An Investigation on the Causes of Derailments in the Loccomotive Industry

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Abstract

The aim of this project is to investigate the causes of derailments in the locomotive industry. The focus is on a specific locomotive Yard. Several derailments have occurred on this line and an investigation is critical in finding out what is causing these derailments. The primary objectives of this research are to determine whether the use of poka-yoke devices can be utilised in managing derailments, and to further investigate the applicability of poka-yoke devices.
Past evidence from literature points out that railway derailments have a huge impact on operations, production and the employees' health and safety. Data is collected from a population of 60 employee's. The investigation provides a recommendation of using poke-yoke devices to detect potential failures in an operation and the cause of erratic process behavior with the objective of minimizing and avoiding freight derailments. The analysis of results revealed that 66.67% of derailments at the Yard were caused by operational failures (human errors), while 16.67% is caused by infrastructure failures, rolling stock and other failures contribute 8.33% of failures which lead to derailments. This paper contributes to the continuous discussion on processes failures reduction in the locomotive industry.

Keywords
Poke-yoke, derailments, mistake proofing, Toyota production system, locomotive

SECTION 1:

1.1.Introduction
From the past evidence, one can easily identify that defects can really have a negative impact on the company's image. Mistakes happen all the time and they often have a significant effect on our everyday lives and even at the workplace. Most of these mistakes often happen sometimes without the worker even being aware that he or she is committing an error. The outcome of mistakes in organizations often leads to the production inability and high costs of reworking/repairs of these products or processes. This means that workers must put in extra work in fixing these kinds of mistakes and this is time consuming and costly and slows down production and organizational efficacy. The implementation of mistake proofing devices might reveal avenues or somewhat give an indication of eliminating railway derailments to avoid further damage to rolling stock and infrastructure.
The paper further outlines the introduction of poka-yoke devices in minimising and or eliminating the misfortune of derailments at in the locomotive industry. Poke-yoke was first developed for manufacturing environments but has drastically improved to accommodate the service sector and any other organization. Shigeo Shingo invented poka-yoke in the 1960's to industrial processes in the attempt of preventing human errors. Poka-Yoke is a Japanese word means 'mistake proofing', a term that was adopted and formalized by Shigeo Shingo as part of the Toyota Production System(TPS), it was first called Baka-Yoke which meant 'fool proofing' or in the modern terminology 'idiot proofing' and then after thorough consideration it was reduced to a milder poka-yoke 'mistake proofing', (Shigeo 1986).

Poka yoka is a mechanism in an organization that helps a machine or equipment operator avoid (yokeru) mistakes (poka). The goal of mistake proofing is to eradicate product defects through preventing, correcting and drawing attention to effortlessly occurring human errors. He elaborates that mistakes that create product defects can be engineered from the overall procedure and eliminate defects and increase customer satisfaction. (Shigeo 1986).
Therefore, discovering errors at their source must prevent defects before they can even reach the customer. Poka-Yoke devices are not theoretical and can be put to work at any time, at any organization and even in your home, these tools cannot be limited only to a manufacturing sector and by studying the basic ideologies of mistake proofing one can simply design devices that can be put to work anywhere. (Shigeo,1986).

1.2.Problem statement

Rail marshalling yards are depots in which wagons and containers are shunted and joint together to a locomotive (train) to put together a complete train in the intent to move commodities. The organization investigated is located within the iron-ore and manganese business unit, and in this organization trains are coupled to transport iron-ore and manganese from Sishen mines to Saldanah Bay whereby they can be shipped abroad.
The overall performance to date for the ore export line has been compromised due to the misfortune of derailments that occurred within the organization as well as on the main lines.
A derailment is an incidence that occurs when a train deviates from its main line, this usually because of various factors which are to be further outlined in the paper. When derailment incidents occur it often leads the death, operational incapability, inability to adhere to train schedules which then hinder opportunities to improve service quality and profits in the organization.
The impact of these derailments leads to disruptions in operations and production as trains had to be cancelled due to the lines closed for repairs resulting from extensive damage to rolling stock and to infrastructure. It also causes delays in terms of coupling and preparation of trains for departure, thus affecting arrival times which are a very important aspect of service delivery.

1.3.RESEARCH QUESTIONS

What are the means available of minimizing derailments at TFR?
Could the use of poka-yoke devices be a solution to manage derailments?

