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Draft Version

Impact of COVID-19 on the Factors Influencing On-Time Software Project Delivery: An Empirical Study

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Keywords: Empirical Study, COVID-19, Factors, On-Time Software Delivery, SDLC Models

Abstract: The objective of this research paper is to investigate the impact of COVID-19 on the factors influencing on-time software project delivery in different Software Development Life Cycle (SDLC) models such as Agile, Incremental, Waterfall, and Prototype models. Also to identify the change of crucial factors with respect to different demographic information that influences on-time software project delivery. This study has been conducted using a quantitative approach. We surveyed Software Developers, Project Managers, Software Architect, QA Engineer and other roles using a Google form. Python has been used for data analysis purposes. We received 72 responses from 11 different software companies of Bangladesh, based on that we find that Attentional Focus, Team Stability, Communication, Team Maturity, and User Involvement are the most important factors for on-time software project delivery in different SDLC models during COVID-19. On the contrary, before COVID-19 Team Capabilities, Infrastructure, Team Commitment, Team Stability and Team Maturity are found as the most crucial factors. Team Maturity and Team Stability are found as common important factors for both before and during the COVID-19 scenario. We also identified the change in the impact level of factors with respect to demographic information such as experience, company size, and different SDLC models used by participants. Attentional focus is the most important factor for experienced developers while for freshers all factors are almost equally important. This study finds that there is a significant change among factors for on-time software project delivery before and during the COVID-19 scenario.

1 INTRODUCTION

One of the main reasons for software project failure is not choosing the proper methodologies. There are many Software Development Life Cycle (SDLC) models such as Waterfall, Agile, Incremental, Prototype, Spiral, etc. Software companies follow different SDLC models according to their needs and project requirements. Cost overrun and on-time delivery is a major issue in the software industry and the success of a project depends on them (Chow and Cao, 2008). Effort estimation is crucial for any software project since it helps to deliver on time with the defined constraints (Jørgensen, 2004). This study investigates the impact of the COVID-19 pandemic on the crucial factors that impact on-time software project delivery in different SDLC models and how the level of impact of these factors shifted with respect to different demographic information such as company size, developers' years of experience and different SDLC models used software professionals.

Covid 19 pandemic has impacted everything including the software development paradigm. It was a challenge for the team to interact properly although online platforms such as Google meet, Zoom, and other platforms made the interaction possible but it was not quite smooth. Several factors impact on-time delivery (Kula et al., 2021) and during the pandemic, these factors might be changed to different degrees. We investigated the research gap and found that no study has yet been conducted that describes how the important factors of on-time delivery have changed over time, especially during COVID-19 in different SDLC models. This has motivated us to conduct this research study and measure the impact of COVID-19 on-time software project delivery in different SDLC models. Previous studies were mostly Agile model related therefore we cover different SDLC models in this study. In another previous study, the success fac-

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tors are stated (Tam et al., 2020) for Agile software development but it is not determined how these factors influence on-time software delivery.

The main contributions of this paper are:

- An overview of the impact of COVID-19 on-time software project delivery in different SDLC models.
- Identification of the top factors which are responsible for on-time software project delivery in different SDLC models before and during COVID-19.
- Identification the change of impact level of important factors for on-time software project delivery with respect to different demographic information.

The rest of this paper is structured as follows. Related works have been described in Section 2. In Section 3 research survey design has been explained. Detailed survey results have been presented in section 4. Finally, conclusions have been discussed in section 5.

2 RELATED WORKS

(Chiyangwa and Mnkandla, 2017) investigated the critical success factors (CSFs) of the Agile software development model and found six different CSFs. (Dhir et al., 2019) investigated both success and failure factors that impact project Implementation using Agile methods. (Ram et al., 2019) surveyed two software companies through semi-structured interviews for evaluating process metrics in Agile software development. (Ghayyur et al., 2018) reviewed previous studies and extracted 25 common motivators and 14 common demotivators factors. (Srivastava et al., 2020) evaluated the Agile success factors.

