Inquiry into the Effectiveness of Eight Discipline-Based Problem-Solving

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ABSTRACT

Purpose: The eight discipline (8D) report is a method for solving problems in industry and is based on an eight-step problem-solving process and is often called an 8D report. The 8D report has been covered in the literature; however, much of the literature on 8D reports only describes the use of 8D reports and fails to evaluate 8D reports empirically. The purpose of this research is to determine if the use of 8D reports combined with training within an organization leads to finding root causes more quickly.

Methodology/Approach: The research uses a mixed-methods approach. A case study describes the implementation of 8D reports in a manufacturing organization in the automotive industry. The paper then looks at five years' worth of data after the implementation of an 8D-based process for addressing quality problems and determined if there is a significant difference in the time to find root causes after the implementation of 8D reports combined with training.

Findings: The research found that the time to solve problems was reduced between the early and later years after the implementation of an 8D process and related training. Faster problem resolution means resources can be redirected elsewhere, as well as a reduction in scrap or rework.

Research Limitation/Implication: The paper only looked at the use of 8D reports in the case study organization.

Originality/Value of paper: This paper provides evidence supporting the effectiveness of 8D reports as an approach to problem-solving. The case study aspect also provides guidance for managers seeking to implement 8D reports in their organizations.

Category: Research paper

Keywords: eight discipline report; problem-solving; training; quality

1 INTRODUCTION

Organizations across industries are confronted with quality failures with impacts potentially reaching customers (Suárez-Barraza and Rodríguez-González, 2019). Good quality is important to customers (Ly Duc and Bilk, 2022) and quality failure costs are often around 20% of an organization's gross sales (Krishnan, 2006). Problem-solving is performed to address the quality failures confronting organizations. The eight discipline (8D) report is a problem-solving methodology in use since the 1970s (Rambaud, 2011) is usually referred to as the 8D report. The 8D report is frequently used in industry; however, there is little research available in the literature on this topic. There is no research into what extent the use of 8D increases the effectiveness of solving the problem, with efficiency understood here as a function of time.

The use of an 8D report in the automotive industry is a requirement of the standard IATF 16949 (Ionescu et al., 2022); however, the literature contains little scientific assessment of the effectiveness of 8D reports and often consists of case studies such as Skurkova and Prjajova (2022) and George, Ranjha, and Kulkarni (2021) and papers of a descriptive nature such as Park and Jeong 2019 and Barsalou, (2023). Empirical evaluations of the effectiveness of 8D reports consist of individual failure investigations and their results. For example, Atigre, Sha and Patil (2017) report a scrap rate reduction from 37.95% to 6.57% after the use of an 8D report to investigate the scrap rate of a coupling disk part. Rathi et al. (2022) describe a 72% reduction in defects after using the 8D methodology to address a gearbox problem. Divanoğlu and Taş (2022) describe a reduction of chronic quality problems from 1,071 ppm (Parts Per Million) to 0 ppm by using the 8D methodology together with a Failure Modes and Effects Analysis (FMEA).

The use of 8D reports has been described in the literature and the use of 8D reports has been shown to be effective in reducing the number of failures in individual cases; however, the impact of large-scale implementation of 8D reports remains unstudied. The results of this study would be useful for managers contemplating the use of 8D reports due to both confirming the effectiveness of 8D reports combined with training, and due to an explanation of how one organization achieved the results.

This paper evaluates the effectiveness of 8D report combined with supporting training in bringing problems to resolution sooner than not using an 8D report. This paper uses the implementation of an 8D-based problem-solving process in a manufacturing organization to determine if the time to solve problems was reduced after the implementation of 8Ds. In addition to implementing 8Ds for problem-solving, the organization began tracking the time it took to solve the problems, and this research looks at and assesses the first five years after implementation.

2 LITERATURE REVIEW

2.1 Background on 8D Reports

The 8D report is often used in the automotive industry for suppliers to report on quality problems and is a common method for problem-solving. The name 8D is short for "eight disciplines" (Bossert et al., 2018) and these eight disciplines are the eight steps required in an 8D report. The 8D report is often said to be based on the United States military standard MIL-STD-1520C: Corrective Action and Disposition System for Nonconforming Material from the 1940s and it became known in the Automotive Industry after being used by Ford Motor Company in the 1970s (Rambaud, 2011). The 8D report provides "a fact-based approach to problem-solving", "a standardized reporting format", and "an outline of the appropriate planning tools and the appropriate analytical tools for each step of the problem-solving process" (Palady and Snab, 2000).

