcerned, if not irresponsible component. The people who are in the positions of guiding the higher education policies and the education framework to prepare students with relevant knowledge and skill needed in the industry at any particular time and near future are mostly the ones who have little or no idea of the whole domain. They are the people who have the full-time employment with the government without any monitoring, control and accountability towards the post they are

holding; and, most certainly without any fear of losing their jobs, if their skills and knowledge are not relevant to the needs of the time. No wonder, they have little motivation to understand the needs and changes in the skills needed for the employment and their change dynamics. 2. Faculty The recent explosive growth of educational institute and the entry of non-serious players in the domain of education have resulted in adopting the path of the least resistance in acquiring, developing and retaining the good faculty members. Most of the institutes are owned by the people who are in the game for the quick money rather than for the love of education and cause of developing the society with appropriate skills and capabilities to help the nation.

Page | 72 This goes quite contrary to the reality, as the quality education is actually a long-term cycle process. Nothing good can be achieved by short-term attitude and processes. 3. Students The student needs to be more focused and aware of the career path and choices available. They also need to be aware of the changes and trends in the industry, which will determine their employability. The students should not entirely depend upon the degrees and certificates for their employment and relevance but they also need to augment their skill sets with relevant tools and techniques needed to enhance their career. As the volume of knowledge in any domain in increasing at alarming rates, it becomes very difficult to keep one skilled in multiple domains. So, one should identify early his/her domain of specialization and acquire deep knowledge, skill, and understanding in it. This is the age of specialization and niche and not of generalists. 4. Industry Till recently, especially in India, the industry and academia were two different islands with very little of negligible connection and communication between them. The industry expected the academia to help them solve the real world problems, but academicians were too happy and contented with textbook problems and solutions. Slowly, the industry stopped approaching the academia for their problems and academicians were too happy with their classroom teaching and paper research. The students who are undergoing education in such an environment fail to realize the real world problems faced by the industry. When they come out of the institute, they find themselves quite incapable of even comprehending the issues, as they had no experience of such situations during their study years. Now, there is need to rethink the whole process afresh. All the stakeholders have to do away with their ways of doing things the old way, and adopt the relevant process and systems, which enable them to augment each other's role and effectiveness in the current and future need of the trained professionals. Finally from the Pilot survey before Analysis it was observed that virtually all passing out Post Graduate were absorbed in the market and the employability was claimed to be 100%. Although the claims are there it was a challenge to investigate the matter in more comprehensive manner, Hence the research work to find out the employability factor of

Page | 73 M.Sc. Students whose employability largely depend upon the project they undertake during the M.Sc. Computer Science course. Chapter 4 Data Analysis and Interpretations 4.1 Introduction 4.2 Personal Details 4.3 Project Details 4.4 General Technical Questions 4.5 Project Development 4.6 Miscellaneous questions 4.7 Hypothesis Testing

Page | 74 Chapter 4 Data Analysis and Interpretation 4.1 Introduction This chapter depict analysis of data collected from survey of project reports of students from different colleges in

Savitribai Phule Pune University. Data was collected from reports of students who have cleared their masters in computer science. The reports were studied for the parameters like gender of students, guide detail, project details, technical details, project development details, etc. The chapter includes the discussion on findings and interpretations on the findings. There are tables and charts on the table values analyzed from the data collected. 4.2 Personal Details Data was collected from individual report of students. The gender of student was also one of the questions to know the difference of technological level of students depending on their gender. The study was of the reports submitted between years 2012 to 2017, hence the reports studied from which year was also mentioned. With this information, data was collected to know the mode of project; that means project developed in group or singularly. Employment status was also known from alumni section to know the productivity of project made during their studies by the student. Questions were asked regarding guides like domain of guide in which he/she is expert, qualification of guide to know the depth of knowledge of the guide and experience of guide to get the information regarding the guide whether he/she has adequate knowledge about rules of developing project as per the guidelines given by the Savitribai Phule Pune University. Table 4.1: Gender classification of Students Sr. No. Gender Total Percentage 1 Male 273 54.6% 2 Female 227 45.4% 3 Total 500 100%

Page | 75 Source: - Data collected from project reports As per table 4.1 it is clear that 54.6% of students who have developed and submitted project reports are males whereas 45.4% of them are females. This shows that nearly equal percent of students from both the gender are studying and have completed their project. Chart 4.1: Gender classification of Students Chart Inference: - From chart 4.1 it can be interpreted that, nearly same is the ratio of males and females in technical education at higher level with a difference of around 5%. This can also be interpreted as to there is no gender distinction in students undertaking and pursuing higher education weather it is traditional or technical education. Table 4.2: Year of Submission of Reports Sr. No. Year Total Percentage 1 Year 2012-13 84 16.8% 2 Year 2013-14 104 20.8% 3 Year 2014-15 102 20.4% 4 Year 2015-16 93 18.6% 5 Year 2016-17 117 23.4% 6 Total 500 100% 55% 45% Gender Male Female

Page | 76 Source:- Data collected from project reports The data collected gives the information about the study of reports from selected colleges by the way of random sampling in different years from year 2012-13 to 2016-17 as depicted in table 4.2. It is nearly 20% sample from each year was selected for the study with little variations. Chart 4.2: Year of Submission Reports Inference: - From chart 4.2 it can be interpreted that in years 2013-14, 2014-15 and 2016-17 more students were admitted and submitted their reports whereas in years 2012-13 and 2015- 16 less students were admitted and submitted their report. This can be Inferred in a way that there is mixed response from students opting for master's degree in computer science. This course being a technical course it was found the demand fluctuated with the market requirement and the knowledge imparted in the course. Table 4.3: Mode of Project Development Sr. No. Mode Total Percentage 1 Alone 327 65.4% 2 In Group 173 34.6% 3 Total 500 100% 17% 21% 20% 19% 23% Year of Submission

Page | 77 Source:-Data collected from project reports From table 4.4 is clear that around 65.4% of students worked alone on their project whereas 34.6% students worked in group.

