ELEKTROTEHNIŠKI VESTNIK 90(4): 191-198, 2023
ORIGINAL SCIENTIFIC PAPER

Impact of the Student Syndrome on the project completion time

Tomaž Aljaž

Fakulteta za industrijski inženiring, Šegova ulica 112, 8000 Novo mesto, Slovenija
E-pošta: tomaz.aljaz@fini-unm.si

Abstract. Improving the competitive advantage in the global marketplace is one of the major goals of any organization where the development of the information technology and associated services plays a significant role. Today, many improvements and optimization initiatives are managed through information technology projects, thus relying on the success of the projects to reach the goal. One of the most important aspects of the project management in the information technology is the uncertainty in estimating the duration of activities that usually require the involvement of human resources who are rarely working on a single task. In this situation, the human behavior can have a major negative effect on both the duration and cost of a project if inadequately managed. One area of the human behavior is called the Student Syndrome which is a phenomenon where doing things is delayed until right before the deadline.

In an information technology project this means that programmers postpone their project tasks until the deadline, while before it they work at a very relaxed pace with lots of slack and think there is enough time for doing other things. As a result, they simply waste the time required to solve uncertainties that might impact the project work.

The study analyzes and quantifies the impact of Student Syndrome on a single project completion time using a simulation-based approach. It provides an insight to be considered by the project manager to ensure the project to succeed. The impact of Student Syndrome is explained by analyzing the project networks. Simulations show that eliminating the Student Syndrome considerably and immediately positively effects the project completion time shortening it by up to 35 percent compared to the situations with the Student Syndrome.

Keywords: Project management, Student Syndrome, Human behavior, Discrete Event Simulation, Constraint Management

Vpliv študentskega sindroma na zaključevanje projektov

Izboljšanje konkurenčne prednosti v sedanjem poslovnem svetu je eden izmed temeljnih ciljev vsake organizacije, pri čemer ima razvoj informacijske tehnologije in z njo povezanih storitev pomembno vlogo. Danes se številne izboljšave in pobude za optimizacijo upravljajo prek projektov, ki uporabljajo moderne rešitve s področja informacijske (komunikacijske) tehnologije, s čimer je doseganje tega cilja odvisno od uspešnosti zaključevanja projektov. Eden od najpomembnejših vidikov vodenja projektov je negotovost pri ocenjevanju trajanja dejavnosti, ki običajno zahtevajo sodelovanje virov, ki se le redko ukvarjajo z eno samo nalogo. V teh razmerah ima lahko človeško vedenje, če ni ustrezno upravljano, velike negativne učinke tako na trajanje kot na stroške projekta. Eno od področij človeškega vedenja se imenuje študentski sindrom – gre za pojav, ko ljudje odlašajo z opravljanjem dejavnosti do trenutka tik pred rokom. Pri projektih s področja informacijske tehnologije to pomeni, da programer odloži svoje projektne naloge do roka, medtem ko je sprva delal zelo sproščeno in z veliko rezerve, ker je mislil, da ima dovolj časa za vse. Posledično zapravlja čas, ki bi ga lahko imel na razpolago ob morebitnih težavah pri izvedbi projektnih nalog.

Cilj študije je analizirati in količinsko opredeliti vpliv študentskega sindroma na čas dokončanja posameznega projekta s pomočjo simulacijskega orodja. Ocenjevanje uspešnosti na podlagi simulacije zagotavlja potrebne vpoglede, ki jih mora vodja projekta upoštevati pri vodenju projektov, da bi zagotovil uspešnost projekta. Za podrobnejšo razlago vpliva študentskega sindroma je analizirano večje število različnih primerov projektov. Simulacije kažejo, da odprava študentskega sindroma zagotavlja znatno in takojšnje izboljšanje časa dokončanja projekta za okoli 35 odstotkov v primerjavi s projekti, kjer je prisoten študentski sindrom.

Ključne besede: projektno vodenje, študentski sindrom, človeško obnašanje, diskretne simulacije, upravljanje omejitev

1 INTRODUCTION

To compete today and in the future, organizations are using their information systems and associated information technology to quickly react to changes introduced by the global market. Initiatives that rise out of these changes usually come in a form of a project [1], thus trying to meet the requirements of the customer and increasing the business value of their products or services. The business value can be measured with the productivity gain, product quality, customer satisfaction and various profit and market-oriented measures [2].

