(HP Print Bar Testing) Case Study

<Abstract>

This case study showcases a successful Lean development project for one of the print bar testing processes at HP in Singapore. The learning sessions and project implementation were guided by a Lean coach from Lean Transformation Innovation Centre (LTIC) team as well as the faculty members in Singapore Institute of Technology (SIT).

The case study follows HP's Lean journey through the Lean Project and shows how HP was able to achieve not just the project goal of a significant reduction in manual process by operators, but also reinvigorates the Lean thinking culture within the team members involved. It also shares many lessons the project team members learnt from the Lean programmes.

In addition, it explains challenges faced by different stakeholders and how they overcame these difficulties and hurdles. Lastly, it discusses key success factors and concludes the case.

Prologue

"The printer stopped again!", exclaiming Fatimah rubbing her tired eyes to get her eyes ready to see the computer screen to spot any signs of problems running the scripts. At 5:20pm now, with less than 2 hours before her 12-hour shift ends, she tries to rush to complete the test job. But there are many more test scripts to run and she has to run each script manually. She also needs to walk around different printers and scanners to facilitate different test processes. Whenever a printer stops unexpectedly like this, it takes up her time as she needs to find out the cause and resolve the issue. This eats into her limited time left and her supervisor, Mei Li, is anxiously waiting for her to complete this test.

Mei Li just spoke to Jackson, one of the six engineers who requested for special test jobs last week. He called yesterday and called again today. He asked Mei Li when her operators would complete the test job he requested. He said, "Mei Li, I need the test results quickly. Can you ask your operators to expedite? Actually why is testing only one print bar taking so long? It's been more than a week. Last time the test job I asked you to do also took a long time to complete. My boss is chasing me for the report." Mei Li explained to him once again, how much manual work the operators have to do with every print bar testing, but she felt that he didn't seem to understand. Jackson said only one print bar, but Mei Li got many such requests from different engineers. Operators have to facilitate those special tests on top of the existing regular test jobs. When she was about to check on Fatimah's progress, she heard Fatimah calling out her name.
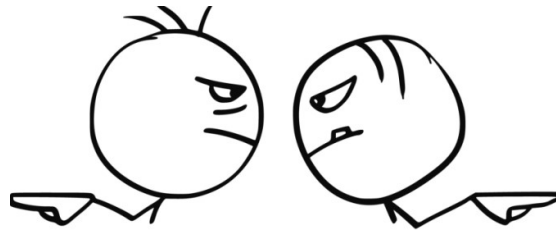
After struggling for a while, Fatimah decides to get Mei Li to help solve the problem. "Mei Li, I had a lot of errors today. Whole day I rush here and rush there to run different scripts and prepare the scanning process. I don't think I can finish this test job before I go home today. Can you ask the engineers to reduce this kind of extra tests? You know all of us are already too busy with the usual test work. I am so tired now."

This is not the first time Mei Li hears such complaints from her operators. She feels sorry every time she hears about the difficulties faced by her operators as she knows how hard her operators work. It's now late March and she is worried how her team is going to meet the productivity improvement target for the year. Her boss told her to participate in the Lean Project organised by the engineer team earlier this year, but she does not know much about Lean and is not sure how it will help her current situation. In fact, she is worried it will be just extra burden and her operation will be disrupted by this project, which means not meeting the targets.

Fast forward to late September this year, Mei Li is happy because her operators' job is now much easier with a significant reduction in manual work processes after the Lean Project is completed. She has also implemented a visual tracking system as part of the Lean management project, which she can show to the engineers to explain why her operators are busy and how much rework is done at each step. Engineers now understand operators' challenges and issues much better after going through the value stream mapping process together as part of the Lean Project.

This case study presents how the HP team has achieved what is described in 'Prologue' through the Lean[1] Project offered by the Singapore Institute of Technology (SIT). It also illustrates the struggles and challenges faced by the HP team members along the way and showcases how they have overcome the difficulties.

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[1]Lean Project: Refer to *Appendix* at the end of the case study for a brief description of this programme.

HP's Lean Journey

HP, a multinational company incorporated in the US about 70 years ago, is a brand many people are familiar with at home as well as in office. The product portfolio includes printers, computers, mobile devices, and various IT solutions and services that are used by many people around the world. Through these products and services, HP aims to 'engineer experiences that amaze' and 'create technology that makes life better for everyone, everywhere'.

To achieve their vision, HP places the quality of their products and services as one of the top business priorities. In this regard, what the LSDP project team does at HP is critical to the business as it is directly related to gaining the trust of the customers. The project team comprised of product engineers and operation team members in the test lab. They were involved in the quality testing process of the print bars for the latest 'HP PageWide Technology'.