The first step in an 8D report, D1, is establishing a team to solve the problem. The problem is then defined as part of step D2 (Park and Jeong, 2019). Step D3 is where an immediate containment action is implemented, if available, (Barsalou, 2023), step D4 is where a root cause analysis is performed to find both the cause of the failure and the reason the failure was not detected. Permanent corrective actions are chosen and verified in step D5, and the corrective actions are then validated to determine if they are effective during step D6. The seventh step of an 8D is D7, which is where lessons learned are implemented to prevent a reoccurrence of the problem. The final step is D8, where the team is congratulated for their contributions (Jung, Schweisser and Wappis, 2017).

The application of the 8D approach varies between organizations. Various organizations perform the steps differently, although the eight steps of an 8D may remain the same. In one example of the use of an 8D report, an organization received a customer complaint so an 8D team was formed with members possessing the skills needed to address the problem. Data was then collected to describe the problem using facts; in this case, the problem was described as a specific delivery note number on a given date with packaging that did not meet the specification. Specifically, the wrong box was used (Alexa and Kiss, 2016).

Biban, Dhounchak and Shakti (2017) present an 8D report case study for a broken mounting lug. The step D2 problem description was based on questions that were part of the 8D form. The document asked what the problem was, why it was a problem, where it was detected, who detected it, when was it detected, and how many were detected. This 8D also asked what the specification requirement was and what was observed. In addition, it asked for the lot size.

Two step D3 actions were described by Skurkova and Prjajova (2022) to address an imprint on an automotive seat covering. To protect the customer from defective parts, an external organization was contracted to perform a 100% check of all seat covers on the customer's assembly line and a quality wall was

implemented in the organization with a check of all seats directly after assembly in the organization.

Darekar et al. (2013) presented a case study of 8D use for a vehicle fuel line leakage. In this example, brainstorming was used to create an Ishikawa diagram as part of step D4. For step D5, corrective actions, the authors explained that multiple actions would be implemented to correct the brainstormed ideas. The fuel line bracket design was changed, vibration proofing was added, and a change in the production process was made to account for a potential assembly-related failure cause.

Customer complaints pertaining to drywall screws were investigated using an 8D report. An Ishikawa diagram was created and the hypotheses in the Ishikawa diagram were investigated. Four different quality problems were identified, so four corrective actions were developed as part of step D5. Statistical methods such as capability studies and the paired t-test were then used to verify the effectiveness of the corrective actions as part of step D6. Lessons learned from the investigation were carried over into drawings and standards as part of step D7 (Chen and Cheng, 2010).

George, Ranjha and Kulkarni (2021) used an 8D report to address the failure of train wheel bearings. The issue was closed at step D8 after the root cause was validated as a historical problem that would not occur again, resulting in an avoidance of an estimated $3,700,000 in costs for replacing bearings. The investigation was documented prior to closing of the issue.

2.2 Background on Training in Industry

Training in an organization is an essential strategy for ensuring employees gain necessary new skills (Nafukho et al., 2023), and can be readily conducted to teach employees how to use an 8D report (Reidemeister, 2016). Employees are normally adult learners and receptive to many training approaches. Adult learners are often described as being over 25 years of age and being employed full-time, although younger people may qualify for this description (Chen, 2017).

Adult learners differ from younger students and there are things that need to be considered when teaching them. Tielker (2019) recommends providing adult learners with a brief presentation with key points and then splitting the training participants into groups to perform tasks. The groups should then discuss their results with each other. Tielker (2019) also recommends encouraging jokes and having the participants share knowledge with each other.

Training may be presented online as e-learning. There are six steps to developing content for e-learning; performing a needs assessment, developing the training material, developing the media, testing the training, production, which is where the training is presented, and assessing the training (Caudill, 2013). Training may also consist of blended learning, which is a combination of online learning and

classroom-based learning; however, it is critical to ensure instructors are competent in creating and delivering blended learning (Abusalim et al., 2020).