(Marques et al., 2017) found that most of the failure factors had a direct impact on the project delivery. (Butt and Jamal, 2017) found that frequent request changes made by clients have a negative effect on on-time delivery and cost. (Bergmann and Karwowski, 2018) reviewed the previous studies and divided project success factors into 6 main categories such as management, process, project, organizational, people, and technical factors. (Hujainah et al., 2018) performed a systematic literature review to understand and list newly developed Requirement Prioritization techniques. (Edison et al., 2021) investigated how the implementation of a hybrid methodology will enhance software project success and found hybrid models are flexible and adaptable. This study (Hussain et al., 2018) identified five motivator factors for Agile adoption. (Kamal et al., 2020) explained the benefits of Agile methods. (Arcos-Medina and Mauricio, 2019) did a systematic literature review on different SDLC models and discussed pros and cons of each methods.

3 RESEARCH DESIGN

This research work is designed through the study of various previous research papers. This helped us to identify the research gap and design the research questionnaires for this study. Previous studies focused particularly on Agile software development. After identifying the research gap, in this study, we explored how different factors affect on-time software delivery in different SDLC models over the time, especially during COVID-19.

3.1 Purpose of the Study

The purpose of this study is to analyze and quantify the effects of the COVID-19 pandemic and other variables on the timely completion of software projects in different SDLC models. In this study, we focused on the following research questions (RQs) and these questions have been adopted from this (Kula et al., 2021) study, we have modified the questions with the concept of COVID-19.

- **RQ1**: How much does each of the following factors influence on-time software project delivery [Before and During COVID-19] ?
- **RQ2**: Do any other factors or certain types of circumstances, need to be added to ensure on-time software project delivery?

There were 25 questions under RQ1 adopted from (Kula et al., 2021; Tam et al., 2020; Chiyangwa and Mnkandla, 2017).

- **DQ1**: Which of the following best describes your role at your company?
- **DQ2**: How many years of work experience do you have in the software development industry?
- **DQ3**: What is the size of your company?
- **DQ4**: Which software development life cycle model has been practiced or followed by you ?

3.2 Research Method

This research study was conducted on different IT professionals such as Project Manager, Software Developer, Software Architect, QA Engineer, DevOps from 11 different software companies in Bangladesh.

An extensive literature review was performed before conducting this research study which helped us to get a solid idea about the topic and identify research gap. In this study, quantitative method in 4 point likert scale format has been used to collect data (Harpe, 2015). Python has been used in data analysis step. We studied the previous literature (Laitinen, 2018) and found that Net Promoter Score (NPS) is a metric which is used to measure how likely people suggest a thing to others. In this study, NPS along with mode and mean have been calculated. The methodology in Figure 1, represents the flow of research method that was developed in four stages: Research Design, Data Collection, Data Analysis and Final Result.

3.3 Data Collection Method

In this study, purposive sampling methods were used. IT professionals who were involved in the software project deliverable were included in the sample's inclusion criteria. The individuals who possessed primary features for selection criteria were filtered and addressed with proper instructions. The questionnaires were organized in two sections that addressed the demographics and factors impacting on-time software project delivery before and during Covid-19 pandemic.

Most of the questions were designed as close-ended in a 4-point Likert scale format such as no impact, small, moderate, and large impact. The factors were presented in a random order to the survey participants to reduce ordering bias and a short description was included to explain the factors to participants. After the design of questionnaires and selection of participants, a pilot test was conducted before the initiation of the data collection process. It ensured that the interview questions were understandable to the IT professionals. Therefore, after the successful identification of misinterpretations and corrections of questions in the pilot test, quantitative data collection was initiated via Google form.

3.4 Data Analysis Method

After the completion of the data collection phase, an in-depth data analysis was performed using Python. Then, different statistical parameters such as NPS, Mode, Mean were calculated. NPS calculation allows to determine the most impactful factors while the calculation of Mode help to identify the central tendency. The factors were assessed from the obtained data where respondents revealed their approach to software deliverables before and during COVID-19 and their correlation with on-time software project delivery. As a result, taking these factors into account improved the generalizability of the findings.

