The Effect of Six Sigma on TVET Course Syllabus Development Learning Institutions in Pasir Gudang, Johor

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Abstract

There are a few major components learning institutions would look out for in their course syllabus while playing a vital role in the performance of technical and vocational education and training in any academic or student outcome. The process structure determines whether the students gaining knowledge and skills are in the condition of improvements from the previous syllabus or have the ability to adopt the knowledge in the future. The Six Sigma methodology has extensively been used as a structured approach to problem-solving, and it shall be used to test the potential effects of improvements obtained from the previous syllabus. This study was conducted in educational institutions in Pasir Gudang, Johor, to observe how Six Sigma implementation applies in affecting the structural processes in the syllabus. A sample of 176 members of the academic department were randomly selected and requested to complete a questionnaire on how the Define-Measure-Analyze-Improve-Control (DMAIC) method has influenced the structural procedures of their course syllabus. By using Statistical Package for the Social Sciences (SPSS), more time is available for the researcher to appreciate the underlying assumptions of the various methods utilized in carrying out the correlation and regression studies. The findings indicated that the core field of study and knowledge of standard requirements significantly affect course syllabus process structure and Six Sigma. It is recommended by the researcher that other organisations, especially in the Technical and Vocational Education and Training (TVET) institutions, to apply the DMAIC strategy in the course syllabus process structure. Six Sigma is applicable to be used to improve the course syllabus process structure.

Keywords: TVET, Six Sigma, DMAIC, course syllabus, learning institutions.

Introduction

Technical and Vocational Education and Training (TVET) programs are essential for providing learners with the practical skills required to fulfil industrial needs. Nonetheless, their efficacy is frequently compromised by various obstacles, such as obsolete curriculum, inadequate alignment with industry benchmarks, and insufficient incorporation of developing technology (Khalid et al., 2021). The inefficiencies yield graduates inadequately equipped for the job market, raising questions over the relevance and efficacy of TVET programs in mitigating skills shortages (Renaud, 2009). This necessitates the identification of systemic barriers and the formulation of initiatives to enhance TVET outcomes.

Numerous structural problems impede TVET institutions from achieving their maximum potential. Resource limitations, the absence of standardised quality assurance protocols, and inadequate teacher preparation intensify these issues (Amudalat & Yusuf, 2024). Moreover, stakeholders, such as policymakers and administrators, frequently have difficulties in ensuring coherence between educational programs and labour market demands (Joo, 2018). Consequently, comprehending the determinants influencing TVET success is essential for formulating effective solutions.

Innovative approaches such as Six Sigma's Define-Measure-Analyze-Improve-Control (DMAIC) framework provide a systematic strategy for tackling these inefficiencies. Although widely utilised in manufacturing and service industries, the application of DMAIC in the educational sector, especially for enhancing TVET performance, is yet inadequately investigated (Sabtu & Matore, 2023). The deficiency in the research highlights the necessity to examine the particular effects of DMAIC on curriculum design, instructional quality, and program efficiency (Jayamohan & Bhasi, 2024).

The incorporation of Six Sigma methodologies into the development of TVET syllabuses has garnered considerable interest as a strategy for enhancing educational quality and relevance. The structured approach of Six Sigma, especially the DMAIC model, is gaining traction in education to improve teaching-learning processes, optimise resource use, and align curricula with industry standards (Jayamohan & Bhasi, 2024).

Research demonstrates that the application of Six Sigma in higher education can result in systematic enhancements in curriculum design and delivery, therefore improving teaching effectiveness and students' satisfaction (Toqir et al., 2024). By utilising quality control techniques inside the Six Sigma framework, educational institutions can gain a comprehensive understanding of their operations and make specific enhancements to rectify inadequacies (Sabtu & Matore, 2023).

Furthermore, the implementation of Six Sigma in TVET has demonstrated an enhancement in operational efficiency and the cultivation of a dynamic learning environment that more effectively addresses the requirements of stakeholders, including students and employers (Haerizadeh & Sunder, 2019).

Traditional curriculum framework and the TVET curriculum syllabus model can exhibit parallels and differences. This study aims to address this gap by examining the application of DMAIC in improving TVET learning, and identifying strategies to align educational offerings with industry needs.

Although it holds promise, implementing DMAIC in educational settings poses distinct problems. Cultural opposition, insufficient knowledge in quality management, and misaligned institutional objectives frequently obstruct successful implementation (Haerizadeh & Sunder, 2019). Furthermore, the absence of customised frameworks for implementing DMAIC in TVET environments needs study to investigate adaptations that can efficiently overcome these obstacles.