This ratio belongs to both males and females students combined. As per the analysis of data it is clear that to work alone is the first choice of the students. Chart 4.3: Mode of Project Development Inference:-From chart 4.3 it becomes clear that students are not in favour of working in groups. Majority of students worked alone on their project. They lack attitude of team work. They are at loss during their studies because they are required to work in team throughout their life hence forth. Finally it can be inferred that if the project is completed in a group there is more concentrated effort and it makes the project more sound technically even students can opt for publication if there is come innovative aspect in the project. Table 4.4: Employment Status Sr. No. Status Total Percentage 1 Employed 402 80.4% 2 Unemployed 98 19.6% 3 Total 500 100% 65% 35% Project Development Mode Alone In Group

Page | 78 Source:-Data collected from project reports Table 4.4 gives the data regarding the employment status of the student. It is observed that 80.4% of the students are employed whereas 19.6% are unemployed. The students unemployed have many students who were pursuing further studies. In some cases female students are not on job because of marriage and do not supports their spouses in family setup. Chart 4.4: Employment Status Chart 4.4 depict a picture that majority of students are employed more than 80%. In remaining those 20% students majority of them are female students, who are not employed because of family, marriage, etc. There are some responses who were not employed because of further studies. This shows that nearly 100% of the students are employed and that they are getting work recognition because they have gained a little work experience during development of their project. The reliability of project have given students on edge over their competitions as they were able to get job on campus drive itself. Table 4.5: Domain of Guide Sr. No. Guide Domain Total Percentage 1 Academics 39 93% 2 Industries 03 7% 80% 20% Employment Status Employed Unemployed

Page | 79 3 Research Nil 0 4 Public Sector Nil 0 5 Total 42 100% Source:-Data collected from project reports It has been observed from table 4.5 that some project were having guide from industries or public sector. Majority the guides were from academics. This can be interpreted in a way that poor research activity was being observed during project development. Inference:-It can be inferred that if more and more research based guides and industry background professions come into academics a new dimensions for projects and a new insight is given to the students on latest issues in market. Table 4.6: Qualification of Guide Sr. No. Guide Qualification Total Percentage 1 Graduate 7 16.67% 2 Post Graduate 23 54.76% 3 Doctorate 12 28.57% 4 Others Nil 0 5 Total 42 100% Sorce:-Data collected from project reports From table 4.6 it becomes clear that 28.57% of guides are doctorate, 54.76% are post graduate whereas 16.67% are graduate in their qualification. This table gives us knowledge to know the capability of guides for the project development.

Page | 80 Chart 4.5: Qualification of Guide Inference:- Chart 4.5 depicts data regarding qualification of guides. Majority of guides are postgraduate and doctorates. There were some guides who were just a graduate but guiding to post graduate students. In such cases the situation was different. The guides were graduated from computer science but post graduated from Business Administration or Social welfare or Physical education. It was also found that in 16.67% there were guides who were engineering graduates in computer science,

since they were having domain knowledge they were given students to guide the projects.Even amongst those guides many were doctorates. This can be interpreted that almost all guides were capable of guiding the students. Table 4.7: Experience of Guide Sr. No. Guide Experience Total Percentage 1 0-5 years 12 28.57% 2 5-10 years 24 57.14% 3 Above 10 years 6 14.29% 4 Total 42 100% Source:- Data collected from project reports 17% 55% 28% 0% Qualification of Guide Graduate Post Graduate Doctrate Others

Page | 81 While seeking information regarding experience of guides, the responses received are shown in table 4.7. The table shows that around 57.14% of guides were having experience between 5yrs to 10yrs where as 14.29% of them were having experience above 10yrs. In all around 64.43% of all guides were having experience above 5yrs. Chart 4.6: Experience of Guide Inference:- from the table as regards experience of guide it can be inferred that majority of guides are well experienced to guide the students in development of their project. Only 28.57% of guides were having experience less than 5 years. This can be interpreted that majority of guides were experienced in handling the projects. It can be inferred that experience do help but young minds also think in different manner and hence can contribute to the development of project in a more comprehensive manner. 4.3 Project Details Here the details of the projects were discussed like type of projects students have opted in terms of research, regular, sponsored, etc., domain of project students worked on like application, system, networking, mobile, security, etc., project platform like MS Windows, Linux, Android, etc., project framework like dot net, Java, web based, etc., frontend and backend used, ready tools used like Matlab, Talend, Weka, Rapid miner, Google earth, etc. and data base used like MS Access, Oracle, MySQL, MS Excel spreadsheets, etc., 29% 57% 14% Experience of Guide 0-5 years 5-10 years Above 10 years