Received 17 March 2023
Accepted 12 April 2023

A project is a “temporary endeavor undertaken to create a unique product or service” [3]. Ideally, in a project a task schedule would be prepared in advance to assign just enough tasks to resources that need to work on by considering their availability, skills, and competences. However, in a highly dynamic environment of the development in the information technology area, with demand fluctuation, customer behavior, high degree of the task duration variability and technology uncertainty, this kind of scheduling is unrealistic. Moreover, an unexpected completion delay of a task can delay on one or more scheduled tasks, likely to result in a domino effect on the remaining project tasks. The result of the domino effect is visible in Standish Group Chaos Study report [4], where over more than 25 years some 50.000 software development projects have been evaluated each year.

Table 1: Standish Group Chaos Study revealing success rate of IT projects from 1994 to 2020.

	1994	1995 - 1999	2000 - 2004	2005 - 2009	2010 - 2014	2015 - 2020
Successful	16%	27%	30%	33%	38%	35%
Challenged	53%	43%	51%	46%	43%	46%
Failed	31%	30%	19%	21%	19%	19%

The Standish Group Chaos Study shows that a project success is limited to a triple-constraint schedule, i.e., the time, budget and scope. A project is considered successful if it satisfies each of the triple constraints. A project is considered challenging if it satisfies only two of the three constraints (for example, if it is delivered on time and within the budget but does not have the desired scope). On the other hand, a project is considered failed, if it is abandoned before it is completed or is completed but not used. The results of the report shows that some 35 percent of projects are successful, while some 46 percent are challenging, meaning that there is a significant space for improving in the managing projects.

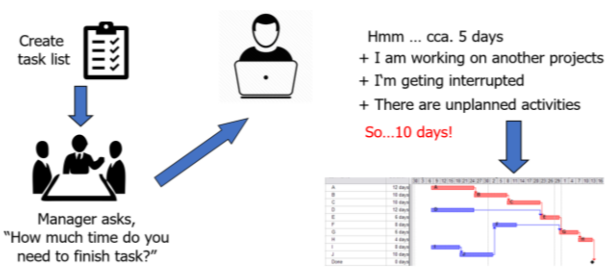

Figure 1. Traditional project tasks and schedules [19].

A traditional approach [5], [6] to the issue is to estimate the workload and to set the completion time for the individual tasks or groups of tasks (e.g., a new software release), based on the customer needs or priority. If a task execution involves a high degree of the uncertainty and last-minute customer changes are expected, its estimation is usually inflated to meet the dates (see Figure 1).

Another side effect of the task due dates is when a project team postpone their activities until the last possible time and then do their best to meet the deadline after a significant amount of the time has already been spent, rather than starting their work on the designated day, taking the allocated time, and allocating their efforts in a smooth flowing way, thus resulting in a delay of the scheduled work, the quality of work is reduced and the stress in the work environment is increased (see Figure 2). This side effect of the human behavior is called the Student Syndrome [7].

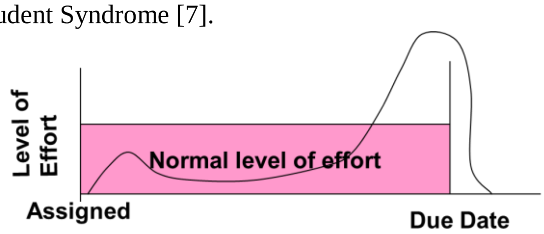

Figure 2. Student Syndrome example [19].

The above graph displays the level of the effort of the work a project member puts into a task and the amount of the time spent on it. The task length, or the time taken for the task completion, is shown by the vertical lines. On the left line is an assigned date and the due date is on the right line. The figure shows that at the task assignment date an effort is taken to evaluate the real effort to be put into a task (not the allocated time) and then when the due date is approaching there is a significant amount of the effort put into a task to complete it on-time, but usually the time lost can no longer be compensated, thus resulting in a completion delay (or reduced quality). The delay of several scheduled tasks has a domino effect on the remaining project tasks (see Figure 3).