1.4. RESEARCH OBJECTIVES

To investigate means of reducing derailments in the locomotive industry.
To investigate the applicability of poka-yoke devices in avoiding derailments.

SECTION 2:

LITERATURE REVIEW

Railway derailments cause many deviations, loss and damage. These losses and damages are aligned with Infrastructure, vehicles, passenger service operations and rail (D-Rail 2012B). The study on derailments has been conducted in several European countries such as The United Kingdom, Germany and Austria and the D-Rail Study has identified the following as the eight major causes in Europe and they have been classified into three categories namely, operations, rolling stock and infrastructure. These causes are Wheel Failure (Rolling Stock), Hot axle box and axle rupture (Rolling Stock), Excessive Track Twist (Infrastructure), Excessive Track Width (Infrastructure), Skew Loading (Operations), Spring and suspension failures (Rolling Stock), Rail Failures (Infrastructure), Track height (Infrastructure) [D-Rail 2012b)
(Chattopadhya et al,2011) Illustrates that several factors combined are a known cause to locomotive derailments. These factors are track related issues, rolling stock, train control issues and other factors such as terrorist attacks. Over 60% of locomotive derailments are mainly triggered by track related issues such as rail buckling, rolling contact fatigue (RCF), rail track wheel geometry issues, insulated rail joints and weather conditions.
Cracks that branch up leads to surface spalling, while those branching down are mainly Mode I driven cracks lying close to the rail's diagonal plane (Mackie&Preston 1998) The outstanding stress, initiating from the rail and wheel traction forces, influences the circulation of fatigue cracks points out (Alan &Fateh 2007). When there is no maintenance conducted, these cracks could grow to exceed a certain ratio which then would result to sudden rail

material fracture and therefore, derailment. Considering this, crack growth resistance and fracture toughness properties of rail steels are often used to describe the RCF damage of railway tracks (Vitez, 1977)

2.1.1. POKA-YOKE DEVICES

An introduction of mistake proofing devices is said to assist in avoiding or minimising errors by means of an engineering process which eliminate this problem at its source. (Shigeo 1986).
(Shimbun 1988) points out the characters of poka-yoke device as follows:

- Simple and cheap, if the devices are expensive then their purpose will not be effective as cost-effectiveness is ideal in putting them to work.
- They are part of the process, implementing what Shingo calls '100% inspection'.
- They should be placed close to where mistakes often happen, for the purpose of providing rapid response to workers so that mistakes can be corrected on the spot.

FINDING DEFECTS IN THE SUBSEQUENT PROCESS

We often don't expect to find defects, but if a product we are using does not conform to its specifications, it can be ruled out as a defect. Users are best at noticing defects. Since subsequent processes are also linked to 'users' of the product being manufactured, they can be classified as experts in finding defects. Whenever products are produced in a continuous flow, each part is often sent out to the next process as soon as it is finished and defects are found immediately (Shimbun 1988). A shutdown procedure is another function of poka – yoke which assists in the elimination of defects. Whenever there is a signal of a defect the machine automatically shuts down and prevents further defects from occurring. Shutdown procedures have been used in many organizations especially in Information Technology Corporations to avoid activities of cyber theft, whenever a system becomes too vulnerable to the 'cyber virus' it automatically shuts down. (Shigeo 1986).

Shimbun (1988) States that the goal of mistake proofing is to completely engineer a process whereby mistakes can be prevented, immediately detected and corrected effortlessly.

SECTION 3

3.1. FINDINGS

Out of the 60 questionnaires issued out, the response rate is satisfactory and a total of 60 responses is gathered.

How often do derailments occur?