4 RESULT AND ANALYSIS

In this study, 72 responses have been received from different roles such as Software Developer, Software Architect, Project Manager, QA Engineer, DevOps, etc from 11 different software companies in Bangladesh. In this section, we will describe the findings of this study regarding the impact of COVID-19 on-time software project delivery and the change of impact level of factors with respect to different parameters.

4.1 Demographics

Role: The survey participants were asked questions regarding their role in the software company. question DQ1 make sure that the participants are in the target population. Figure 2 depicts the role of the respondents in the software company. People working in different roles at software companies participated in this survey. The majority of the respondents were Software Developers and Project Managers. Software Architects, QA Engineers, and DevOps also participated in this survey as all of them play a role in on-time software delivery.

Work Experience in Software Industry: Work experience in the software industry is important demographic information for our study. We asked question DQ2 which reveals the work experience of participants. Results are shown in figure 3, most of the participants in this study have a software industry experience of one to five years while the least of participants have ten to twenty years of industry experience.

Company Size: Question DQ3 had been asked to the participants to know the software company size. In this study, we find that the level of impact of factors for on-time software project delivery changes with respect to company size which has been described in detail later. Figure 4 shows the company size of the survey respondents.

Use of Software Development Life Cycle (SDLC) models: We asked participants question DQ4 to know about their followed SDLC models during software developments. Participants in this study responded that they follow mainly four SDLC models Agile, Incremental, Waterfall and Prototype Models. Results shown in figure 5 describe the use of SDLC models by survey participants. The Agile model is followed by most of the participants while the Prototype model is practiced or followed by the least of the