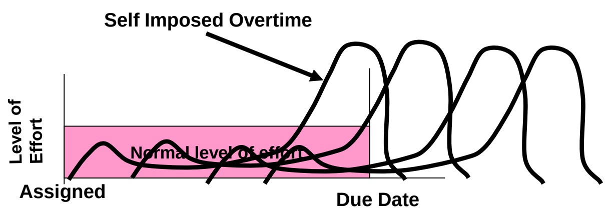

Figure 3. Student Syndrome rifle effect [19].

The focus of the study presented in the paper is to show the devastating effect of the project-task deadline approach and human behavior in a form of the Student Syndrome for different projects. The paper contributes to the research in managing the information technology projects by (i) giving a comprehensive overview of the impact of the human behavior, i.e., the Student Syndrome, on the project completion time, (ii) validating the findings by using a discrete-event simulation model built with PmSim [18] and (iii) reducing the impact of the human behavior on the project.

The study is organized as follows. Section 2 briefly reviews the literature our study is based on. Our observation is that not much has been done in the academic literature to analyze the human behavior in terms of the Student Syndrome in the project environment. Section 3 defines the problem and Section 4 the research methodology. Section 5 presents results and summarizes and discusses our findings. Section 6 draws conclusions and gives implications for further work.

2 LITERATURE REVIEW

In a typical project, many task completion times are unpredictable. Therefore, any task that takes longer than planned, typically prolong the project completion time. On the other hand, task that take less than planned do not reduce the project completion time. One of the reasons for this asymmetry is also the human behavior, where Student Syndrome and Parkinson Law are the most well-known behavior phenomena.

The Student Syndrome means that people think they have enough time to complete a task and therefore hold off starting the work until the last possible moment. If any variation occurs after the last possible moment to start, the work is completed late. On the other hand, the Parkinson's Law implies that the time it takes to complete a task and report its completion is not less than the amount of the time that is made available for it [8]. The effect of the Parkinson's Law is that the potential benefit of an earlier than expected task completion time is lost. This fails to compensate for a later delayed completion of other tasks.

There is a relatively little work in research and academic area devoted to the Student Syndrome and its impact in the project management environment, especially on the project completion time. [9] describes how three behavioral issues such as the Student Syndrome, team member stress and organizational slack, affect a typical project. Oppositely, there has been quite considerable research done in the field of the Parkinson Law. [10] evaluates the impact of the Parkinson's Law and provides guidelines for project managers how to reduce it in a project environment, especially in multi-month or multi-year project with shared resources. [11] improves the productivity in a software development, where the developer extra time is not revealed as an "available time", but is totally consumed, resulting in a loss of productivity and lack of meeting the scheduled project completion time. [12] researches the pervasive behavioral problem of the Parkinson's Law in the project execution and an approach to resolve the Parkinson's Law by using an incentive scheme on project networks with a low density and type of the project network.

In the Theory of Constraints (TOC) Critical Chain Project Management (CCPM) [13] and Drum Buffer Rope (DBR) [14], solutions are simulated to demonstrate benefits of their use in order to reduce the impact of the human behavior on the project completion time. [15] deals with the CCPM scheduling where resources used multiple times in a single project or are shared between projects and are impacted by the human behavior, where any unexpected delay in a single task can cause a significant domino effect, delaying one or more projects. In [16] and [17], task-completion time-performance improvements using DBR when a number of the tasks in the system is controlled and are subject to the human behavior impact.

The paper offers a simple methodology to analyze the impact of the Student Syndrome on the project completion time and a discrete-event simulation model to evaluate the results of the presented research.

3 PROBLEM DEFINITION

According to [11], project management is a business process that supports about 30 percent of the world's economic activity. However, the project success rate can be low (Section 1). One of the reasons of a poor performance is the human behavioral phenomenon called the Student Syndrome, resulting in a failure to deliver the project by the set deadline and potentially negatively impacting the overall project performance.

The simulation gives answers to the following questions:

- What is the average probability of the project completion time in single project environment (to be used as a baseline)?
- What is the impact of the sequential or parallel project tasks on the same process for a single project completion time?
- What is the impact of the resource allocation on the same process for a single project completion time?
- What is the impact of the Student Syndrome on the same process for a single project completion time in terms of the different project scenarios?