Training is an investment for an organization and the results of training can only be considered as a success if the material learned can be applied in practical situations. Organizations conduct training to pass critical information on to employees so that employees understand and can use tools and systems, to fill in gaps in employees' knowledge, and to improve the organization's culture (Tielker, 2019).

Training in industry is not the same as education. The objective of education is much broader than training. Education seeks to impart knowledge of facts and theories in a wide range of topics. Training is more specific and is oriented towards a specific process or task (Dew, 2021). Training within an organization may be conducted by external trainers hired to deliver the training, or internal trainers, such as SMEs (subject matter experts). Internal SMEs often lack training skills (Boyers, 2017), but should be considered when the training is specific to the organization, or it will be repeated often. In such cases, the selected trainers should be trained in training-specific skills, such as "Train-the-Trainer" (Carnell, 2019).

Training is critical for promoting a quality culture within an organization and is used to improve the skills of employees to pursue continuous improvement (Els and Meyer, 2022). A potential quality-related training topic is the use of 8D reports and Reidemeister (2016) presents the following example of a training agenda, consisting of explaining reasons to use 8D reports and the 8D process, explaining the 8D method for corrective actions, comparing problem-solving methods, group exercises using 8D reports, communicating with customers during problem-solving, and review of a case study.

Organizations use different strategies for training and development, although there are similarities between the approaches used. The most common method is instructor-led training in a classroom environment, followed by coaching/mentoring, and finally e-learning (Schallock et. al., 2018).

There are many approaches and models that can be used when conducting training. The what, why, and how model of teaching begins with an explanation of what will be taught, moves on to an explanation of why the subject matters and how it can be applied, and then an activity is performed to demonstrate how to perform the task being taught (Dew, 2018).

Training should be informal, the class size should be low, and case studies should be used. Training can also be broken down into very short segments that only cover one topic. Reidemeister (2016) gives the example of an organization that does weekly one-and-a-half-hour long training sessions; the duration is sufficient for covering the material, without disrupting the workday.

Organizational training efforts are more successful when they have both sophisticated training systems and strong management support. An example of a

training system was presented in an organization that started with summary training for upper management, followed by a training plan for staff. This was then followed by basic and advanced sessions for line management with later coaching and guidance. An advantage of this approach was getting top management support for the training (Schallock et. al., 2018).

3 METHODOLOGY

This paper uses a mixed methods approach. Mixed methods research combines qualitative data and quantitative data (Cameron and Molina-Azorin, 2011). First, a case study is presented. A case study is a form of qualitative research that explores a single unit, such as one organization or event (Alam, 2021), and provides more details on the specific case to illustrate real-world phenomenon. (Verleye, 2019). Case studies can be supplemented with quantitative data (Amadi, 2022) and this paper then uses statistical methods to support the case study.

The organization in this paper was a large tier 1 supplier producing parts for Original Equipment Manufacturers (OEMs) in the automotive industry. The organization was confronted by a large number of customer complaints due to failed parts being detected both at customers' facilities and in vehicles driven by end-users. The number of failures of a given failure type was sometimes in single digits, but the customers had a zero defects expectation. In other cases, problems were statistically extensive. In one example, nearing five repairs per one thousand deliveries. Regardless of the failure rate, all the failures needed to be addressed.

To address the failures, a problem-solving team was formed. There were two people and one location in the first year; two additional people in other locations joined the team late in the second year. In total, there were representatives of the team present at manufacturing and assembly sites in three countries located in Asia, Europe, and North America. The problem-solving team supported employees in using the 8D methodology. The number of problem-solving team members grew between years two and five as the methodology demonstrated its value to the organization. As the methodology evolved, the level of support varied between problems and ranged from simply providing process coaching to fully leading all problem-solving activities. However, even with the team's growth, the number of problem-solving team members was relatively low and only a small of percentage the total problems were actively supported by a problem-solving team member.

The problem-solving team also provided extensive training to the organization starting in the year after the team was formed. The training participants were adult learners and the trainers, who were members of the problem-solving team, were SMEs. The training consisted of a 30-minute online e-learning training followed by three different three-hour instructor-led sessions. This training was

used to communicate organization-specific norms and deliverables for each 8D step, and additionally worked through many full 8D examples. Student feedback, as well as practical experience, led to continuous improvements in the training material and the process documentation.