This study seeks to fill existing gaps by analysing the implementation of DMAIC in enhancing TVET outcomes, exploring systemic barriers to performance, and identifying strategies to align educational programs with industry requirements. The findings will enhance the relevance, efficiency, and impact of TVET programs, ensuring the production of industry-ready graduates who can contribute to economic growth.

Addressing these challenges requires an examination of the integration of structured methodologies, such as DMAIC, into the operational framework of TVET institutions. Research must concentrate on identifying optimal practices, quantifying the concrete advantages of DMAIC implementation, and investigating strategies to address potential challenges. This research seeks to connect theoretical frameworks with practical applications, thereby improving the ability of TVET programs to produce graduates who are prepared for industry. It addresses the question of how DMAIC and similar tools can be adapted to tackle the practical challenges that TVET programs encounter in aligning educational outcomes with industry needs.

Literature Review

TVET programs are acknowledged worldwide for their crucial role in providing individuals with skills that are pertinent to industry needs, enhancing employability, and responding to the requirements of the labour market. The performance of TVET programs frequently falls short, influenced by systemic challenges including outdated curricula, inadequate industry alignment, and restricted resource allocation (Khalid et al., 2021). Research shows that these inefficiencies result in graduates who lack adequate preparation for the job market, which diminishes the significance of TVET in achieving economic and social objectives (Renaud, 2009). Although certain institutions have progressed in refining their methodologies, numerous others continue to face challenges in ensuring quality and consistency in program delivery (Amudalat & Yusuf, 2024).

In addressing these problems, organised quality management approaches such as Six Sigma, namely its DMAIC framework, have been suggested as viable solutions. The DMAIC paradigm offers a structured approach for detecting inefficiencies, quantifying results, and executing enhancements. Research has shown the relevance of Six Sigma in educational settings, including improvements in curriculum quality, teaching methods, and operational efficiency (Jayamohan & Bhasi, 2024). Integrating DMAIC into educational processes has led to increased student satisfaction and enhanced program outcomes (Sabtu & Matore, 2023). Implementing Six Sigma in educational institutions faces obstacles due to cultural opposition and insufficient skills in quality management, which often hinder acceptance (Haerizadeh & Sunder, 2019).

TVET programs exist inside intricate institutional frameworks where resource limitations, organisational culture, and industry dynamics converge to affect outcomes. To effectively implement Six Sigma, institutions must consider these contextual aspects while aligning their tactics with overarching educational objectives. Models such as Tinto's Institutional Integration Theory and the Theory of Planned Behaviour have been utilised in TVET research to comprehend the relationship between institutional practices and student results (Renaud, 2009). These models indicate that synchronising institutional initiatives with student expectations and industry requirements is essential for success. Nonetheless, deficiencies remain in the adaptation of these ideas to include structured quality improvement methodologies like DMAIC into institutional practices.

The current literature emphasises the potential of Six Sigma approaches in mitigating inefficiencies in TVET while also identifying considerable obstacles. Research on the use of DMAIC in various educational contexts, especially in resource-limited settings, remains sparse (Sabtu & Matore, 2023). Addressing these problems necessitates a twofold strategy: enhancing institutional capacity for quality management and formulating context-specific frameworks that connect theoretical models with practical applications.

Hence, it can be deduced that TVET programs and Six Sigma can reduce educational inefficiencies, but their combination faces structural and operational challenges. This study examines possible Six DMIAC integration methods for TVET contexts and proposes a framework that aligns institutional practices with industrial needs to improve education quality for students. The capability of Six sigma DMIAC flow is tabulated in Table 1.

Table 1. The DMAIC Phases adopted (Abdulla & Kavilal 2022).

Phase	Details
Define (D)	Educational institutions identify key problem and goals areas that need improvement, such as suitable course syllabus, structure program, and program learning outcome.
Measure (M)	Institutions collect data on various performance metrics, such as assessment of internal academic and industry, evaluations of program structure and industry feedback. This data provides a baseline for assessing the course syllabus development for the program.
Analyse (A)	Examining the collected data to identify root causes of performance issues. This may involve analyzing trends, correlations, and patterns in student performance data.
Improve (I)	Implementing solutions to address the identified root causes. This could include revising the curriculum, enhancing teaching methods, and taking industry advise on new program development.
Control (C)	Sustaining the improvements made. This involves setting up monitoring systems, regular reviews, and continuous feedback mechanisms to ensure that performance gains are maintained.