4 SIMULATION SET-UP

Our study uses a quantitative approach, which includes the use of a simulator, and research methods, such as analysis of the literature and personal experience. A simulator is used to know and understand different parameters of the project one at a time rather than losing the effects of an individual variable in the noise of many interacting parameters, event that scope is the same. Using the simulator enables us to manage different parameters how project tasks are handled, especially addressing the human behavior, such as the Student Syndrome, required for systematic evaluation of our study.

Following the example [15], we utilize a PmSim simulation tool [18] that is used in the Washington State University ETM program. It allows us to comparatively analyze the results of our study. The simulated environment consists of several different projects with different tasks and different resource allocations (sequential, parallel and mixed).

Moreover, in a (typical) project, tasks are subject to a high degree of uncertainty and to predict how much time a task will take is very difficult, especially in new subject areas. As a result, resources often overestimate the duration of a task they submit to the project manager to ensure that it is completed on defined time and to show their high utilization.

The simulation follows the basic rules to identify impact of the Student Syndrome in projects [19]:

- The project task duration is 14 days with confidence rate of 90 percent.
- Each resource uses a normal distribution to define the task completion deadline.
- One day of the task completion is one day, which is eight hours.
- For each task, a set scope of resources is defined.
- The simulation starts with a zero task before each resource (e.g., "clean table" before start).
- The human behavior in the form of the Student Syndrome can be enabled or disables in the simulation run.
- Each simulation is run for 1000 interactions.

Other simulation assumptions are:

- Simulations are modeled as "machines". The human behaviors, such as the Parkinson's Law, multitasking, sick leave, etc., which could cause an additional delay and affect the overall performance of the simulation, are not modeled.
- There are no problems with the resources and logistics:
    - No lead time at the beginning of each task.
    - No prioritization of the tasks.
    - Independent process – no artificial delays.
    - No technical interruptions.

4.1 Sequential project simulation

The simulation setup for the sequential project consists of five sequential project tasks executed by different resources. The simulation starts by completing the first task, followed by second, and so on, compliably with assigned resource and task duration (see Figure 4).

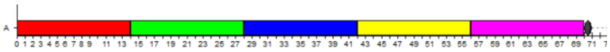

Figure 4. Project example with sequential tasks and different resources.

Each resource has planned 14 days to complete the task, thus making a 70-day project completion time.

4.2 Parallel project simulation

Many, if not all, project plans have points when two (or more) tasks are to be completed before a next task begins. These tasks are called convergent points.

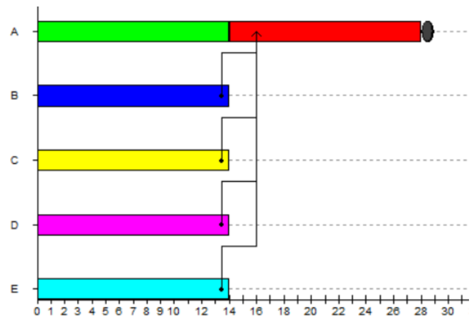

Figure 5. Project example with parallel tasks and different resources.

In Figure 5, five different resources start a project task in parallel and all must be completed before the last project task begins - convergence point in a project. Each resource has a planned duration of 14 days to complete its task, thus resulting in a project completion time of 28 days.

4.3 Resource-conflict project simulation

The simulation uses a combination of sequential and parallel tasks with resource contention. It investigates a project with limited resources (in our simulation, two) where a single resource might be required to perform more activities simultaneously.

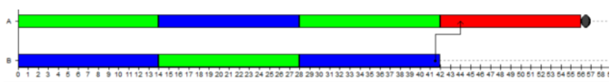

Figure 6. Resource-conflict project simulation.

The planned project completion time is 56 days. Each resource has a planned duration of 14 days to complete its task (see Figure 6). If one of the resources complete its task earlier, it cannot start before the other completes its own.

4.4 Project simulation

A project with several sequential project tasks, combined with parallel ones in more complex project environment with several interdependencies, is simulated. Additional resources are added to get the project more realistic.

The planned project completion time is 98 days. The planned task completion time for each resource is 14 days (see Figure 7).