A spreadsheet was used by the problem-solving team to track the status of every customer-reported failure. Each problem was entered into the spreadsheet along with the name of the customer, the exact product that failed, a description of the problem, the name of the team leader, the date the problem started, the date the problem was closed, details pertaining to the status of the problem, the location where the failure occurred, and the name of the specific part or component that failed.

Five complete years' worth of data were available, so they were used in this study. The details have been changed to protect the anonymity of the organization; the years were changed to first through fifth and the days to close the problem were changed by multiplying all the data by the same random number.

During the period of the study, specifically, after year two, a Key Process Indicator (KPI) metric was established in the organization to track the time from D0 declaration to D4 completion. This metric had a target set annually to drive continuous improvement for the problem-solving process and was 5% of the formulation of the organization's annual performance bonus. The timeline of events is depicted in Fig.1.

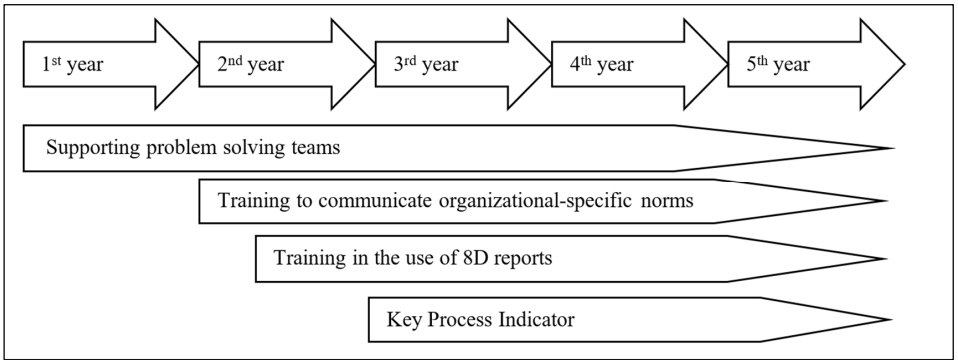

Figure 1 – Improvement of 8D Problem Solving – Supporting Actions

4 RESULTS

Three items were excluded from the study due to missing closing dates; the status of the problems had been entered into the date fields, instead of the actual dates. Problems started before the first year were also excluded; these were the older problems that had still not been solved by the time the use of 8D reports was implemented and they would have skewed the data, since older problems that had been solved were not open long enough to be entered into the new tracking list.

In total, there were 85 remaining problems investigated over the course of the five years of the dataset. Table 1 displays summary statistics for the problems from the spreadsheet.

Table 1 – Summary Statistics for Time to Problem Closure by Year

Year opened	Total count of problems	Mean number of days	Median number of days
First	25	21.24	21.2
Second	12	19.37	20.1
Third	20	11.44	9.7
Fourth	20	7.96	6.3
Fifth	8	6.03	6.5

The data were analysed using Analysis of Variance (ANOVA) to determine if there was a statistically significant difference in the means of the time to problem closure for each of the five years. An ANOVA is used for determining if there is a difference in means between multiple samples of data. Data should be normally distributed when performing ANOVA, so probability plots were created that graphed the values against the expected percentiles to determine if the data are normally distributed (Montgomery, Runger and Hubele, 2001). The null hypothesis is "the data are not normally distributed" and the alternative hypothesis is "the data are normally distributed." An Alpha value of 0.05 was used and the probability plots in Table 2 show p-values less than 0.05 for the first and fourth years. An ANOVA can still be performed; however, caution is warranted when interpreting the resulting p-values.

Table 2 – Summary Statistics for Probability Plots of Anonymized Days

Year	Mean	StDev	N	AD	P-Value
First	21.24	13.94	25	0.758	0.042
Second	19.37	10.16	12	0.126	0.978
Third	11.14	8.031	20	0.582	0.115
Fourth	7.957	5.624	20	0.828	0.027
Fifth	6.034	4.100	8	0.211	0.783

Notes: StDev – Standard Deviation; N – Sample Size; AD – Anderson Darling.