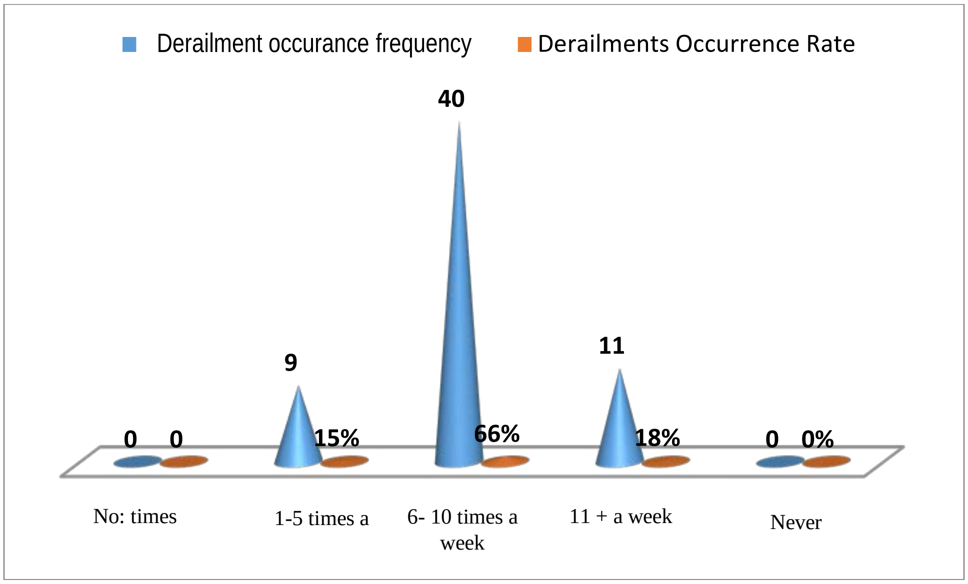

CHART 3: the number of derailments in each period.

(Chart 3) depicts that acording to the employee responses, in a given week 15% of derailments occur, while 66% of the time there are between 6 and 10 derailments, however only 18% of the employees stated that they happen more than 11 times in a month. This causes a huge problem and the yard manager is required to implement a process to ensure that this nightmare ends, remember that there are also costs aligned to derailments as well as the safety and health of the yard employees.

3.1.1. Preventive Maintenance Plan

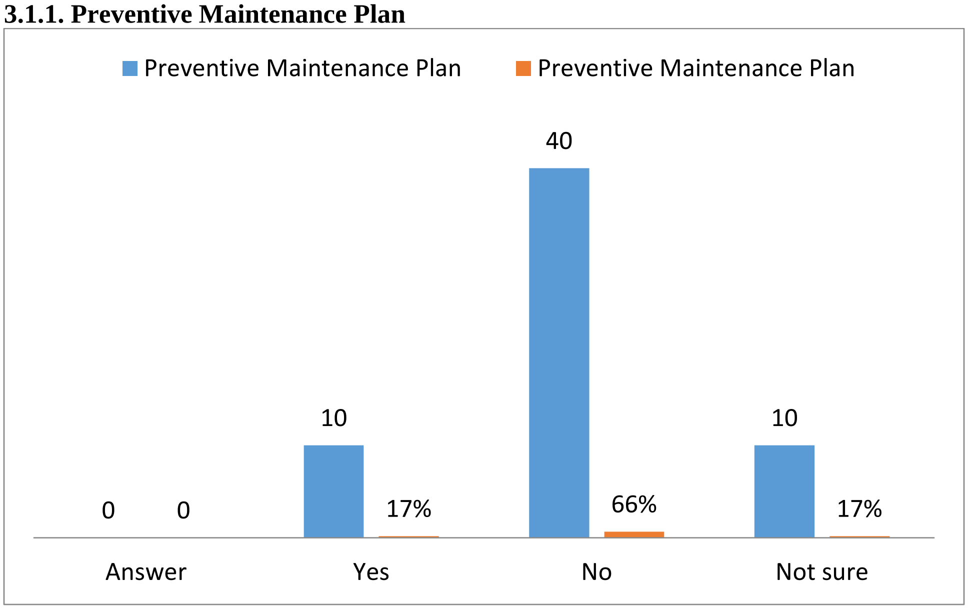

Chart 4: Shows the results of a preventive maintenance plan

66% of employee's respond that there is no preventive maintenance plan at the yard, without this plan the quality of operations is being compromised, thus this means that nothing is being done to avoid these derailments, due to the number of derailments occurring at the yard, action is only taken after such a setback has resulted. Only 17% of employees state that there is a preventive maintenance plan while the remaining 17% are not sure if the plan exists.
Chart 4 further illustrates, the evidence that the maintenance plan is of minimal or no existence in the production processes. Thus, the statistical process control chart (ρ-chart) below, presents the findings on the sampling attributes measuring the percentage defective in a sample.