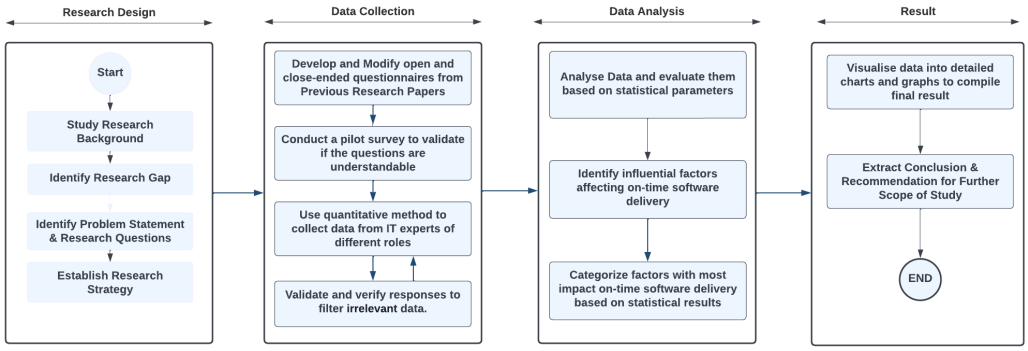


Figure 1: Research Methodology

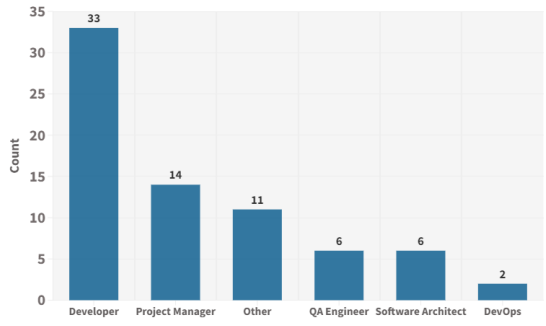


Figure 2: Survey Respondents' Role in the Software Company

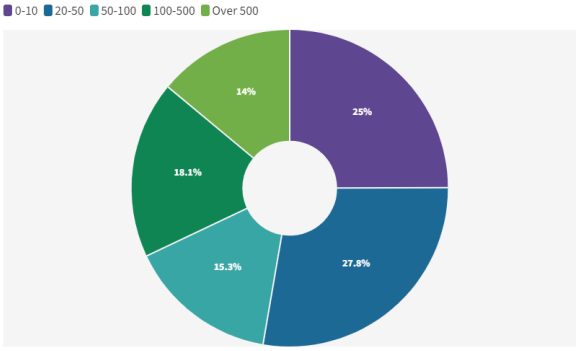


Figure 4: Survey Respondents' Company Size

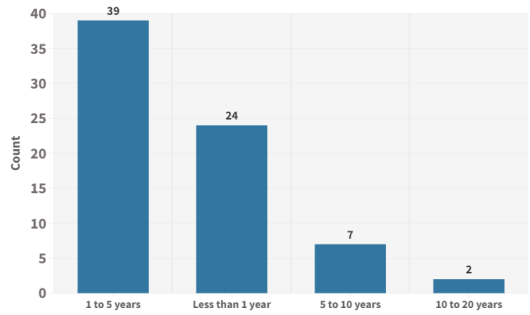


Figure 3: Survey Respondents' Work Experience in the Software Industry

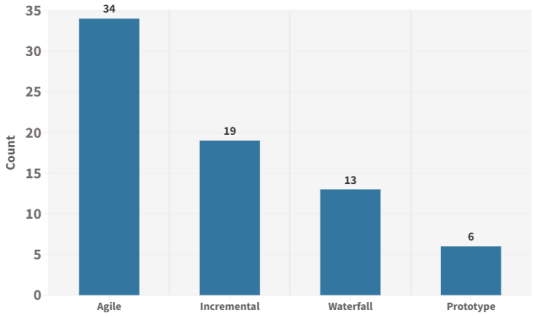


Figure 5: Use of SDLC Models by Survey Respondents

participants during software development.

4.2 Impact of COVID-19 On-Time Software Project Delivery

In this research survey, we identified the top factors which influenced on-time software delivery before and during COVID-19. Data have been collected on a 4-point Likert scale. In this study, the collected data have been mapped using table 1. Quantitative analysis has been applied to the survey data based on the mapping. We identified the top factors that impact on-time software project delivery during and before COVID-19. We also identified changes in the level of impact of factors with respect to different parameters such as respondents' company size and software industry experience. Net Promoter Score (NPS) has been used to identify the top factors (Laitinen, 2018). Mode and Mean are also calculated.

NPS = (Count of Promoters - Count of Detractors) / Total Participants

Influential Factors for On-Time Software Project Delivery During COVID-19: Figure 6 represents identified top 5 factors during COVID-19 that have the highest NPS which means they have the

Table 1: Likert Scale Data Mapping

Text Rating	Quantitative Rating	Type
No Impact	1	Detractors
Small Impact	3	Neutral
Medium Impact	5	Neutral
Large Impact	7	Promoters

highest impact or influence on-time software project delivery during COVID-19 according to survey participants. The mode and mean of those factors have also been calculated. Attentional focus was the most influential factor for on-time software project delivery during COVID-19. Team Stability, Communication, Team Maturity, and User Involvement were also significant factors for on-time software project delivery respectively. The identified factors are described below.

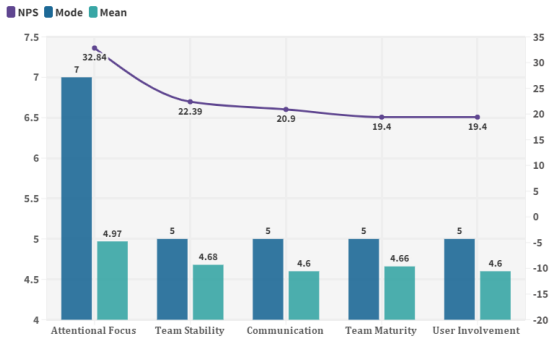


Figure 6: Top Five Factors for On-Time Software Project Delivery During COVID-19

Attentional Focus: In software development, Attentional Focus is an essential key element to accomplish the assigned task. Attentional Focus is to concentrate dedicatedly on a specific task or increased focus on a specific task which helps to achieve the task. Our findings in figure 6 from this study indicate that the most important factor impacting on-time software project delivery is Attentional Focus.