The ANOVA was performed using Welchs's method in the software program Minitab, version 17 (see Fig. 2). Welch's method assumes that the distributions of each data set are not the same. The null hypothesis is "all means are equal" and the alternative hypothesis is "not all means are equal" (Barsalou and Smith, 2019) and an Alpha of 0.05 was used. The resulting p-value was less than 0.05, therefore the null hypothesis was rejected.

One-way ANOVA: First Year; Second Year; Third Year; Fourth Year; Fifth Year

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were not assumed for the analysis.

Factor Information

Factor	Levels	Values
Factor	5	First Year; Second Year; Third Year; Fourth Year; Fifth Year

Welch's Test

Source	DF Num	DF Den	F-Value	P-Value
Factor	4	33.0624	8.77	0.000

Model Summary

R-sq	R-sq(adj)	R-sq(pred)
28.09%	24.50%	20.24%

Means

Factor	N	Mean	StDev	95% CI
First Year	25	21.24	13.94	(15.49; 27.00)
Second Year	12	19.37	10.16	(12.91; 25.82)
Third Year	20	11.44	8.03	(7.68; 15.20)
Fourth Year	20	7.96	5.62	(5.32; 10.59)
Fifth Year	8	6.03	4.10	(2.61; 9.46)

Figure 2 – ANOVA Results for Time to Closure by Year

An ANOVA shows only that there is a difference in one or more means; it does not show which means differs, so an interval plot is used to determine which confidence intervals do not overlap. The interval plot in Fig. 3 shows a difference between the first year and years three through five. The second-year overlaps with both the first and third years and the last two years only overlap with the third year, indicating a statistically significant difference between the first two years and the last two years.

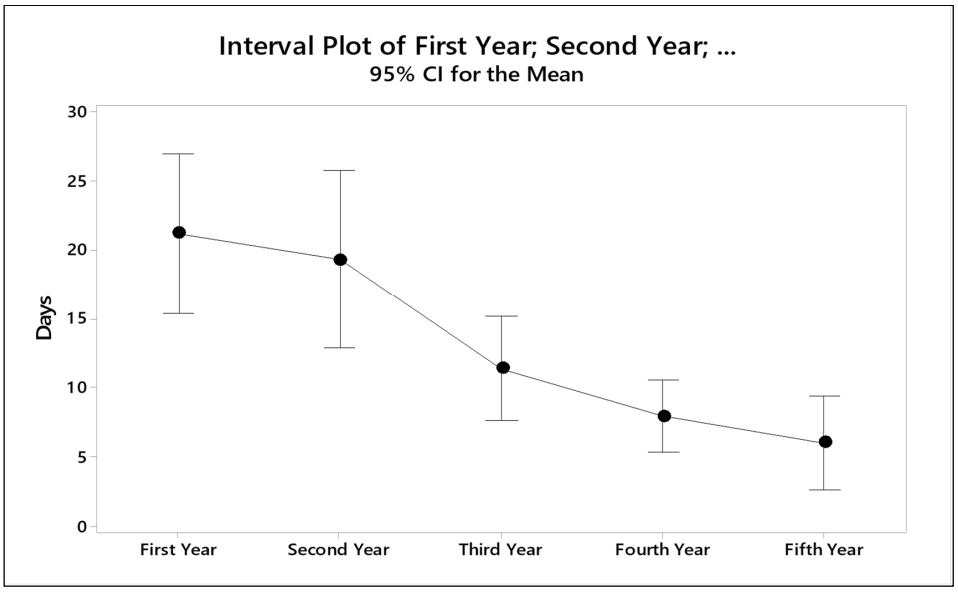

Figure 3 – Interval Plots for Time to Closure by Year

The ANOVA can't be fully trusted due to the lack of normality for two of the years, so the data were also analysed using a distribution-free test that does not require the data to follow the normal distribution. Here, Mood's median test was selected, as it compared the median value in each data set, and it did not require the distribution of the data sets to have the same shape (Barsalou and Smith, 2019). The null hypothesis is "all population medians are equal" and the alternative hypothesis is "not all population medians are equal". An Alpha of 0.05 was used and the p-value of 0.022 shown in Fig. 4 indicates that the null hypothesis should be rejected. This is additional evidence that there is indeed a statistically significant difference between the data in the years.