Table 1 illustrates that Six Sigma can significantly influence TVET and education, enhancing performance and outcomes. Educational institutions can identify and rectify issues systematically through the DMAIC methodology, resulting in increased student satisfaction, higher retention rates, and improved employment opportunities. Previous studies indicate that Six Sigma can enhance various aspects of education, including the development of course outlines, the improvement of facilities to facilitate student learning and performance, the formation of collaborative learning groups, and the overall enhancement of teaching and learning processes (Abdulla, A., & Kavilal, 2022; Arafeh, M., et al., 2021; MacIel-Monteon et al., 2020). Six Sigma's systematic approach guarantees that improvements are based on data, remain uncomplicated, and yield enduring solutions. It serves as a valuable resource for educational institutions aiming to improve their programs.

This article seeks to examine the implementation of Six Sigma methodology in the formulation of TVET course syllabi, highlighting its capacity to reconcile discrepancies between academic training and industry requirements while maintaining quality and relevance.

Specifically, this study aims to identify key factors influencing TVET performance, examine the application of Six Sigma methodology, and improve institutional performance in delivering these programs. This study aims to examine the concrete implementation of the DMAIC phases of Six Sigma in addressing performance issues related to course syllabus development at TVET institutions in Pasir Gudang, Johor.

Methodology

This study utilised a quantitative research design, crucial for producing evidence-based knowledge and enhancing practice. Quantitative methods establish a structured approach for the collection and analysis of numerical data, yielding essential insights into the relationships among variables (Sousa et al., 2007). This study employed a survey method, a well-established technique for collecting structured data. Surveys are widely utilised across various disciplines for their systematic and efficient data collection capabilities, aiding in the understanding of complex phenomena. This research employed a questionnaire, a standardised instrument that guarantees uniformity in responses, facilitating rigorous statistical analysis (Collins, 2003; Artino et al., 2014; O'Rourke, et al., 1988).

The questionnaire was developed through a rigorous process to ensure its reliability and validity. Expert validation was performed to enhance the instrument, confirming its effectiveness in measuring the intended constructs. The process involved face and content validation, as suggested by Elangovan & Sundaravel (2021), incorporating feedbacks from experts and scholars in the discipline. This validation establishes the questionnaire's relevance and adequacy for capturing the study's nuances. The comprehensive approach employed is consistent with established best practices for survey design, as indicated by Draugalis et al., (2008). This survey targetet stakeholders involved in TVET programs at higher education institutions (HEIs) around Pasir Gudang, Johor, Malaysia.

A total of 300 questionnaires were distributed, yielding 176 completed responses. The data were analysed utilising IBM's Statistical Package for the Social Sciences (SPSS), Version 27. SPSS is a well-established tool utilised in social sciences, business, and health research for data management and analysis (Alili & Krstev, 2019). It enables diverse statistical analyses and data manipulation, yielding outputs that are essential for researchers.

SPSS V.27 provides various advanced features such as multidimensional scaling, factor analysis, MANOVA, and a priori power analysis. These functions allow researchers to investigate intricate relationships between data variables and guarantee strong statistical interpretation. The revised software version offers improved tools for power analysis, which are especially beneficial for complex study designs, including repeated measures and longitudinal studies (Muller, 1992). Essential statistical methods to be utilised comprised of ANOVA, correlation tests, and factor analysis, which aid in recognising patterns and relationships within the data.

This research seeks to elucidate the elements influencing TVET performance by utilising the functionalities of SPSS V.27. The stringent quantitative technique, along with sophisticated analytical instruments, guarantees that the results are both dependable and practical, enhancing the current dialogue in TVET and higher education research.

Results and Discussions

A series of questionnaires were used to gather the data, and SPSS V.27 Statistics programme was used to examine the results. To fulfil the project's objectives, the researcher the data will be analysed and and conclusions will be drawn from the investigation.

Pearson's correlation coefficient r in relation to the P-value. The Pearson correlation coefficient ranges from -1 to 1. In general, the correlation expresses the degree to which two variables vary similarly on average. A positive correlation exists when one variable increases while the other increases. The correlation coefficient will be closer to 1 in this situation. When one variable decline while the other increases, there is a negative connection and the correlation coefficient approaches -1. To interpret the correlation, it can be determined by observing on the aspects such as direction of the relationship and level of significance.

The null hypothesis is being tested to determine whether there is any or no evidence to imply correlation exists based on this sample. The data indicates which of these opposing hypotheses is more likely to be accurate. If it is the Pearson Correlation Coefficient, we may express this test using a hypothesis (H1) as follows:

H1: Six Sigma DMAIC has an effect on TVET performance

Some evidence have been observed to display that all the service quality components are monotonically associated in the sample and that strong evidence also exists for H1 to be accepted as the SPSS displays the p-value for this test as .001.