Page | 82 Table 4.8: Type of Project Sr. No. Project Type Total Percentage 1 Research 377 75.4% 2 Regular 106 21.2% 3 Sponsored 17 3.4% 4 Other Nil 0 5 Total 500 100% Source: Data collected from project reports Table 4.8 shows 75.4% of projects were Research based, 21.2% of projects were regular whereas 3.4% of projects were of sponsored. It is clear from statistics that around 79% of projects were having some commercial value. This also gives us information about the practical approach of projects students are developing. Chart 4.7: Type of Project Inference: It can be inferred from the table that majority of students are developing projects which are solving some or the other problem either it may be sponsored project to help the client solve the problem or research projects to solve some typical problems. This can be interpreted in a way that most of the projects are commercially viable. More and more projects when they gain commercial value until also increase credibility of Institutes and the courses run by the institutions under SPPU University. 3% 21% 76% 0% Type of Project Research Regular Sponsored Other

Page | 83 Table 4.9: Project Domain Sr. No. Project Domain Total Percentage 1 Application 98 19.6% 2 System Nil 0 3 Networking 7 1.4% 4 Database 381 76.2% 5 Mobile 2 0.4% 6 Security 12 2.4% 7 Other Nil 0 8 Total 500 100% Source:- Data collected from project reports From table 4.9 it is observed that 76.2% of project domain was based on database whereas 19.6% of project domain was application based. There were other domains like security with 2.4%, networking with 1.4% and security with 2.4%. Not a single system level project has been

observed during the study. Chart 4.8: Project Domain Inference:- It can be inferred from the table that majority of students worked on database based projects. Some of the projects were application oriented whereas few were 20% 0% 1% 76% 1% 2% 0% Project Domain Application System Networking Database Mobile Security Other

Page | 84 security based, networking based and mobile based. It can be interpreted that students were in favor of database projects, Database being easy to do is adopted most and is popular similarly 19.6% application based projects are really encouraging. Table 4.10: Project Platform Sr. No. Project Platform Total Percentage 1 Windows 498 99.6 2 Linux 0 0 3 Android 2 0.4 4 Matlab 0 0 5 Other 0 0 6 Total 500 100% Source:-Data collected from project reports Table 4.10 shows statistics that 99.4% of projects were using MS Windows platform for developing their projects where as very small that is 0.4% of projects were android based. Rest of the platforms like Linux and Matlab were not at all preferred. Chart 4.9: Project Platform 100% 0% 0% 0% 0% Project Platform Windows Linux Android Matlab Other

Page | 85 Inference:- It can be inferred from the table that all the projects were using windows platform for their development. Except a couple of projects all were using the same platform. Windows platform is most preferred by the students. The reason is availability and cost where as if Matlab and other platforms are used then their application will also be more comprehensive and the students will be able to perform and do it in innovative manner making their project more meaningful and create a value of project in itself. Table 4.11: Project Framework Sr. No. Project Framework Total Percentage 1 Dot Net 468 93.6% 2 Java 13 2.6% 3 C & C++ Nil 0 4 C# 2 0.4% 5 Android 2 0.4% 6 Web Based 15 3% 7 Other Nil 0 8 Total 500 100% (Source: Data collected from project reports) From table 4.11 it can be analyzed that 93.6% of projects were developed on dot net framework whereas 3% were web based. 2.6% were using Java and few projects i.e. 0.4% were using C++ and Android. Most of the projects were using dot net framework.

Page | 86 Chart 4.10: Project Framework Inference:- It can be inferred that dot net framework is the most preferred framework of the students. Some of the projects used Web based and Java with C++ and android but majority of projects were dot net based. The changes in Information Technology rapid and hence from the above it can be concluded that if students opt for new languages it would give them variety in application in a way making it innovative and different from other projects. Front End Used From data collected by the project reports, it is clear that Visual studio dot net was the most preferred front end software used. Besides this few more front end tools like HTML based web designing software's, mobile based Android software and Java based software were used as front end. C# was also amongst the front end software used in the development of projects. Back End Used At back end most of the projects used Oracle database. With this few more databases like MS SQL Server, MySQL, MS Access, PostgreSQL, etc. were used at the back end. These databases were used for database projects which were the maximum projects. It is thus clear that databases used at the back end were the only back end software used. 94% 3% 0% 0% 0% 3% 0% Project Framework Dot Net Java C & C++ C# Android Web Based Other

Page | 87 Table 4.12: Ready Tools Used Sr. No. Tools Used Total Percentage 1 Matlab Nil 0 2 Weka Nil 0 3 Talend Nil 0 4 Rapid Miner Nil 0 5 Google Earth Nil 0 6 Other Nil 0 7 Total 0 0% Source:- Data collected from project reports From table 4.12 it is clear that not a single project used advanced software tool like Matlab, Weka, Talend, Rapid Miner, Google Earth, etc. for the development. It is thus interpreted that still new technology is not being implemented in the projects by the students. If it is used then by using different tools students can bring variety in their projects and improve their market value even the employability with higher remuneration can be expected if these ready tools are used. Table 4.13: Database Used Sr. No. Database Used Total Percentage 1 Oracle 314 62.8% 2 MySQL 57 11.4% 3 MS Access 10 2% 4 Excel Worksheet Nil 0 5 Other 119 23.8% 6 Total 500 100% Source:-Data collected from project reports