Mood Median Test: Anonymized Days versus Year Opened

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Mood median test for Anonymized Days
Chi-Square = 11.45    DF = 4    P = 0.022

                                    Individual 95.0% CIs
Year Opened  N<=  N>  Median  Q3-Q1  -------+---------+---------+---------
Fifth Year     7   1     6.5    7.3  (-----*-----)
First Year     9  16    21.2   21.8            (---------------*-------)
Fourth Year   13   7     6.3    8.8     (--*-------)
Second Year    3   9    20.1   15.0               (------------*-------)
Third Year    11   9     9.7   10.0        (----*----)
                                    -------+---------+---------+---------
                                         7.0      14.0      21.0

Overall median = 10.6
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Figure 4 – Mood's Median Test for Time to Closure by Year

The data indicate that problems took longer during the first and second years after the implementation of a problem-solving team using 8D reports, so the first and second years were combined and then the remaining years were combined into a second set of data to determine if problems were solved in less time two years after implementation. This data was then analysed using the Student's two-sample t-test to determine if the mean of the first two years was higher than the mean of the second two years with a given level of statistical confidence (see Fig. 5). A Student's two-sample t-test is robust to non-normal data and works well with heavily skewed data if sufficient data is available. The Alpha used was 0.05 and the resulting p-value was less than 0.05, so the null hypothesis was rejected. There was a statically significant difference between the first two years and the last three years.

Two-Sample T-Test and CI: First and second year; Third, fourth, and fifth year

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Two-sample T for First and second year vs Third, fourth, and fifth year

                          N  Mean  StDev  SE Mean
First and second year     37  20.6   12.7      2.1
Third, fourth, and fifth  48  9.09   6.77     0.98


Difference = μ (First and second year) - μ (Third, fourth, and fifth year)
Estimate for difference:  11.55
95% lower bound for difference:  7.68
T-Test of difference = 0 (vs >): T-Value = 5.00  P-Value = 0.000  DF = 51
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Figure 5 – Two Sample t-test for First Two Years versus Last Three Years

The time to solve a problem was reduced by the third, fourth, and fifth years.

5 DISCUSSION

This study found a reduction in time to solve problems from the first two years after the implementation of 8D reports to the third to fifth years after the implementation of 8D reports. However, there are limitations to the study. The study was centered on only one organization and in addition to implementing 8D reports together with training, a problem-solving team was formed. The problem-solving team was only involved in a limited number of problems but may have still influenced the results. For example, the problem-solving team may have been involved with the more difficult problems that would have taken other employees longer to solve. Furthermore, a KPI metric was implemented during the third year and the metric could have provided employees with an additional incentive to solve problems quicker. The study also lacked a baseline for time to solve problems; therefore, it was not possible to determine if the time to solve problems in the first two years was less than the time to solve problems prior to the use of the 8D methodology and it is unclear if the time to solve problems will continue to be reduced in subsequent years, or if the time to solve problems will plateau or start to increase.

Problems were solved faster with the use of 8D reports together with training. Much of the reduction in time may be attributed to identifying root causes sooner, due to use of the 8D method as a structured approach to problem-solving. However, the direct impact of an 8D report alone remains underdetermined. An opportunity for future research would be to randomly assign employees to either using an 8D report, or not using an 8D report within one organization that is not experienced or trained in 8D reports. Such a study could be used to evaluate 8D reports without the impact of other influences. An additional opportunity for further study would be to repeat the study by implementing the use of 8D reports together with training, but only after establishing a baseline level of performance, so that the time to solve problems before and after implementation can be directly compared.

Having a spreadsheet with known problems can be helpful if a problem reoccurrence; investigators can check to see if the root cause has occurred again. However, a reoccurrence of a problem should not happen if lessons learned were correctly implemented as step D7 of the 8D report.

Much of the current literature on 8D reports consists of case studies, such as Skurkova and Prjajova (2022), instructional papers, such as Barsalou (2023), and assessments of individual cases solved using 8D reports, such as Divanoğlu and Taş (2022). This study has shown that the 8D report, in combination with training, is an effective method for reducing the time to solve problems.

The study has implications for managers. An organization confronted by quality failures can implement both the 8D methodology and training to support the 8D methodology. This study did not assess the short-term impact, but over the long-term, the time required to solve problems can be reduced.