Table 2 shows the descriptive statistic to assess H1. The correlation coefficient value indicates how strongly the value correlates with another variable. It also implies that there is correlation between variable because according to the Pearson Correlation Scale, the p value is less than 0.05. Thus, it can be assumed that all the constructs have hook connections. Moreover, the p value of $p < .001$ indicates that the result is highly significant and it is very unlikely to have occurred by chance alone.

The Pearson Correlation value confirms that there appears to be a strong positive correlation with other factors, since at the value .793 there is no negative symbol. There is significant positive relationship between Six Sigma DMAIC and TVET performance, $r(174) = .793$, $p = .001$.

Table 2. Descriptive Statistics

Correlations			
	DMAIC		Technical and Vocational (TVET) performance
DMAIC	Pearson Correlation	1	.793**
	Sig. (2-tailed)		.001
	N	176	176
Technical and Vocational (TVET) performance	Pearson Correlation	.793**	1
	Sig. (2-tailed)	.001	
	N	176	176

A regression test was also employed to analyze how the independent variables affect the dependent variable. The regression analysis determined how much the predictor factors affected the criterion variable (Davison & Davenport, 2002). Bivariate Regression Analysis is a sort of statistical analysis that can be utilised in quantitative market research during the analysis and reporting stages. Bivariate Regression Analysis is examining two variables to determine the strength of their relationship. The two variables are commonly labelled as X and Y, with the first being an independent variable (or explanatory variable) and the second being a dependent variable (or outcome variable).

The Model Summary provides key insights into the regression analysis. The correlation coefficient RRR is 0.793, indicating a strong positive relationship between the predictor and the dependent variable. The R2R^2R2 value of 0.626 suggests that approximately 62.6% of the variability in the dependent variable can be explained by the model. The adjusted R2R^2R2 value of 0.628 takes into account the number of predictors and provides a more accurate assessment of the model's explanatory power.

The Standard Error of the Estimate is 0.793, reflecting the average distance that the observed values fall from the regression line. The significant FFF change (p = .000) reinforces the finding that the inclusion of the predictor variable significantly improves the model's fit compared to a model without it. Additionally, the Durbin-Watson statistic of 1.633 suggests that there is no strong autocorrelation in the residuals, indicating the model's reliability. Overall, these findings highlight the model's effectiveness in capturing the relationship between the variables.

The ANOVA results indicate that the regression model significantly explains the variability in the dependent variable. With an F-statistic of 294.186 and a p-value of .000, the model demonstrates a highly significant relationship between the predictor and the outcome, suggesting that the predictor variable is effective in explaining changes in the dependent variable. The regression accounts for 59.828 units of variability, while the residuals reflect an unexplained variability of 35.386 units, highlighting the model's overall adequacy.

Additionally, the total sum of squares amounts to 95.214, indicating the combined variability in the dependent variable. The degrees of freedom for the regression (1) and residuals (174) suggest a well-structured model with a sufficient sample size. Overall, these results imply that the regression analysis has effectively identified a meaningful relationship, warranting further exploration or application in predictive modelling.

The main finding from the ANOVA analysis is that the regression model is statistically significant, as indicated by the F-statistic of 294.186 and a p-value of .000. This suggests that the predictor variable has a strong effect on the dependent variable, explaining a substantial portion of the variability (59.828 out of a total of 95.214). The results imply that the model is effective and that the predictor can reliably be used to forecast changes in the outcome variable.

Table 3. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	df1	df2	Sig. F Change	Durbin-Watson
1	.793[a]	.626	.628	.45.793	.628	1	174	.000	1.633

a. Predictors: (Constant), Six Sigma DMAIC
b. Dependent Variable: technical and vocational (TVET) performance

Table 4. Shows ANNOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
1Regression	59.828	1	59.828	294.186	.000[b]
Residual	35.386	174	.203		
Total	95.214	175			

a. Predictors: (Constant), Six Sigma DMAIC
b. Dependent Variable: technical and vocational (TVET) performance

Table 5. Coefficient Test

Model	B	Std. Error	Beta	Lower Bound	Upper Bound	Model	Tolerance	IVF
1 (Constant)	.842	.170	4.947 .000	.506	1.178	1 Constant)		
Six Sigma DMAIC	.729	.042	.793 17.152 .000	.645	.813	Six Sigma DMAIC	1.000	1.000

a. Dependent Variable: technical and vocational (TVET) performance

The Coefficients table presents the regression analysis results for the model. The constant (intercept) is 0.842 with a standard error of 0.170, indicating that when the predictor (Six Sigma DMAIC) is zero, the dependent variable is expected to be approximately 0.842. This value is statistically significant, with a p-value of .000.