Team Stability: In software development, Team Stability is a major factor for a company's success as well as to deliver software projects timely to the clients (Dönmez et al., 2016). Results of this study are presented in figure 6 where team stability has been deemed as the second most important factor.

Communication: In software development, proper communication is a major criteria to understand the user requirements and deliver quality software products(Rasheed et al., 2021). Figure 6 shows that Communication is perceived as the third most important factor for on-time software project delivery during COVID-19.

Team Maturity: Team Maturity or Group Maturity is significant for the efficiency of the software development team (Ramírez-Mora et al., 2020). Figure 6 demonstrates that during COVID-19, Team Maturity was considered as the fourth most crucial factor for timely software project delivery.

User Involvement: In software development, User Involvement is a key factor for successful project completion (Bano et al., 2018). User Involvement helps to understand the user requirements and deliver proper software products which eventually leads to user satisfaction.

Influential Factors for On-Time Software Project Delivery Before COVID-19: In this survey, we also investigated the influential factors which were responsible for on-time software project delivery before COVID-19. The higher NPS value of a factor means the higher impact of that factor on-time software project delivery according to survey participants who were Software Developers, Software Architects, Project Managers, QA Engineers, and DevOps. Figure 7 represents the top five factors that have the highest impact on-time software project delivery before COVID-19, they are Team Capabilities, Infrastructure, Team Commitment, Team Stability, and Team Maturity. Team Stability and Team Maturity are found as common important factors both before and during COVID-19.

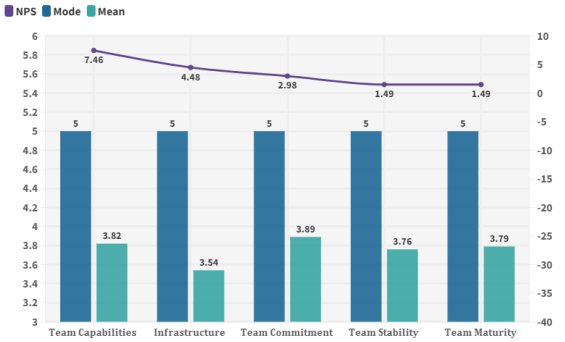


Figure 7: Top Five Factors for On-Time Software Project Delivery Before Covid-19

Team Capabilities: In software development, Team Capabilities is the expertise or skills of the software development team's members which is a crucial factor for successful project delivery (Vishnubhotla et al., 2018). In this survey we find Team Capabilities was the most important factor for on-time software project delivery before COVID-19. Results are shown in figure 7.

Infrastructure: Infrastructure is essential for software development, testing, and maintenance. Unavailability of Infrastructure leads to late delivery of software projects to the clients(Harter and Slaughter,

2003). Figure 7 shows that Infrastructure was a major factor for on-time software project delivery before COVID-19.

Team Commitment: Team Commitment is the dedication of the team member to the timely delivery of the product and their concentration on attaining the team's goal. Team Commitment is an important factor for on-time delivery (Moe et al., 2009). In this survey, Team commitment is also found as a major factor for on-time delivery of the software project before COVID-19 as shown in figure 7.

Comparison of factors before & during COVID-19: The comparison in table 2 shows that during COVID-19 the most important factor for on-time project delivery was Attentional Focus while before COVID-19 Team Capabilities was the most important factor. Team Stability and Team Maturity were important for on-time software project delivery both before and during COVID-19. The results are shown in Table 2 and it is clear that there is a change of factors that are responsible for on-time software project delivery during and before COVID-19. Before COVID-19 most important factors were Team Capabilities, Infrastructure and Team Commitment. Whereas during COVID-19, these factors did not play any significant role.