6 CONCLUSION

A large international organization in the automotive industry was confronted by customer complaints due to failed parts. Therefore, the organization implemented the use of 8D reports as both a report and a problem-solving methodology. A problem-solving team was also formed to provide 8D-related support and to conduct training in the 8D methodology.

Problems were tracked in a spreadsheet that contained five years' worth of data. The data was statistically analysed and a statistically significant reduction in time to solve problems was identified when the first two and last three years were compared. Based on the results of this study, managers should consider implementing the 8D methodology organization-wide, together with systematic training in how to apply the 8D methodology.

REFERENCES

Abusalim, N., Rayyan, M., Jarrah, M., and Sharab, M., 2020. Institutional adoption of blended learning on a budget. *International Journal of Educational Management*, [e-journal] 34(7), pp.1203-1220. DOI: 10.1108/IJEM-08-2019-0326.

Alam, M.K., 2021. A systematic qualitative case study: Questions, data collection, NVivo analysis and saturation. *Qualitative Research in Organizations and Management*, [e-journal] 16(1), pp.1-31. DOI: 10.1108/QROM-09-2019-1825.

Alexa, I. and Kiss, I., 2016. Complaint analysis using 8D method within the companies in the field of automotive. *Review of Faculty of Engineering*, [e-journal] 10(1), pp.16-21. DOI: 10.14232/analecta.2016.1.16-21.

Amadi, A., 2022. Integration in a mixed-method case study of construction phenomena: From data to theory. *Engineering, Construction and Architectural Management*, [e-journal] 13(3), pp.61-74. DOI: 10.1108/ECAM-02-2021-0111.

Atigre, P.S., Sha, A.P. and Patil, V.R., 2017. An application of 8D methodology for minimizing the defects in manufacturing process: A case study. *International Journal of Engineering Research & Technology*, 6(9), pp.123-126.

Barsalou, M. and Smith, J., 2019. *Applied statistics manual: A guide to improving and sustaining quality with Minitab.* Milwaukee, WI: Quality Press.

Barsalou, M., 2023. Back to basics: 8D or A3*? Quality Progress*, 56(1), pp.56.

Biban, L.K. and Dhounchak, D. and Shakti, 2017. 8D Methodology: From concept to application across manufacturing industries. *International Journal of Scientific Research in Science, Engineering and Technology*, 3(6), pp.558-563.

Bossert, J., Duffy, G.L., Reid, D.R. and Rooney, J.J., 2018. Speaking your language. *Quality Progress*, 51(8), pp.16-37.

Boyers, P.E., 2017. Back to basics: Maintaining knowledge. *Quality Progress*, 50(5), pp.64.

Cameron, R. and Molina-Azorin, L.R., 2011. The acceptance of mixed methods in business and management research. *International Journal of Organizational Analysis*, [e-journal] 19(3), pp.256-271. DOI: 10.1108/19348831111149204.

Carnell, M., 2019. Six Sigma solutions: A sign of the times. *Quality Progress*, 52(4), pp.50-52.

Caudill, J.G., 2013 Designing workplace E-Learning. B*ulletin of the IEEE Technical Committee on Learning Technology*, 15(4), pp.19-21.

Chen, H.R. and Cheng, B.-W., 2010. A case study in solving customer complaints Based on the 8Ds method and Kano model. *Journal of the Chinese Institute of Industrial Engineers*, 27(5), pp.339-350.

Chen, J.C., 2017. Nontraditional adult learners: The Neglected Diversity in Postsecondary Education. *SAGE Open*, [e-journal] 7(1), pp.1-12. DOI: 10.1177/2158244017697161.

Darekar, S., Pendum, D.V., Shukla, P. and Joshi, P., 2013. Systematic fact finding and problem solving for leakage in high pressure line in diesel engine. *MR International Journal of Engineering and Technology*, 5(1), pp.39-44.

Dew, J.R., 2018. Learning sbout learning. *Quality Progress*, 51(7), pp.30-35.

Dew, J.R., 2021. The right mix. *Quality Progress*, 54(5), pp.22-27.

Divanoğlu, S.U. and Taş, Ü., 2022. Application of 8D methodology: An approach to reduce failures in automotive industry. *Engineering Failure Analysis*, [e-journal] 134, 106019. DOI: 10.1016/j.engfailanal.2021.106019.