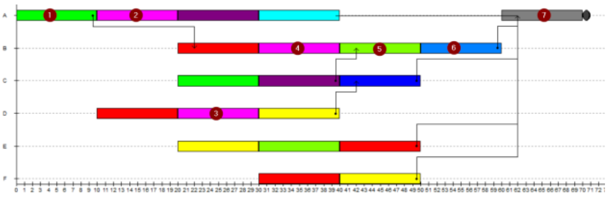

Figure 7. Project simulation environment.

In the project Critical Path (CP) [3] the tasks are numbered from 1 to 7. CP indicates the longest sequence of tasks that must be completed to complete a project. The tasks on the CP are called critical activities and when delayed, the whole project is delayed.

Also, the project tasks can be scheduled completely in two well-known approaches to staring the project tasks on a non-critical task with no time restrictions. Therefore, tasks can be scheduled As Soon As Possible (ASAP) or As Late As Possible (ALAP) relative to the start and the end of the project [3].

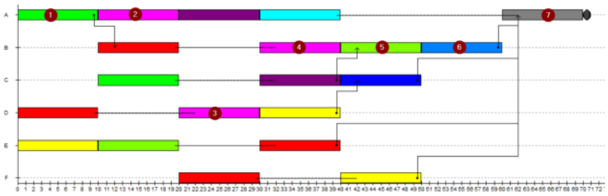

Figure 8. Project simulation environment with tasks started "as soon as possible".

Starting a task ASAP (see Figure 8) is usually considered the best approach. However, there may be situation when all the necessary information is not available at the start of the task, which can negatively effect the task completion.

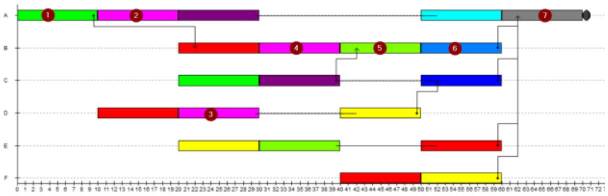

Figure 9. Project simulation environment with tasks started "as late as possible".

To avoid issue with the ASAP scheduled tasks, ALAP scheduling can be used (see Figure 9). However, an unexpected situation could prolong the task completion and the completion of the CP tasks will be rescheduled.

5 RESULTS AND DISCUSSION

Table 2 summarizes results of one thousand simulation runs for different approaches, considered in our study. All completion task times are normalized to provide comparable data for the analysis.

Table 2. Summary of 1.000 simulation runs.

	Probability to meet the planned completion time	**Normalized Median completion time**	**Normalized completion time with a 90% probability**
Sequential 1	100%	71%	84%
Sequential 2	92%	90%	100%
Parallel 1	92%	82%	100%
Parallel 2	58%	100%	111%
Resource conflict 1	98%	80%	93%
Resource conflict 2	69%	96%	105%
Project 1	99%	85%	92%
Project 2	79%	96%	103%
Project-ALAP 1	94%	94%	99%
Project-ALAP 2	50%	100%	104%
Project-ASAP 1	99%	86%	93%
Project-ASAP 2	83%	96%	102%

The vertical axis shows the following parameters for each of our simulations:

- Sequential project: initial simulation scenario with five project tasks, each implemented by different resources.
  - Sequential 1: with no Student Syndrome.
  - Sequential 2: with a Student Syndrome.
- Parallel project: Simulation scenario with five different tasks executed in parallel and each completed before the implementation of the last project task.
  - Parallel 1: with no Student Syndrome.
  - Parallel 2: with a Student Syndrome.
- Resource conflict: Adding a resource contention into a simulation scenario.
  - Resource conflict 1: with no Student Syndrome.
  - Resource conflict2: with a Student Syndrome.
- Project: Simulation scenario with sequential and parallel task, with task interdependencies and resource conflict:
  - Project: initial project simulation
    - Project 1: with no Student Syndrome.

        - Project 2: with a Student Syndrome.
    - Project – ALAP: project tasks are executed As Late As Possible.
        - Project-ALAP 1: with no Student Syndrome.
        - Project-ALAP 2: with a Student Syndrome.
    - Project – ASAP: project tasks are executed As Soon As Possible;
        - Project-ASAP 1: with no Student Syndrome.
        - Project-ASAP 2: with a Student Syndrome.