It is a unique technology developed by HP and offers a number of benefits to consumers such as lower cost, faster speed, and better print quality. A print bar is a core component of the Pagewide Writing Engine in this new technology and is not replaceable unlike the print head included in small ink cartridges in home printers. Therefore, the print bar should be durable and testing its reliability is imperative for the success of the products in the market.

Product engineers designed the test process and analysed the test results while the operations team conducted the tests and collect the data for the engineers. Many people in the team were long service employees working for HP for 10 to 20 years or more. They cited some of the secrets of employees' long service as factors such as good teamwork, open culture and flexible work environment at HP.

HP PageWide Technology
Breakthrough speed, professional quality

HP PageWide Technology breakthroughs enable the high performance and robust print quality of HP Officejet Pro X Series printers, which bring the best of toner- and ink-based printing to small workteams by delivering high levels of reliability, color and black print quality, and productivity. These printers offer low product acquisition costs, have low total energy consumption, and produce color pages at up to twice the speed and up to half the printing cost compared with color laser printers.

HP Officejet Pro X Series Printer

Pagewide Writing Engine Assembly

Source: HP Technical White Paper

What was the problem?

In order to meet the quality requirements, the test process for the print bar has to be very comprehensive covering all aspects of possible defects or failures that can happen in the life span of the print bar. As described in the 'Prologue' above, before the Lean Project, one of the test processes required a substantial amount of manual interruption by operators in between various test steps and different scripts. One of the operation technicians described the problem as follows:

> "As a middle person between operator and engineer, we get requests from engineers and arrange the test with operators. When the data output is not out, we get questioned by engineers. We also get complaints from operators. They complain the machine is too far. Because they have to keep going back there and come back to check on the paper and go back there. So make many trips."

This process took up the most manpower resources, at more than half the entire test process in this lab. The management decided to take on the Lean journey with SIT with the aim to achieve significant reduction in manual touchpoints during this specific process.

Lean was not new to many HP team members, especially those who were in the operation team. Kaizen[2] and Kanban[3] were constantly encouraged and implemented, but they were too focused on individual tasks or processes than looking at the entire test process. They also implemented Visual Management (VM)[4], which did not sustain due to the reasons in the comments below.

"Actually we had a bad experience. When implementing, we used a lot of time to go and prepare, but after one month we started hear complaints. They said it's very troublesome…they didn't like it. And I think after half a year, we decided that we could not use it. So it actually didn't work for us. Every day we go and update but in the end we don't see the benefit from doing that. We write down in our book, we write down the down time, but we don't know what to do with this data. It was just for the sake of collecting data."

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[2] **Kaizen**: Continuous improvement of an entire value stream or an individual process to create more value with less waste. (Source: Lean Enterprise Institute, http://www.lean.org)

[3] **Kanban**: A kanban is a signaling device that gives authorization and instructions for the production or withdrawal (conveyance) of items in a pull system. The term is Japanese for "sign" or "signboard." (Source: Lean Enterprise Institute, http://www.lean.org)

[4] **Visual Management**: The placement in plain view of all tools, parts, production activities, and indicators of production system performance, so the status of the system can be understood at a glance by everyone involved. (Source: Lean Enterprise Institute, http://www.lean.org)

How has the Lean Project helped HP solve the problem?

A Lean coach, the SIT faculty and the HP project team worked closely together across a few months to achieve the reduction in manual time reduction goal. At the same time, the coach transferred the knowledge on Lean principles and tools to the HP members to augment their Lean thinking capabilities and reinforced their Lean culture. In this sense, the Lean Project was a blended learning programme based on an action learning approach, where HP employees developed their capability not just from the classroom learning sessions, but also through working on and resolving a real work problem.