Page | 88 Majority of projects were database based projects. From data collected and depicted in table 4.12 it can be analyzed that 62.8% of projects used Oracle, 23.8% projects used other databases like PostgreSQL, MS SQL Server, etc. whereas 11.4% of projects used MySQL as the database. Chart 4.11: Database Used Inference:- It can be inferred from the table that, most of the projects used Oracle as the database. MySQL with other databases like MS SQL Server and PostgreSQL were amongst the other databases used by the students. It can thus be interpreted that Oracle is the most preferred database amongst students developing projects. 4.4 General Technical Questions In this section of the chapter, light is being thrown on different aspects of the project development like, preliminary investigation, feasibility study, system analysis, problem specification, system designed, charting down of design specifications, system development, system coding & testing, system implementation and system documentation. Al these aspects were observed in project reports submitted by the students as a part of their curriculum to the department library. 63% 11% 2% 0% 24% Database Used Oracle MySQL MS Access Excel Worksheet Other

Page | 89 Table 4.14: General Technical Information Sr. No. Questions Yes No Total Per. Total Per. 1 Whether preliminary investigation was done? 487 97.4% 13 2.6% 2 Whether feasibility study was performed? 479 95.8% 21 4.2% 3 Whether system analysis was done? 483 96.6% 17 3.4% 4 Whether problem specification was done? 492 98.4% 8 1.6% 5 Whether system was designed? 500 100% Nil 0 6 Whether design specifications were written down? 65 13% 435 87% 7 Whether system was developed? 500 100% Nil 0 8 Whether system was coded & tested? 134 26.8% 366 73.2% 9 Whether system was implemented? Nil 0% 500 100% 10 Whether system documented? Nil 0% 500 100% Source: Data collected from project reports Observations depicted in table 4.13 are regarding technical details of software development life cycle. From table 4.14 it is clear that 100% of projects were having system design and systems were developed whereas 100% of systems were not implemented as well as documented. In 97.4% of projects primary investigation was done, whereas 95.8% of project was found with feasibility study. In case of system analysis 96.6% projects were having that done as well as 98.4% of projects have done problem specifications. Only couple of parameters were there with less positive responses those were only 26.8% of project codes were tested and 13% of projects were having their design specification documented.

Page | 90 Chart 4.12: Preliminary Investigation Inference:- From chart 4.12 it can be interpreted that almost all the projects studied has done there preliminary investigation. This gives us an idea regarding the use of software development techniques by the students during their project development. Preliminary investigations give you insights about the project of whether it can be continued or not. Chart 4.12: Feasibility Study Inference:- From chart 4.12 it can be interpreted that majority of projects were with the feasibility study complete. This gives us knowledge about the details of project development 97% 3% Preliminary Investigation Yes No 96% 4% Feasibility Study Yes No

Page | 91 phases students had gone through and ultimately decide about going ahead with the project and completing it, homework on feasibility makes it realistic in implementations. Chart 4.12: System Analysis Inference:- Chart 4.12 portrays a picture about the system analysis that was done by most of the projects during their development by the students. This also can be interpreted that most of the students had analyzed their system during its development. It can be inferred that if the system analysis is undertaken it makes project work implementation without giving or creating obstacles in implementation. Chart 4.12: Problem Specification 97% 3% System Analysis Yes No 98% 2% Problem Specification Yes No

Page | 92 Inference:- Chart 4.12 helps in interpreting the data that almost all the projects had their problem specifications except few. This gives a clear picture about the development phases of the project those were taken care. If the obstacles are taken care by assessing them in advance then implementation of project becomes smooth. Chart 4.12: Design Specification Inference:- Chart 4.12 gives a negative picture about design specifications. It shows that almost all or most of the students missed to concentrate on design specifications. There are doubts raised here about the student‘s knowledge of software development life cycle. They all missed this phase. There is a role of guide that comes into picture as to why guide has not guided about this phase of the project development? System design in otherwords gives a blue print in the hands of researchers, hence if the design is specified in advance it reduces the obstacles and the possible bottlenecks which can arries during implementation of the project. 13% 87% Design Specifications Yes No

Page | 93 Chart 4.12: System Coding and Testing Inference:- Similarly chart 4.12 shows another negative picture about system coding and testing. This can be interpreted in a way that almost three quarter of the projects studied were not tested. Again questions are raised on the reliability of guidance and the work undertaken by researcher as this is one of the important aspect of project implementation. 4.5 Project Development There are some project development related steps like type of process model used for development of the project, type of testing of project done to improve the quality of project, type of cost estimation model used, development of presentation and report writing. There are some basic points associated with the fundamentals of programming like making of flow chart, use of algorithms, use of data flow diagram, use case diagram, entity relationship diagram, process diagram, etc. As a student they are required to perform some more tasks like calculated complexity of project, preparation of time line chart, plagiarism report and paper presented on the concerned topic. Table 4.15: Process Model Sr. No. Process Model Total Percentage 1 Incremental 102 20.4% 27% 73% System was Coded & Tested Yes No