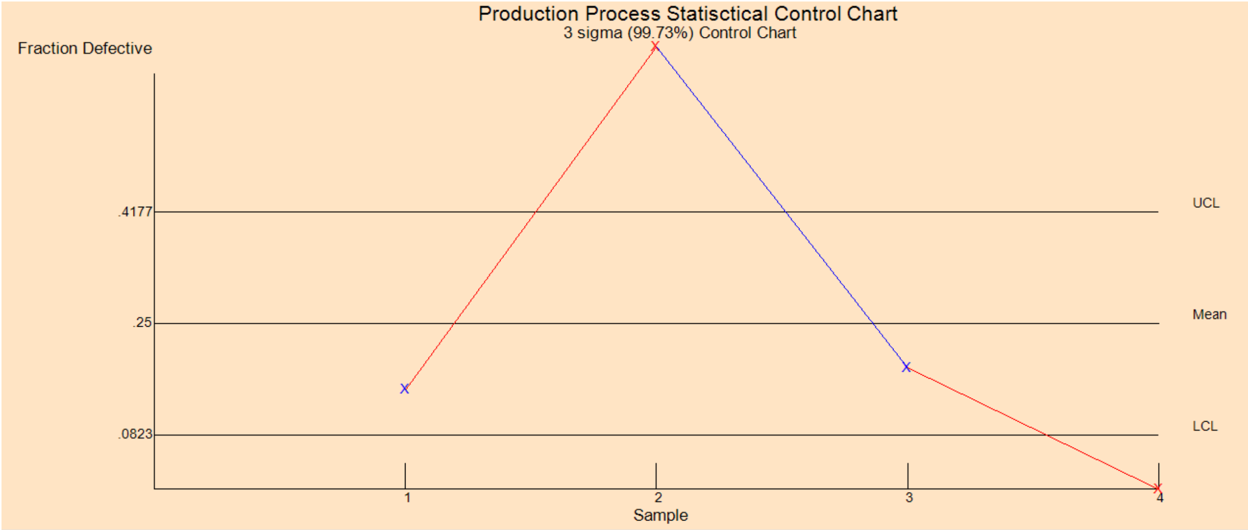

CHART 5: Results on the measurement of percentage defective in a sample

Statistical process control involves establishing standards, monitoring standards, making measurements, and taking corrective action as a product or service is being produced. Samples of process outputs are examined; if they are within acceptable limits, the process is permitted to continue. If they fall outside certain specific ranges, the process is stopped and, typically, the assignable cause is located and removed.

Chart 5 above show two outputs that falls beyond and below the acceptable limits (i.e beyond upper control limit, UCL and below lower control limit, LCL) of this process. It also presents an abnormal (erratic) pattern. Consequently this indicates the need for the investigation of the cause.

The computed UCL and LCL for this process yielded 0.415 and 0.085, respectively.
Where: Samples 1 to 4 represents the range of time the derailments occurred.

Sample 1 → 1 - 5 times
Sample 2 → 6 – 10 times
Sample 3 → 11 times and more
Sample 4 → Never

Thus, percentage defectives for samples 2 and 4 are outside the acceptable limits, with 0.67 and 0.00 proportion of defects. Hence the process is out of control and the cause is to be investigated.

Numerous evaluation/investigative tools such as poka yoke devices, are at deposal to be utilised for effective detection of the deviation.