Table 2: Comparison of factors before and during COVID-19

Top 5 factors during COVID-19				Top 5 factors before COVID-19			
Factors	Mode	Mean	NPS	Factors	Mode	Mean	NPS
Attentional Focus	7	4.97	32.84	Team Capabilities	5	3.82	7.46
Team Stability	5	4.68	22.39	Infrastructure	5	3.54	4.48
Communication	5	4.6	20.9	Team Commitment	5	3.89	2.98
Team Maturity	5	4.66	19.4	Team Stability	5	3.76	1.49
User Involvement	5	4.58	19.4	Team Maturity	5	3.79	1.49

Change of Impact Level of Factors with Respect to Employee Experience: We have already identified the top five factors for on-time software project delivery both before and during COVID-19. In the second level of analysis, we investigated how the impact level of these identified factors changes with respect to different demographic information. The Mode has almost same value for factors and NPS has already been calculated to determine the factors. In the second level of analysis, The Mean value of these factors with respect to employee experience and company size has been calculated and presented in figure 8,9,10, and 11 respectively.

Figure 8 depicts change of impact level of identified top factors with respect to software professionals' experience during COVID-19. These factors do not have the same level of impact on the different levels of experienced people. In figure 8, results show that more experienced software professionals (5-10 years of experience) voted for Attentional Focus more. For fresh graduates or software professionals (0-1 years of experience) all the factors have a similar type of impact.

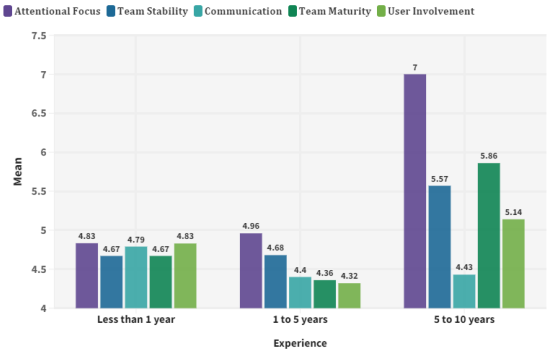


Figure 8: Change of Impact Level of Factors with Respect to Professionals' Experience

In figure 9, two patterns or trends of factors with respect to software professionals' experience have been presented. There are two figures side by side in figure 9 where the left figure shows that Attentional Focus and Team Stability are increasing as experience increases. This means that these two factors were more significant during COVID-19 for experienced software professionals compared to less experienced software professionals for delivering software projects timely. On the other hand, the right figure shows that Communication, Team Maturity, and User Involvement have dropped for 1 to 5 years of experienced software professionals but increased again for 5 to 10 years of experienced software professionals.

Change of Impact Level of Factors with Respect to Company Size: In figure 10, results show that more emphasis is placed on Attentional Focus in large software companies. However, Team Stability becomes more crucial in mid-sized (100-500) companies. Figure 11 shows that the trend of all the factors upward for large software companies (Over 500).

Change of Impact Level of Factors with Respect to different SDLC Models: In this study, we find that the impact level of factors is not the same in different SDLC models. Figure 12 shows that Attentional Focus and Team Maturity were most significant for Agile practitioners during COVID-19. For Waterfall practitioners, User Involvement was less significant and this is perceptible as in the waterfall model requirements are defined at the beginning, and in the whole development process, users do not get involvement.

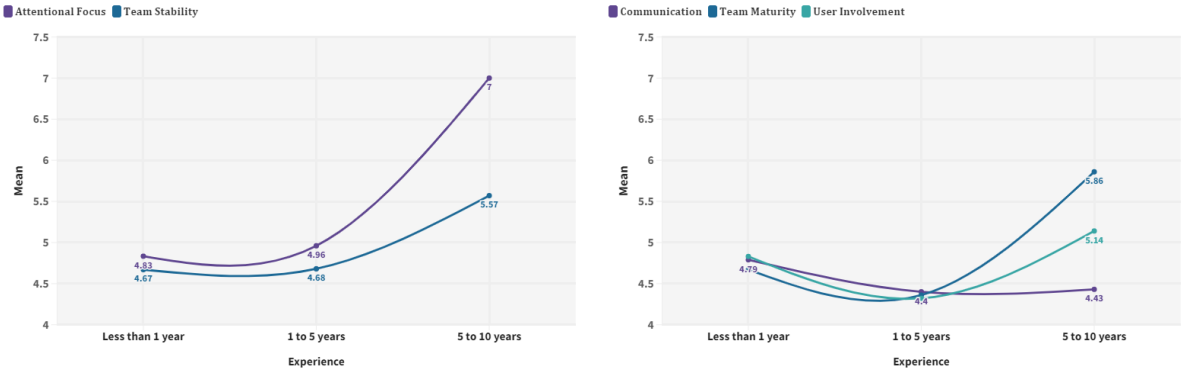


Figure 9: Change of Impact Level of Factors with Respect to Professionals' Experience