Page | 94 2 RAD 18 3.6% 3 Spiral Nil 0 4 Waterfall 380 76% 5 CMM Nil 0 6 V Shaped SDLC Nil 0 7 Prototyping Nil 0 8 Agile Nil 0 9 Total 500 100% Source:-Data collected from project reports Table 4.15 shows that amongst the listed process models, 76% of projects were made using waterfall model with 20.4% projects using Incremental model and 3.6% of projects using Rapid Application Development (RAD). No other model was used by the students for developing projects. Chart 4.13: Process Model Inference:- It can be inferred from the above table that waterfall process model is mostly used by the students. There are other models like Incremental and RAD those are used, but agile model was not used in single project. This can be interpreted that agile model and new technological development is lacking terms of process model selection by the students. 20% 4% 76% Process Model Incremental RAD Spiral Waterfall CMM V Shaped SDLC Prototyping Agile

Page | 95 Variety in project will come only by using latest models with a certain degree of innovation even the present models can be customized for the application in new setting as per the requirement. Table 4.16: Testing Model Sr. No. Testing Model Total Percentage 1 Unit 23 4.6% 2 Integration Nil 0 3 System Nil 0 4 Acceptance Nil 0 5 Regression Nil 0 6 Black Box 32 6.4% 7 White Box 17 3.4% 8 Mutation Nil 0 9 Specification Based 62 12.4% 10 Boundary Value Analysis Nil 0 11 State Based Nil 0 12 Total 134 26.80% Source: Data collected from project reports Table 4.16 shows testing model used in project developments by different students. In all only 26.8% of students tested their projects using one of the model and rest 73.2% projects didn‘t used any testing model for testing their projects. When these projects were studied which tested using one of the testing model, it is observed that 12.4% of projects used specification based testing model, whereas 6.4% used black box testing and 4.6% used unit testing with 3.4% using white box testing.

Page | 96 Chart 4.14: Testing Model Inference:-From chart 4.14 it is clear that majority of projects tested using specification based testing. But this cannot be generalized that specification based testing is the most widely used techniques as majority of students had not tested their projects. Hence it can be interpreted that testing of software using one of the testing model is needed and students are needed to perform testing of their projects. This can give advantage to students for making it worth implementing and such projects will also be taken by the stakeholders as they find it feasible if the projects are tested and creates a confidence to implements it if taken by them. Table 4.17: Cost Estimation Model Sr. No. Cost Estimation Model Total Percentage 1 SLOC Nil 0 2 COCOMO 2 0.4% 3 CMM Nil 0 4 Others Nil 0 5 Total 2 0.4% Source:- Data collected from project reports As shown in table 4.17, only 0.4% of the projects estimated the cost of projects whereas all the projects missed cost estimation. The only 2 reports were with cost estimation 17% 0% 0% 0% 0% 24% 13% 0% 46% 0% 0% Testing Model Unit Integration System Acceptance Regression Black Box White Box Mutation Specification Based

Page | 97 done using COCOMO model. This is important because it becomes a ready to use product and can be commercially exploited as against these projects where estimated cost is not depicted and in order to do estimation and further work stakeholders may not be interested in its commercial exploitation. Table 4.18: Report Documentation Sr. No. Report Documentation Total Percentage 1 MS Word 500 100% 2 Adobe Acrobat Nil 0 3 Latex Nil 0 4

Others Nil 0 5 Total 500 100% Source: Data collected from project reports Table 4.18 shows all 100% projects used MS Word for documenting and thesis writing. Not a single project used any other software for reporting and documentation. Latest research software Latex was also not at all used by any of the students for reporting and documentation. Table 4.19: Presentation Developed Sr. No. Presentation Total Percentage 1 MS Power Point 500 100% 2 Adobe Acrobat Nil 0 3 Flash Nil 0 4 Others Nil 0 5 Total 500 100% Source: Data collected from project reports Table 4.19 shows that all 100% projects used MS Power Point for making their presentation. Not a single project used any other presentation software like flash for presentation. Latest research softwares like Flash, Acrobat, etc. were also not at all used by any of the students for

Page | 98 presentation work. If these presentation software's are used then it can present a different picture altogether. Table 4.20: Developmental Questions Sr. No. Presentation Total Percentage 1 Flow chart used 500 100% 2 Algorithm used 500 100% 3 Data flow diagram used 462 92.4% 4 Use case diagram used 500 100% 5 E-R diagram used 415 83% 6 Process diagram used 12 2.4% 7 Complexity of project calculated Nil 0 8 Time line chart used Nil 0 9 Plagiarism of report checked Nil 0 10 Paper on project presented 113 22.6% Source: Data collected from project reports On studying table 4.20 it is clear that all 100% of students used flowcharts and algorithms in their project reports. Even all 100% students made use case diagram whereas not a single project either calculated complexity of their project, neither used time line chart to represent different activities taking place at different time interval as well as no report used any tool to check the plagiarism of the textual content of the report. It can be inferred from the above table that feasibility of project implementation depends upon the time line proposed because some projects are to be completed in specified time as it can bring disadvantage to the stakeholders while implementing.