The horizontal axis shows the following parameter values:

- Probability to complete as scheduled: probability of completing project within the scheduled flow time of the simulation.
- Normalized Median completion time: normalized median value of completion time of the simulation.
- Normalized completion time with a 90 percent probability: Normalized flowtime of all project task to be completed within a 90 percent probability.

The first analysis is made with a complex configuration of the project simulation, including additional tasks and the different resource allocations. However, increasing the number of tasks and associated resource do not provide any significant additional information that would justify the increased complexity and scale of the simulation.

5.1 Probability to complete a project by the deadline

The project completion time, i.e., the time taken to complete a project, is important parameter for the project success. Consequently, shorter project completion time is desirable for its leading to an increased business value [6].

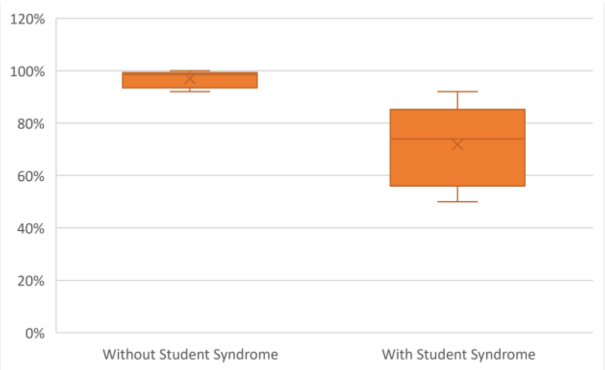

Figure 10. Quartile chart of the probability to complete project as scheduled at the end of the simulation run.

Figure 10 shows the area of the values for the average task completion times for different scenarios. The probability to complete a project as scheduled is the highest for the scenarios with no Student Syndrome (on average from 92 to 100 percent) and with a low dispersion. The results for the scenarios with a Student Syndrome (on average from 50 to 92 percent) are significantly lower and with a high dispersion. Therefore, probability of completing a project as scheduled with no Student Syndrome is on average 97 percent and with a Student Syndrome 72 percent.

This means that the expected project completion time is by 35 percent longer when tasks are impacted by a Student Syndrome. The main cause is the variability of the task execution, resource contention and converged points of the parallel tasks. Individually, the tasks may be performing well, but the negative impact at the convergence points is significant. Including a Student Syndrome in the project task completion increases the negative effects and contributes to missing the project completion time.

5.2 Normalized median project completion time

The normalized median project completion time is the median amount of the time it takes to complete a project (in our simulation measured in days) compared to the project scheduled completion time. Therefore, a low normalized project completion time is preferable.

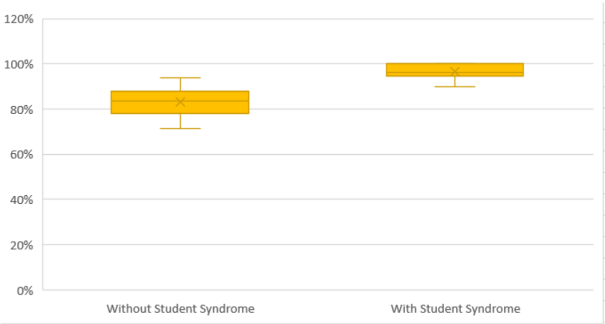

Figure 11. Quartile chart of the normalized median project completion time at the end of a simulation run.

Figure 11 shows the area of the values for a normalized median project completion time at the end of a simulation run. The simulations with the Student Syndrome have the highest values, on average from 90 to 100 percent, meaning that the median values are in range of scheduled completion times meaning that the project is likely to be delayed. On the other hand, the results with no Student Syndrome are on average from 71 to 94 percent, giving a better confidence in meeting the project completion times.

As result, normalized median project completion time with no Student Syndrome is on average 83 percent and with the Student Syndrome it is 96 percent. This means that the expected project median completion time with the Student Syndrome is by 14 percent longer.

5.3 Normalized project completion time with a 90 percent probability

The completion time with a 90 percent probability is treated as being a low still acceptable value [19] by the project management community.