The most powerful learning came from the Value Stream Mapping (VSM) [5] activity at the beginning of the project. During the VSM process all the employees who were involved in the print bar test process gathered and put together all the steps required to complete the test from beginning to end. They analysed and discussed each step to identify wastes, which were problems to solve. They then used the payoff matrix to prioritise the problems that could generate a bigger impact while requiring less resource. Figure 1 below shows what the project team did during the VSM activity.
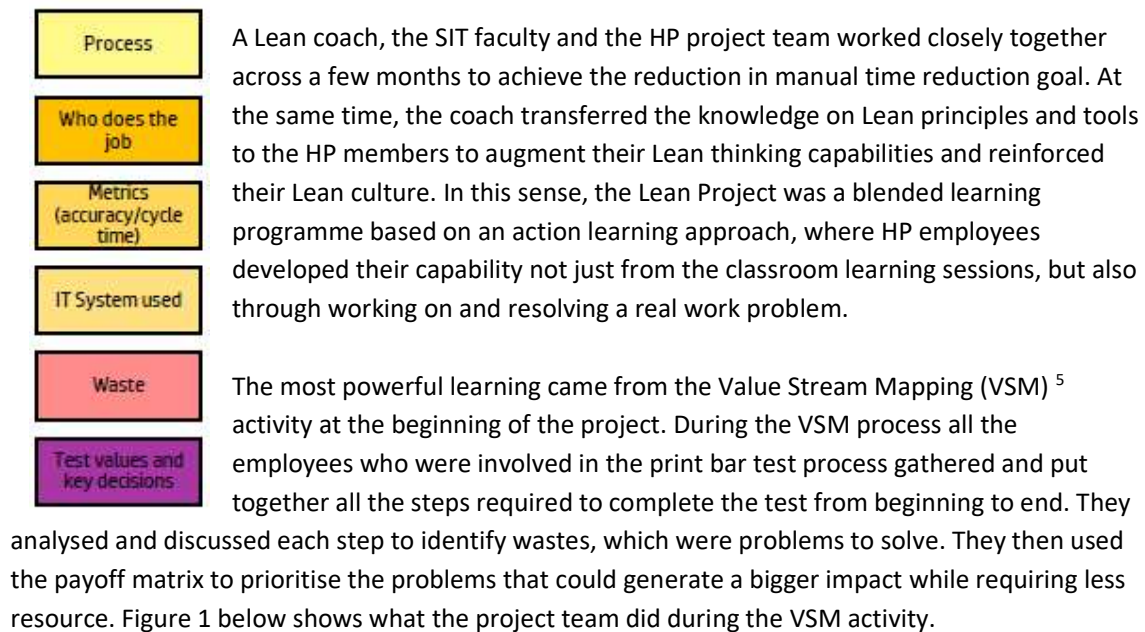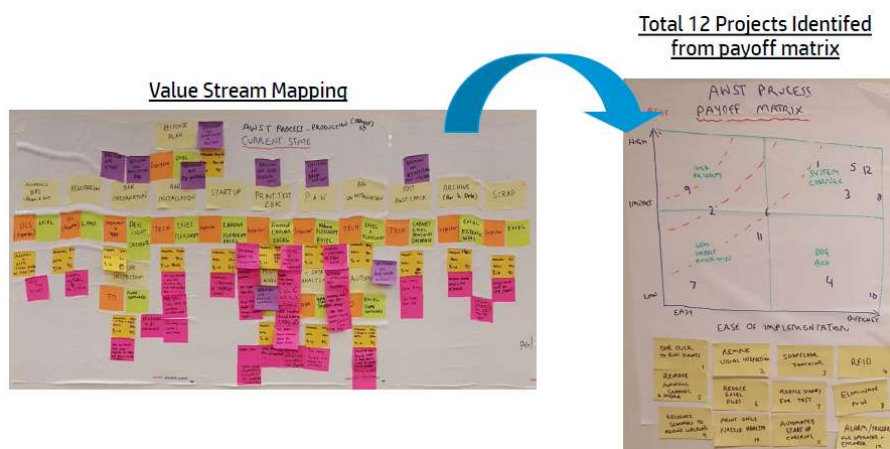
Figure 1. Value Stream Mapping (VSM) Activity

This activity enabled the project members to see the entire test process together and understand the issues faced by different teams. Below is how some of the HP team members described the VSM experience.

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[5] **Value Stream Mapping**: A simple diagram of every step involved in the material and information flows needed to bring a product from order to delivery. (Source: Lean Enterprise Institute, http://www.lean.org)

"VSM brings everything into context. With this activity, we get to go from a bigger picture down to a smaller picture. I think that part really helps a lot. It's easier to identify the area we need to focus. We know how to look at the issue in the bigger picture, because all the activities are linked and some of the problems cannot be solved from looking at the specific problem only."

"We got engineers as well as all the operation team members from technician to trainer, and also to operators, they're all involved. I think it's quite good because when we want to do some changes, it needs to change from the bottom because it would be easier to change."

The project team selected a few key problems and implemented countermeasures, which resulted in the outcomes listed in Table 1 below. At the end of the Lean Project, HP has achieved the goal of significant reduction of the operator's manual time during the test process.