Page | 99 Chart 4.15: Data Flow Diagram From chart 4.15 it can be interpreted that almost all students used DFD's to explain the flow of project. Except few projects all the students used DFD i.e data flow diagram to show the flow of information in a particular project. Chart 4.15: Entity Relationship Diagram 92% 8% Use of Data flow diagram Yes No 83% 17% Use of E-R diagram Yes No

Page | 100 As majority of project were using databases at the back end, there needed Entity Relationship (ER) diagram to explain the distribution of tables and keys in those tables. Therefore as shown in chart 4.19 majority of 83% projects used ER diagram in their project reports. Chart 4.15: Process Diagram Chart 4.15 shows that almost all the projects except few has not at all used process diagram. They either missed the process diagram or they are not aware of the importance of the process diagram. This very crucial for the project implementation & feasibility. Chart 4.15: Research Paper 2% 98% Process diagram used Yes No 23% 77% Research Paper on Project Yes No

Page | 101 Chart 4.15 depicts around ¾ of the total number of students had not presented any technical paper in any level of journals, or seminars and conferences. This gives rise to speculations that the data collected and analyzed during the project development by the students may not be authentic hence the data and other related information is not tested,

neither plagiarism is checked nor paper ids published except by few students. It was observed that students finished projects first before final presentation in a way there was no sufficient time for the paper presentation & publication which can always be done after final examination anytime in future. 4.6 Miscellaneous Questions There were some general questions those were to be answered by observing the project report of the student. In all the answers were summarized and considering majority of responses the output is presented in the report. 1) Whether the report examined has all the components of SPM covered? List them. Almost all the reports observed as sample, covered majority of components of Software Project Management (SPM). There were some components those were missing from most of the project reports. The list of components present and absent from majority of reports is as given below. Components Present in reports Components Absent from reports Scope Statement Critical Success Factors Deliverables Human Resources Plan Work Breakdown Structure Stakeholder List Schedule Timeline Quality cost estimation Communication Risk Register

Page | 102 Procurement Plan 2) Whether the student had gone through all the points of SPM and implemented them in project? It has been observed from the survey study that the project evaluation process used by the Projects Guide and the Grade system used by the examiners are at par with the guidelines of the Savitribai Phule Pune University. 3) Whether the output is available in report showing completeness of project? It has been observed in almost all the reports that, the output of the project in the form of their forms, screens, output reports generated, etc. are available in the reports studied. 4) How many marks he secured in the project? This question gave us no response, as the students were not present at the time of survey or study. One more point was that their result or marks were not available on the report. 5) Any other observation you feel to address. It was analyzed that the changing trends, in adoption of Software Project Management Principles in Project Based Learning components of Computer Science Course. The quality of project is being seen improving by using SPM and other minutes while developing projects. However emphasis to make it feasible to accept by the stakeholders in the market should be stressed upon user by the credibility of Institutions and the university at large will automatically increase.

Page | 103 4.7 Hypothesis Testing Hypothesis No. ( I ) Z- Test (I) Employment Status of Learners with Respect to Software Project Management of M.Sc. Program of Computer Science. Hence by Applying Z - test H 0 The Proportion of employability of Learner is 80%. H 1 The Proportion of employability of Learner is greater than 80%. Table 4.21: Employment Status Employed % Unemployed % 1 Employment Status 402 80.4 98 19.6 Table 4.22: Z-test for Employment Status Z-test Test of p = 0.80 vs p < 0.80 at 95% i.e. Sample X N Sample p P-Value 1 402 500 0.804 0.438 We observed that p=0.438< α (level of significance =5%). Hence we accept Ho. i.e. The Proportion of Employability of Learner is 80%. Hypothesis No. ( II ) H 0 There is no significant difference between using agile and RAD methodology for software project development. H 2 There is significant difference between using agile and RAD methodology for software project development. Table 4.23: Process model used for Software Development Process Model Used No. Students Total % 1 RAD 18 500 3.6 2 Agile Nil 500 Table 4.23: Z-test of Process model used for Software Development

Page | 104 Z-test Test of p = 0.06 vs. p > 0.06 at 95% i.e. Sample X N Sample p P-Value 1 18 500 0.036 0.011 We observed that p=0.011> α (level of significance =5%). Hence, We Reject H 0 . i.e. There is no significant difference between using agile and RAD methodology for software project development. From the above result we concludes that no college/Institute is using agile development methodology for software project development, where as it was found that nearly 4% college/institute is using RAD methodology. Finally we conclude that by rejecting Null Hypothesis and Accept Alternative Hypothesis —There is significant difference between using Agile and RAD methodology for software project development||.

Page | 105 Chapter 5 Findings, Conclusions and Suggestions 5.1 Introduction 5.2 Findings 5.3 Conclusions 5.4 Suggestions

Page | 106 Chapter 5 Findings, Conclusions and Suggestions 5.1 Introduction This chapter gives findings, conclusion and suggestion of the study. The analysis of data collected from survey of project reports of students from different colleges in Savitribai Phule Pune University was done to know the productivity of project in terms of academically and individually. Data was collected from reports of students who have cleared their masters in computer science. The reports were studied for the different parameters. The sections in this chapter give the discussion on findings conclusion and suggestions on the findings. 5.2 Findings 1. As per table 4.1 it is clear that around 54.6% of students who has developed and submitted project reports are males whereas 45.4% of them are females. 2. The data collected gives the information about the study of reports from selected colleges by the way of random sampling in different years from year 2012-13 to 2016-17 as depicted in table 4.2. It is nearly 20% sample from each year was selected for the study with little variations. 3. From table 4.4 is clear that around 65.4% of students worked alone on their project whereas 34.6% students worked in group. This ratio belongs to both males and females students combined. 4. Table 4.4 gives the data regarding the employment status of the student. It is observed that 80.4% of the students are employed whereas 19.6% are unemployed. 5. It has been observed from table 4.5 that not a single project was having guide from industries or public sector or research background. All the guides were from academics.