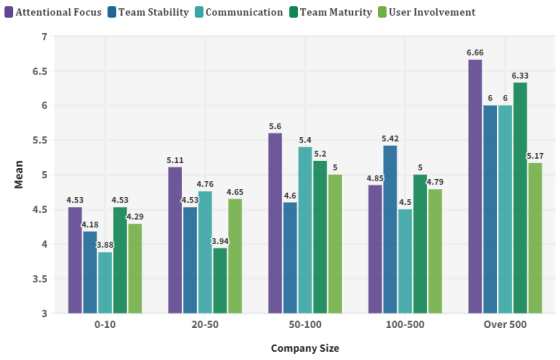


Figure 10: Change of Impact Level of Factors with Respect to Company Size

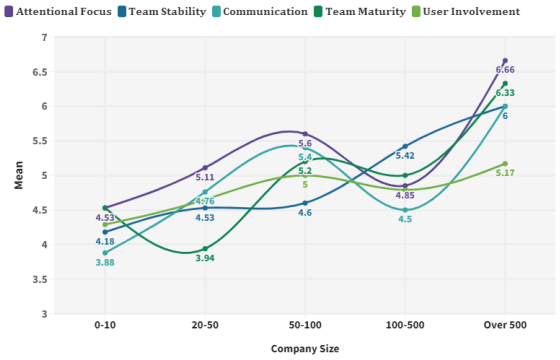


Figure 11: Change of Impact Level of Factors with Respect to Company Size

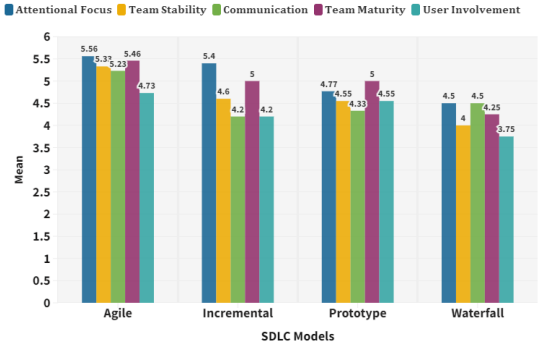


Figure 12: Change of Impact Level of Factors with Respect to different SDLC

5 Conclusion

In this paper, we investigated the impact of COVID-19 on the factors which are influencing on-time software project delivery. For our inquiry, we used quantitative methods. Based on 72 responses from 11 different software companies of Bangladesh, we conclude that User Involvement, Attentional Focus, Team Stability, Communication, and Team Maturity were the most important factors for on-time software project delivery in during COVID-19. On the contrary, Team Capabilities, Infrastructure, Team Commitment, Team Stability, and Team Maturity were the most important factors prior to COVID-19.

Team Stability and Team Maturity found as common factors both before and during COVID-19. We also looked into the impact level change of these identified factors with respect to company size, software professionals' experience and use of SDLC models by software professionals. For experienced developers, Attentional Focus was found as the most significant factor, however, for new developers, all factors are almost equally important. For large software companies, Attentional Focus was crucial whereas Team Stability for mid-sized software companies. Attentional Focus and Team Maturity were most crucial for the developers who follow Agile. On the other hand, as requirements are established at the beginning of the waterfall model and users are not involved during the entire development process, user engagement was less important in the Waterfall development. This study will help software companies to make strategic decisions regarding on-time software project delivery based on the crucial identified factors. Collecting data from software professionals was the greatest challenge in this study. Therefore, conducting this

study on a large population in the future will help to reveal more insights.

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