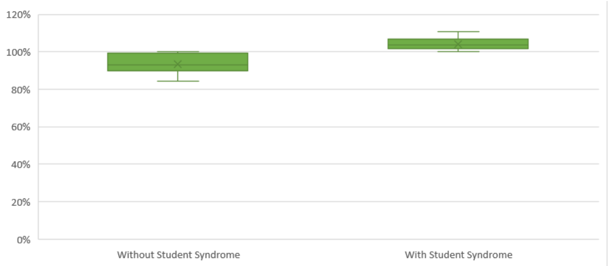

Figure 12. Quartile chart of the normalized project completion time with a 90 percent probability at the end of a simulation run.

Figure 12 shows the area of a normalized project completion time with a 90 percent probability for each simulation run. The projects completion time with no Student Syndrome are always met, even ahead of the scheduled time, on average from 84 to 100 percent. On the other hand, the completion time with the Student Syndrome is in majority simulation runs delayed, on average from 100 to 111 percent.

Moreover, normalized project completion time with a 90 percent probability is with no Student Syndrome on average 93 percent and with the Student Syndrome it is 104 percent. This means that the expected project normalized project completion time with a 90 percent probability with the Student Syndrome is by 10 percent longer.

5.4 Overall results

In project management, predictability and meeting the deadlines, i.e., completed times, are highly desirable by stakeholders, customers, and other interested parties.

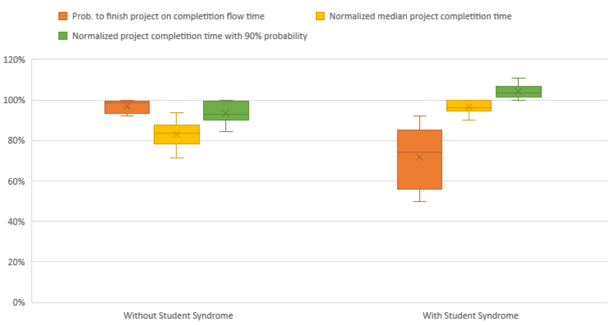

Figure 13. Quartile chart of results at the end of a simulation run for different simulation scenarios.

Figure 13 summarizes the simulation runs, combining results from the previous chapters in Section 5:

- The project completion time with a 90 percent probability is by 10 percent better with no Student Syndrome compared to scenario with it. This means that the project completion times are always within the scheduled completion times with no Student Syndrome.
- The probability of completing a project by a scheduled time with no Student Syndrome shows a 35 percent improvement compared to scenario with it. This means that the probability of completing the project on time is always above 92 percent, while with the Student Syndrome it is always below it.

6 Conclusion

The impact of the human behavior phenomenon called the Student Syndrome on the project completion time is analyzed. Using different project scenarios, task performance metrics and the Student Syndrome shows that the Student Syndrome directly extends the completion time of individual task and evokes a domino effect on the project completion time. The results obtained are analyzed and formalized by using a PmSim simulator.

The first conclusion of the study is that the impact of the Student Syndrome on the project completion times is smaller when performing sequential tasks and the negative effect is considerable when performing parallel tasks. The second conclusion is that convergence points, i.e., the tasks that cannot be started before the preceding parallel ones are not completed, are in most cases missed. The completion delay is noticeable in slack project tasks with a scheduled late start (ALAP) which does not take advantage of starting based on the actual completion of the preceding activity when there is a variability in the tasks completion. The third conclusion is that the Student Syndrome combined with a resource contention and the task completion variability further extends the project completion time. To sum up, eliminating the Student Syndrome positively and immediately effects the project completion time by up to 35 percent compared to situations with the Student Syndrome.

This study does not propose solutions to reduce the impact of the Student Syndrome, but it identifies it as a potential cause of a project failure to meet the project completion deadlines. The study results may help understand the main issues of an efficient project management where the human behavior is only one of them to be addressed before proposing a comprehensive solution.

LITERATURE

[1] Xiaodong Zhang, Le Luo, Yu Yang, Yingzi Li, Christopher M. Schlick & Morten Grandt (2009) A simulation approach for evaluation and improvement of organisational planning in collaborative product development projects, International Journal of Production Research, 47:13, 3471-3501, DOI: 10.1080/00207540802356770

[2] Anavi-Isakow, S., & Golany, B. (2003). Managing multi-project environments through constant work-in-process. International Journal of Project Management, 21(1)

[3] A Guide to the Project Management Body of Knowledge and the Standard for Project Management and the Standard for Project Management - 7th Edition, Project Management Institute, 2021