Table 1. Project Outcomes at HP

Projects	Description	Saving (%)	Other Benefits
Layout optimisation	Relocate scanners to reduce walking time during testing	At least 45% across the various projects	Ergonomics
Visual inspection optimisation	Reduce visual inspection time for incoming print bars		Ergonomics
Reduction of manual data entry	Reduce manual data entry through many Excel files		Digitisation
One-click script	Remove manual selection of scripts (total more than 240 scripts) to run	More than 20% reduction	Error reduction
Rework tracking	Visualise and track rework status for each test process		Visual management

What were the benefits and impact of Lean Project

The team had many immediate benefits of the Lean Project. For example, one of the trainers said the following.

"The biggest difference is before everything was manual, measuring the weight, recording it on Excel. There were too many double jobs that operators had to do, and also a lot of errors because operator could key in the wrong info or wrong value, like an error. And sometimes data went missing as it was not safe to put data into Excel. So there were a lot of complaints from engineer side about those issues. Then currently with the new system, we store everything into the system, so we don't need to do the manual data entry and also no error or missing data."

Also, with the implementation of visual management, the supervisor cited:

> "With one chart, we know the current status, then where our resources are used. Based on that we can do better resource planning and further improve our process in future. I can use the chart to go to the product engineer and say, hey, you are using up my capacity. I can use it to bargain with engineers for better resource and capacity planning. Also, easier to identify issues."

In addition, the Lean Project has affected how the engineers and operators work with each other. In the past, they did not really work closely and did not understand each other very well. For instance, engineers did now really know how operators did the scanning work in details. Similarly, operators did not know why engineers requested certain tasks or why everything needed to be scanned. This has changed during the project and they have learnt more about each other's job and challenges through various activities facilitated by the Lean coach.

HP has achieved not just the short-term project goals, but also the ultimate goal of the programme, which is to encourage Lean thinking capability and reinvigorates the Lean culture among the employees. In fact, the coach commented "that real measure of success is whether Lean thinking continues after the project is over". In case of HP, that seemed to be achieved as the coach saw the team members willing to take on leadership roles and facilitate future improvements after the project. They also started to think about management systems and how to continue the effort in future.

Many HP project members said that they started to use what they had learnt from the Lean Project in their job and apply Lean thinking principles all the time. They achieved the targets for the projects they set out with the programme, but they are still working on further refinement and improvement. Moreover, with an improvement they make in one process, they try to leverage it to improve another process. With these changes, they can focus on other more value-added activities and even started to witness the impact on the people's mindset and culture. This was observed by one of the operation team members as described below.

> "When we see a problem, when we see things that need to be improved, we're ready to work out, we gather the information, we also talk to the engineers. We wish to understand why we are doing. Before we just do whatever people ask to do. But now we changed a different way, ask why, understand, then do. Before that I think that we just do, do, do only, but now we also want to understand why. So we ask engineers why this process is done this way. We try to find if there is a better way to do, or we have other options or not."

From the management side, managers start to observe the different attitude and behaviours such as more openness to change and bottom-up change initiatives.

> "The key change I observed is the people. They start talking more about Lean and they are more open to talk about what should be changed. Instead of us telling them they are telling us 'can we do this?' They also saw their supervisor more accepting to the Lean Project. Those changes encouraged them more to speak up."

With all the benefits and positive effects they have experienced through the Lean Project, the team are not stopping there, but will follow up on the evaluation of the outcomes. Next projects are lined up and the team is planning to re-do the time studies and the Value Stream Mapping (VSM) to identify further improvement areas.

Lessons learnt by the project team

"We start to see the benefits so far, improving the process. So we try to identify some other improvements. The lesson learnt is finding the cause of the issue and then making real improvement."

"So this one actually provided me with a really good structure to follow and to just go with the flow and really improve the process. So I think that's what made the change. I think that is really a big take-away for me."

"For me, I would say the thing that really latched on is the value and the waste law. So to really put the whole programme into summary, value and waste and how do you measure process."

What were the challenges?

Not everything was smooth in implementing the countermeasures and the project team faced many difficulties. The biggest challenge cited by many project members was lack of resources, especially time. All of them had to do their day-to-day work and finding time to do the improvement project required a lot of commitment and extra effort. When they had any emergency work issues, they often had to push back the project work. Below is how one of the project members described the situation.

> "On top of this all day you have existing work that you have to, so time was the biggest challenge. We need to prioritise everything, which one goes first and sometimes we miss out something. Time was very precious."

The project members felt that they could have implemented some of the countermeasures much faster without the time issue. The issue got aggravated by the fact they had very limited manpower and there were many other internal projects and initiatives that needed the same people to be involved.

Another challenge that made the project team struggle was dealing with resistance by the operation team members who were directly affected by the change, but were not part of the project team. Most of them did not fully understand what the project team was trying to do at the beginning. A project member said that it was "difficult to explain and convince the need for change to operators. At the beginning they didn't see the benefits of the change so we had to explain different ideas."