Els, R.C. and Meyer, H.H.W., 2022. Leaders' attitudes towards, and commitment to quality management of training within the military. *The TQM Journal*, [e-journal] 34(7), pp.1-17. DOI: 10.1108/TQM-09-2021-0259.

George, A., Ranjha, S. and Kulkarni, A., 2021. Enhanced problem solving through redefined 8D step completion criteria. *Quality Engineering*, [e-journal] 33(4), pp. 695-711. DOI: 10.1080/08982112.2021.1969665.

Ionescu, N., Ionescu, L.M., Rachieru, N. and Mazare, A.G., 2022. A model for monitoring of the 8D and FMEA tools interdependence in the era of Industry 4.0. I*nternational Journal of Modern Manufacturing Technologies*, [e-journal] 14(3), pp.86-91. DOI: 10.54684/ijmmt.2022.14.3.86.

Jung, B., Schweisser, S. and Wappis, J., 2017. *8D- Systematsich Probleme lösen.* 3rd ed. Munchen: Carl Hanser Verlag.

Krishnan, S.K., 2006. Increasing the visibility of hidden failure costs. *Measuring Business Excellence*, [e-journal] 10(4), pp.77-101. DOI: 10.1108/13683040610719290.

Ly Duc, M. and Bilk, P., 2022. Zero defect manufacturing using digital Numerical control. *Management and Production Engineering Review*, [e-journal] 13(3), pp.61-74. DOI: 10.24425/mper.2022.142383.

Montgomery, D.C., Runger, G.C. and Hubele, N.F., 2001. *Engineering statistics.* 2nd ed. New York: John Wiley and Sons.

Nafukho, F.M., Irby, B. J., Pashmforoosh, R., Lara-Alecio, R., Tong, F., Lockhart, M.E., El Mansour, W., Tang, S., Etchells, M. and Wang, Z., 2023. Training design in mediating the relationship of participants' motivation, work environment, and transfer of learning. *European Journal of Training and Development*, [e-journal] 47(10), pp.112-132. DOI: 10.1108/EJTD-06-2022-0070.

Palady, P. and Snabb, T., 2000. *TAPS: A total approach to problem solving*. USA: PAL Publishing.

Park, B. and Jeong, J., 2019. A novel rule-based MPS model for SME manufacturing factory in Korea. *Procedia Computer Science*, [e-journal] 155, pp.716-721. DOI: 10.1016/j.procs.2019.08.103.

Rambaud, L., 2011. *8D structured problem solving: A guide to creating high quality 8D Reports.* 2nd ed. Breckenridge: PHRED Solutions.

Rathi, R., Reddy, M.C.G., Narayana, A.L., Narayana, U.L. and Rahman, M.S., 2022. Investigation and implementation of 8D methodology in a manufacturing system. *Materials Today: Proceedings*, [e-journal] 50(5), pp.743-750. DOI: 10.1016/j.matpr.2021.05.273.

Reidemeister, E., 2016. All under one roof. *Quality Progress*, 49(3), pp.24-28.

Schallock, B, Rybski, C., Jochem, R. and Kohl, H., 2018. Learning factory for Industry 4.0 to provide future skills beyond technical training. *Procedia Manufacturing*, 23, pp.27-35.

Skurkova, K.L. and Prajova, V., 2022. 8D report application in production process of rear seat. *MM Science Journal*. (Preprint). DOI: 10.17973/MMSJ.2022_11_2022139.

Suárez-Barraza, M.F. and Rodríguez-González, F.G., 2019. Cornerstone Root Causes Through the Analysis of the Ishikawa Diagram, is it Possible to Find Them? A First Research Approach. *International Journal of Quality and Service Sciences*, [e-journal] 11(2), pp.302-316. DOI: 10.1108/IJQSS-12-2017-0113.

Tielker, A., 2019. Back to basics: A formula for learning. *Quality Progress*, 52(7), pp.56.

Verleye, K., 2019. Designing, writing-up and reviewing case study research: An equifinality perspective. *Journal of Service Management*, [e-journal] 30(5), pp.549-576. DOI: 10.1108/JOSM-08-2019-0257.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.