[4] Review Standish Group – CHAOS 2020: Beyond Infinity, https://hennyportman.wordpress.com/2021/01/06/review-standish-group-chaos-2020-beyond-infinity/, accessed 15th of March 2023

[5] Bhardwaj, & Gupta. (2010). Drum-Buffer-Rope: The Technique to Plan and Control the Production Using Theory of Constraints. World Academy of Science, Engineering and Technology, Article 19, page 103

[6] Aljaž T. (2021). Improving throughput and due date performance of IT DevOps teams, Elektrotehniški vestnik 88(3): 121-128

[7] Eliyahu M. Goldratt. (1997). Critical Chain, Gower Publishing Ltd

[8] Gutierrez, Genaro J., and Panagiotis Kouvelis. (1991) Parkinson's Law and Its Implications for Project Management. Management Science, vol. 37, no. 8, pp. 990–1001.

[9] Smith, Derek. (2010). The Effects of Student Syndrome, Stress, and Slack on Information Systems Development Projects. Information in Motion: The Journal Issues in Informing Science and Information Technology. 7. 489. 10.28945/1222.

[10] Prieto, Robert. (2022). Parkinsons-Law. (2) (PDF) Parkinsons-Law (researchgate.net), accessed 15th of March 2023

[11] Kamma, Damodaram & Geetha, G. & Neela, J.. (2013). Countering Parkinson's law for improving productivity. ACM International Conference Proceeding Series. 91-96. 10.1145/2442754.2442768.

[12] Bo Chen, Nicholas G. Hall (2021) Incentive schemes for resolving Parkinson's Law in project management, European Journal of Operational Research, Volume 288, Issue 2, 2021, p 666-681, ISSN 0377-2217, https://doi.org/10.1016/j.ejor.2020.06.006.

[13] Takami Narita, Taynara & Alberconi, Caio & Souza, Fernando & Ikeziri, Lucas. (2021). Comparison of PERT/CPM and CCPM Methods in Project Time Management. Revista Gestão da Produção Operações e Sistemas. 16. 01-20. 10.15675/gepros.v16i3.2815.

[14] Orue, Aitor & AIASTUI, AITOR & García-Sánchez, Álvaro & Apaolaza, Unai. (2023). Capacity buffer management in implementing drum-buffer-rope methodology in make-to-order environments. DYNA. 98. 12-12. 10.6036/10764.

[15] Aljaž T. (2020). From Efficient to Effective Project Teams, Izzivi prihodnosti. 2020, leto 5, št. 1, str. 1-16. ISSN 2463-9281

[16] Tomaž Aljaž. (2014). Out of chaos in 12 months - improving lead time of sprint projects in software development implementing Drum Buffer Rope Solution, ERK

[17] Zupancic, D., Buchmeister, B., & Aljaz, T. (2017). Reducing the Time of Task Execution with Existing Resources – Comparison of Approaches. International Journal of Simulation Modelling, 16, 484-496.

[18] Elyakim Management System. PmSim Version 2.03 (student version)

[19] Holt, J., Aljaž, T., Johnson, R., Holt, S., Furback, R., Button, S. (2014). EM 530 Lecture materials, Washington State University 2014

Tomaž Aljaž is having over 22 years of professional experience in Information & Telecommunication. He is employed with Spar Slovenija where he manages IT projects with a particular focus on improving the performance of the project team, establishing and maintaining an optimal use of resources and reducing the operational risks. He is also a faculty member of the Faculty of Industrial Engineering Novo mesto, Slovenia. His past experiences are related to the R&D environment where he worked as a Resource, Project, Product and Solution manager. He has published several papers on the information technology and telecommunication area, resource management, project management and process improvements using the Theory of the Constraints methodology. He is a holder of a Ph.D. degree in Electrical Engineering received from the Faculty of Electrical Engineering and Computer Science of Maribor and has completed courses in Constraint Management at the Washington State University, USA. For over 11 years he has been teaching at a graduate and postgraduate level the topics related to the performance improvement of organizations, project management, information technology and telecommunication. In 2018 and 2019 he was granted a Certified Scrum Master (CSM) and Certified Scrum Product Owner (CSPO) certificate and in 2014 a Jonah certificate, by the Theory Of Constraints International Certification Organization (TOCICO).