In case of some operators, they actually preferred more overtime work as they wanted extra income so they didn't mind doing more manual work. The project team overcame this resistance by explaining that the project is not intended to reduce their working hours or headcount, but to help them do more valuable work and make their job easier. With constant communication and with the operators starting to see the benefits after implementing some changes, they started to understand and support the project activities.

Initial resistance came from not just operators, but also the operation supervisors and product engineers. One of the key project members confessed his own resistance and shared how he overcame it.

"You get to take a step back and really re-evaluate your thinking and to say that is it really necessary. So some things that are operations also came up with, yes, that's true, make sense then I will try it. , it's really re-evaluating the value of what you're doing. As in for me constantly I like to think of whether what I do makes sense."

Conclusion
There are a number of key success factors for this project according to the HP project members.

- Firstly, unlike the previous Lean experience where only operators were involved, this time the project team felt there was a very strong management support. The senior management team was committed to support the team from the beginning, which enabled participation and support from different departments. This way they were able to have the holistic view of the entire print bar testing process and understand the issues and tasks handled by other departments or teams.

- Secondly, the management team tied the Lean Project goals to the Key Performance Indicators (KPI) of the team members who were involved in the project. It was intended to track the progress, formally recognise the efforts of the team members, and enhance the sustainability of the project outcomes.

- Thirdly, the Lean Project was different from other consultancy projects where the Lean coach and the SIT members followed and supported the team through the entire project cycle until it was completed. The project was also aligned with HP's organisation strategy and objectives which is based on Industry 4.0[6]. In fact, the Lean philosophy of continuous improvement is well aligned with HP's organisational vision of continuous 'reinvention'.

"To engineer experiences that amaze. We won't stop pushing ahead, because you won't stop pushing ahead. You're reinventing how you work. How you play. How you live. With our technology, you'll reinvent your world. This is our calling. This is a new HP. Keep reinventing."

In summary, the Lean Project has been successfully integrated into HP's culture of reinvention and generated substantial short-term results and long-term impact. It has contributed to reinforcing the vision "to create technology that makes life better for everyone, everywhere" by continuous reinvention and improvement.

Appendix: Introduction to the Lean programme in SIT

Lean is about maximising customer value while minimising waste. Simply put, Lean practices create more value for businesses using fewer resources. Key benefits are improved quality and safety, cost reduction, shorter lead time and continuous improvement culture development.

The Lean Project offered by the Lean Transformation Innovation Centre (LTIC) in Singapore Institute of Technology (SIT), is a multi- months Lean capability development programme for employees of enterprises. In the programme, coaches from the Center train and nurture participants to develop Lean thinking capability and adopt Lean practices. They are guided by the SIT faculty to implement the Lean practices within their organisations by addressing current challenges at work and improving real work processes during the programme period.

The programme comprises of a blended classroom training and customised on-site Lean improvement activities. For more information about the LTIC, please visit the following website- Lean Transformation Innovation Centre (LTIC): https://www.singaporetech.edu.sg/lean-transformation-innovation-centre or contact lean@singaporetech.edu.sg.

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[6] **Industry 4.0**: It refers to the Fourth Industrial Revolution, which is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres. Unprecedented possibilities exist with emerging technology breakthroughs in fields such as artificial intelligence, robotics, the Internet of Things (IoT), autonomous vehicles, 3D printing, etc. (Source: World Economic Forum, Retrieved on 21 Oct, 2017 from https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond)

Profile of the curator

Millie Lee is an adjunct adult educator and researcher at Institute for Adult Learning Singapore (IAL) specialised in workplace learning. She has assisted enterprises with designing and implementing various workplace learning interventions. She has also coached and supervised new workplace learning specialists in their certification journey, and has been involved in IAL's research projects on topics related to workplace learning and assessment. Recently she worked closely with the Lean Transformation Innovation Centre (LTIC) at Singapore Institute of Technology (SIT) to integrate Lean management and workplace learning programmes.

Mark Tan is based in Singapore Institute of Technology, LTIC (Lean Transformation and Innovation Center) as Assistant Director. He is in charge of delivering Lean training and project works with the industries, including SMEs. The Center aims to promote and develop Lean practices among local enterprises and drive adoption of Lean thinking, culture and mindset. To date, the Center has embarked on Lean journey with more than 20 enterprises and reached out to more than 350 participants through masterclass and workshop. Prior to joining LTIC, Mark was a Certified Lean Six Sigma (LSS) Black Belt (BB) practitioner mainly with the private sector (across both manufacturing and professional services) for more than 12 years, responsible for both local and regional process improvement initiatives.