Page | 107 6. From table 4.6 it becomes clear that 28.57% of guides are doctorate, 54.76% are post graduate whereas 16.67% are graduate in their qualification. This table gives us knowledge to know the capability of guides for the project development. 7. On asking question regarding experience of guides, the responses received are shown in table 4.7. The table shows that around 57.14% of guides were having experience between 5yrs to 10yrs where as 14.29% of them were having experience above 10yrs. In all around 85.71% of all guides were having experience above 5yrs. 8. Table 4.8 shows 75.4% of projects were sponsored, 21.2% of projects were regular whereas 3.4% of projects were of research level. It is clear from statistics that around 79% of projects were having some commercial value. This also gives us information about the practical approach of projects students are developing. 9. From table 4.9 it is observed that 76.2% of project domain was based on database whereas 19.6% of project domain was application based. There were other domains like security with 2.4%, database with 1.4% and security with 0.4%. Not a single system level project has been observed during the study. 10. Table 4.10 shows statistics that 99.4% of projects were using

MS Windows platform for developing their projects where as minute that is 0.4% of projects were android based. 11. From table 4.11 it can be analyzed that 93.6% of projects were developed on dot net framework whereas 3% were web based. Around 2.6% were using Java and few projects i.e. 0.4% were using C# and Android. 12. From table 4.12 it is clear that not a single project used advanced software tool like Matlab, Weka, Talend, Rapid Miner, Google Earth, etc. for the development. 13. Majority of projects were database based projects. From data collected and depicted in table 4.13 it can be analyzed that 62.8% of projects used Oracle, 23.8% projects used other databases like PostgreSQL, MS SQL Server, etc. whereas 11.4% of projects used MySQL as the database. 14. From table 4.14 it is clear that 100% of projects were having system design and systems were developed whereas 100% of systems were not implemented as well as documented. 15. In 97.4% of projects primary investigation was done, whereas 95.8% of project was found with feasibility study. In case of system analysis 96.6% projects were having that done as well as 98.4% of projects have done problem specifications. Only couple

Page | 108 of parameters were there with less positive responses those were only 26.8% of project codes were tested and 13% of projects were having their design specification documented. 16. Table 4.15 shows that amongst the listed process models, 76% of projects were made using waterfall model with 20.4% projects using Incremental model and 3.6% of projects using Rapid Application Development (RAD). 17. Table 4.16 shows testing model used in project developments by different students. In all only 26.8% of students tested their projects using one of the model and rest 73.2% projects didn't used any testing model neither they tested their projects. 18. As shown in table 4.17, only 0.4% of the projects estimated the cost of projects whereas all the projects missed cost estimation. The only 2 reports were with cost estimation done using COCOMO model. 19. Table 4.18 shows all 100% projects used MS Word for documenting and thesis writing. 20. Table 4.19 shows that all 100% projects used MS Power Point for making their presentation. 21. On studying table 4.19 it is clear that all 100% of students used flowcharts and algorithms in their project reports. 22. 100% students made use case diagram whereas not a single project either calculated complexity of their project, neither used time line chart to represent different activities taking place at different time interval as well as no report used any tool to check the plagiarism of the textual content of the report. 23. Almost all the reports observed as sample, covered majority of components of Software Project Management (SPM). 24. It has been observed from the survey study that the project evaluation process used by the Projects Guide and the Grade system used by the examiners are at par with the guidelines of the Savitribai Phule Pune University. 25. It has been observed in almost all the reports that, the output of the project in the form of their forms, screens, output reports generated, etc. are available in the reports studied. 26. It was analyzed that the changing trends is, in adoption of Software Project Management Principles in Project Based Learning components of Computer Science

Page | 109 Course. The quality of project is being seen improving by using SPM and other minutes while developing projects. 5.3 Conclusion 1. Changing trends is, in adoption of Software Project Management Principles in Project Based Learning components of Computer Science Course. 2. The quality of project is being seen improving by using SPM and other minutes while developing projects. 3. Almost all guides were capable of guiding the students.

Majority of guides were experienced in handling the projects. 4. Students preferred to do the project alone and hence it was seen they had inclination towards database projects and only few projects were found to be commercially liable. 5. Oracle was found to be most preferred database amongst students and it was found students undertaking projects with primary investigation. 6. It was found that students were using dot net framework and platform like Linux and Matlab tool were not at all preferred. 7. The adoption of new technology for project development was not done and is one of the main reasons for projects not being tested. 8. Cent present project didn't calculate their cost and due to which only general feasibility of project was assessed and the study was undertaken. 9. Almost all the projects had their problem specifications except few. This gives a clear picture about the development phases of the project those were taken care. 10. Waterfall process model is mostly used by the students. There are other models like Incremental and RAD those are used.Agile model was not used in single project means new technological development is lacking in terms of process model selection by the students. 11. Majority of projects were tested using specification based testing. But this cannot be generalized that specification based testing is the most widely used techniques as majority of students had not tested their projects.