3.1.2. Poka – yoke devices

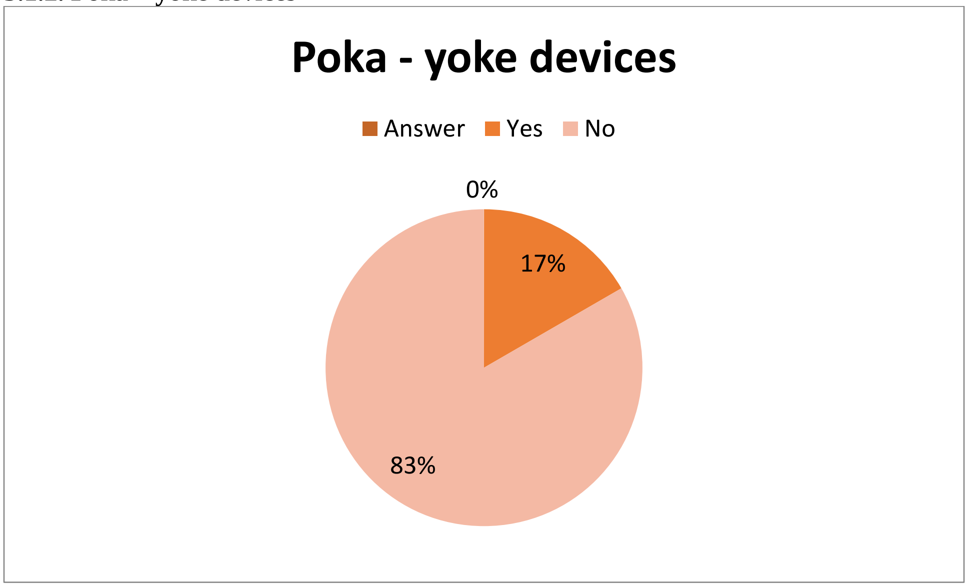

CHART 6: Shows the results of the employees who have heard of poka-yoke devices

The results show that 83% of employees have never had anything about poka yoke devices, while only 17% heard of them, the data reveals that in order for these devices to be put to work, training will be essential in addressing the problem of derailments at yard. These results can come as an aid in introducing new processes that will turn the direction of the company. Existing literature indicates that these devices can be put to work anytime and anywhere (Shingo 1989). Therefore, this approach can be used throughout the organization to improve process reliability and operations.

3.1.3. Leadership and Training

Does management provide training for operating yard points?

CHART 7: Training for yard points

Chart 7 illustrates that atmost 70% of employees have never received any training for yard points but they are expected to control these points. While only 30 % have received training to a certain degree. the results indicate that training is critical because yard points are where trains crossover and derailments are likely to occur at such points. Intensive training should be implemented as soon as possible. The control points within the yard are used to change lines and these operations activities is conducted by yard officials. These officials further use hand tumblers which are thrown to set points for direction, aided by walkie-talkie radios for line-of-sight voice communications. Poor concentration or supervision on communication have been discovered as key point’s related to derailments.

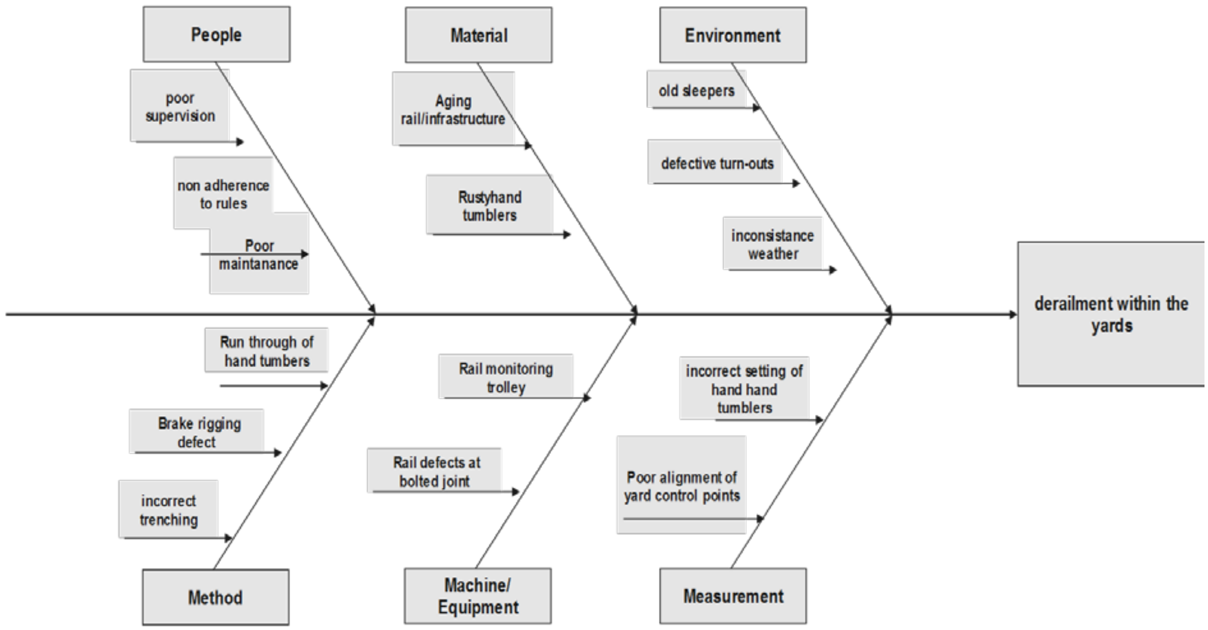

Figure 1: Cause and effect diagram for the causes of derailments

Shunting derailments usually take place at slow speeds, but it still results in extensive damage to rolling stock and infrastructure. They are, however, a significant contributory factor to poor service delivery. Incidences within the shunting yards environment include derailments and collisions were mainly caused by the following aspects:

- Hand tumbler points not set properly.
- Run-throughs of hand tumbler points.
- Shunt movements not supervised properly.
- Poor supervision of rail condition
- Excessive speed in the yards.
- Poor maintenance within yards.
- Aged infrastructure

3.2. SUMMARY

The findings presented the sought answers to the research questions posed in section 1.3. It is indicated that poka yoke devices are the vital means available to be utilised to effectively detect the potential failures and causes of process deviation from average acceptable percentage defective. Once the defects are identified prior to their occurrence, it makes it easy to develop and implement principles and techniques to manage and prevent failure. Thus making the poka yoke devices a solution to manage the derailments in the locomotive industry.

SECTION 4

RECOMMENDATIONS

the use of mistake proofing devices will assist in minimising derailments at TFR. Correctly set yard points will serve as a mistake proofing device as most derailments occur due to the lack of administering correct yard points. If this device is set out correctly drastic changes will be evident and the overall operational capabilities of yard capacity will be achieved.

Based on objective 1 of Investigating the means of minimizing defects in the locomotive industry.

1. Correctly set yard points are fundamental to safe yard operations. The automated point's mechanical system (interlocking system) ensures that a signal indicator to allow a train to proceed over points is only given when it is safe to do so.
2. The automated points are interlocked with a track detection equipment to ensure that the switches cannot be operated whilst a train movement is in process. With hand held tumblers there is no way of asserting that the blades are in position other than by physically assessing them.
3. The automated switch includes a double blade detector to ensure that the switch is completely set and locked. If, however, the switch fails to be correctly set the indicator remains red alerting the train Driver and yard personnel of the potential danger.

Based on objective 2 of investigating the applicability of derailments at TFR.

correctly set yard points will serve as a mistake proofing device as most derailments occur due to the lack of administering of correct yard points. If this device is set out correctly drastic changes will be evident and the overall operational capabilities of yard capacity will be achieved. It is further recommended that training should be implemented immediately for yard points and two other yard safety officials must be employed in the purpose of improving operations at the yard. Very often the derailment is caused by a combination of several contributory causes e.g.: Combination of faults infrastructure and rolling stock and unfortunate train handling/operation. Derailments will continue to be a problem which hampers the objective of the company to be reached. Hand tumblers points (human error) is found as a major cause of derailments within marshalling yards. The problem of hand tumblers points not set correctly can be solved by introducing automated yard points in replacement of manual points tumbler operations within the yards. The automated yards control points are done, points not set correctly and points switched whilst trains or wagons were moving over points will be resolved with this kind of technology.

SECTION 5

CONCLUSION

Derailments are the most common type of train accident on each track type, and most of trains derailed due to points related accidents. Poor adjustment of points and equipment failures are the primary causes of train derailments within the yards, whereas the use of switches and switching rules has a substantial effect on derailment frequency on siding and yard tracks. The interactive effects of derailment speed and accident cause affect train accident frequency and severity.

With the implementation of poka-yoke devices TFR will improve its overall operational capabilities if these devices are being put to work. This will minimise or rather avoid derailments and help find root causes as to why TFR is experiencing such setbacks.

SECTION 6

LIMITATIONS

A **limitation** of this study would be the extent in which management would describe their process designs and models thoroughly as confidentiality can still be reserved or let alone limited to us and thus not getting the precise information. Other business units might consider the use of these mistake proofing devices as a waste of time and this could have a negative impact on our study. Different Business Units use different inspection techniques and they might overlook poka – yoke because they have never heard of it before or they don't just consider it simply because of the entire change of systems process. Another limitation would be the lack of cooperation by employees with the mindset of losing their jobs and not see this as an opportunity for productivity in the workplace.

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Biography

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