Page | 110 5.4 Suggestions 1. Few project guides should be from industries with R & D background to get practical exposure to students and their project. 2. System level project has to be given some weightage. 3. Advanced software tool like Matlab, Weka, Talend, Rapid Miner, Google Earth, etc. should be used for the development. 4. Students should test their projects using any one of the testing models. 5. Projects cost estimation should be done by using available tools. 6. Students should use advance presentation software like flash for making project presentation. 7. Students should calculate complexity of their project and use time line chart to represent different activities taking place at different time interval.

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1 95%

While the curriculum may scaffold development of students' capacity to undertake projects through project based learning and work integrated learning, the

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While the curriculum may scaffold development of students' capacity to

undertake projects through project based learning (PBL) and work integrated learning (WIL), the

2 96%

represents a major extension of expectations regarding a student's capacity to conduct a project. Some guidance for students is appropriate, but too much support will hamper the student's capacity to deal with complex, real-life professional projects. In identifying resources that can be made available to help students manage their projects, questions about the appropriate balance between support and exposure to real-life complexity need to be addressed. Student guidelines and resources will be produced and tested [7] . 1.10

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represents a major extension of expectations regarding a student's capacity to conduct a project.

Some guidance for students is appropriate, but too much support will fail to extend the student's

capacity to deal with complex, real-life professional projects. In identifying resources that can be made

available to help students manage their projects, questions about the appropriate balance between

support and exposure to real-life complexity need to be addressed. Student guidelines and resources

will be produced and tested.

3 100%

Final year project assessment is particularly vulnerable to variation in the quality of supervision because a large number of projects need supervision each year requiring many academics, each of whom may advise students differently about project expectations. Identification and description of good practice would provide academic supervisors with resources for induction and staff development. Guidelines are required to ensure appropriate, consistent support. Students should also be provided with clear expectations about appropriate supervision so they can respond more constructively when expected support is not provided. 1.11

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20

4 98%

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20

5 95%

Many involve industry-based projects in which the industry client's expectations about project outcomes may not align well with the requirements for education and assessment. Industry projects may also involve intellectual property and confidentiality issues that require sound guidelines. Authoritative explanatory guidelines would assist industry partners to understand the educational context and expectations of student's projects. The kind of project a student selects can influence a student's grade. Routine projects may not provide scope for students to demonstrate high levels of professional capability and obtain a high grade. There is debate about what kinds of

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Many FYEPs involve industry-based projects in

which the industry client's expectations about project outcomes may not align well with the

requirements for education and assessment. Industry projects may also involve intellectual property

and confidentiality issues that require sound guidelines. Authoritative explanatory guidelines would

assist industry partners to understand the educational context and expectations of FYEPs.

Selection of Projects: The kind of project a student selects can influence a student's grade. Routine

projects may not provide scope for students to demonstrate high levels of professional capability and

obtain a high grade. There is debate about what kinds of

6 100%

is an extended report or portfolio. It is important that students receive clear advice about requirements, and receive an appropriate level of support in preparing their reports because the

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support in preparing their reports because the

7 87%

report will usually be the first extended report students have prepared. If project assessment is based on report moderation, supervisors and moderators also need shared expectations for assessment, and supervisors must advise students of these expectations. 1.13

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report will usually be the first extended report

students have prepared. If project assessment is based on report moderation (i.e. only on the evidence

presented in the report), supervisors and moderators also need shared expectations for assessment, and

supervisors must advise students of these expectations.

8 100%

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supervisor‘s report, technical report, design portfolio, journal, poster, oral presentations, weightings for technical quality

supervising_and_assessing_final_year_engineering_projects
100%

supervisor’s report,

technical report, design portfolio, journal, poster, oral presentations, weightings for technical quality

9 100%

and communication, etc. The criteria for grading projects use various rubrics that influence assessment and benchmarking processes. A particular issue in assessment is the relative emphasis placed on the product or outcome of the project on the one hand, and on each student‘s thinking, decision-making, management and investigation processes that guided the project on the other. 1.15

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100%

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placed on the product or outcome of the project on the one hand, and on each student’s thinking,

decision-making, management and investigation processes that guided the project on the other.

10 73%

project course coordinators and project supervisors as they are under time pressures, and in isolation from practice at other universities.

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Project course coordinators and project supervisors work in difficult contexts, under time pressures,

and in isolation from practice at other universities.

11 100%

are important vehicles for assessing the capabilities of graduating students and for evaluating program standards. It is critical that teaching and assessment practices are efficient, fair, reliable and valid.

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are

important vehicles for assessing the capabilities of graduating students and for evaluating program

standards, it is critical that teaching and assessment practices are efficient, fair, reliable and valid.

12 90%

intention was to begin to develop good practice guidelines and resources to assist students, supervisors, coordinators and industry partners, and to make these available to the

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intention

community. They intended to stimulate interest in the issues already identified, and to inform the education community of the developments.

is to begin to develop good practice guidelines and resources to assist students, supervisors,

coordinators and industry partners, and to make these available to the community. This paper is

intended to stimulate interest in the issues already identified, and to inform the engineering education

community of the developments.

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