For the predictor variable, Six Sigma DMAIC, the coefficient is 0.729 with a standard error of 0.042, resulting in a standardized beta of 0.793. This strong beta value suggests that Six Sigma DMAIC has a substantial positive effect on the dependent variable. The p-value of .000 further confirms the statistical significance of this predictor. The confidence interval for the coefficient ranges from 0.645 to 0.813, indicating that we can be confident that the true effect of Six Sigma DMAIC lies within this range. The tolerance value of 1.000 suggests that multicollinearity is not a concern in this model. Overall, these results underscore the importance of Six Sigma DMAIC in predicting the outcome variable effectively.

The findings from the Coefficients table indicate that the Six Sigma DMAIC variable has a strong positive impact on the dependent variable, with a coefficient of 0.729. This suggests that for each unit increase in Six Sigma DMAIC, the dependent variable increases by approximately 0.729 units. The standardized beta of 0.793 further highlights the strength of this relationship, indicating a substantial effect.

The statistical significance of this predictor is reinforced by a p-value of .000, confirming that the relationship is not due to chance. The confidence interval for the coefficient (0.645 to 0.813) suggests that the true effect is likely to fall within this range, providing further assurance of the model's reliability. Overall, these findings emphasize the effectiveness of Six Sigma DMAIC as a significant predictor of the outcome variable.

The Regression Test table outlines the main results about the idea that DMAIC has an impact on TVET performance. The regression weight for this connection is 0.729 showing a big positive effect of DMAIC on how well TVET does. The Beta coefficient of 0.628 backs up how strong this effect is hinting that DMAIC can predict performance outcomes in this area.

A p value of < .001 with an F = 294.186 000, relations are statistically significant ($p < 0.05$) and indicate that your hypothesis is supported. If DMAIC methodologies improved educational performance in technical and vocational education as suggested by this meta-analysis, their wide-spread implementation has the potential to be of relevance due to its consequences on skill formation. Implications - These findings provide evidence to support the effectiveness of DMAIC for improved TVET performance.

For the hypothesis of whether Six Sigma DMAIC has a significant effect on TVET performance, Model 2 was used to assess TVET performance → Six Sigma DMAIC (to test H1) DV PredictingDfFp-valueR^2Adj. Operational Performance was significantly predicted by Six Sigma DMAIC; F (1,174) = 294.186, p < .001.

This means that the Six Sigma DMAIC can be critical in developing TVET performance (b =. 729, p <. 001). These results plainly indicate that the Six Sigma DMAIC has a positive impact.

The value of R = .628 depicts that the model explains 62.8% of the variance in TVET performance.

Conclusion

This research has investigated the application of the Six Sigma DMAIC methodology in improving the performance of TVET programs within educational institutions in Pasir Gudang, Johor. The study findings demonstrated that the core field of study and the understanding of standard requirements play a critical role in shaping the structure and processes of course syllabi. The implementation of the DMAIC strategy was shown to significantly enhance the effectiveness and efficiency of these processes, highlighting its applicability as a quality improvement tool in the context of TVET.

The results underscore the potential of Six Sigma methodologies, particularly DMAIC, to improve the structure and delivery of course syllabi in TVET institutions. By addressing inefficiencies and aligning curricular processes with standardized requirements, DMAIC can foster improved academic and institutional outcomes. These findings contribute to the growing body of evidence supporting the integration of structured quality management tools in educational contexts.

Based on these insights, it is recommended that other organizations, particularly TVET institutions, consider adopting the DMAIC framework to optimize their course syllabus development and related processes. This approach not only enhances the quality and alignment of educational offerings but also supports broader institutional goals of efficiency and relevance.

Table 6. Regression Test

Hypothesis	Regression weight	Beta Coefficient	R	F	p- value (p< 0.05)	Hypothesis supported
H_1	DMAIC on technical and vocational (TVET) performance	.729	.628	294.186	.000	Yes

Furthermore, the conclusions derived from this research provide a valuable framework for future studies. Researchers are encouraged to build on these findings to explore the application of Six Sigma in diverse educational settings and across varying institutional contexts. Expanding the scope of investigation will deepen the understanding on how quality management tools can be tailored to address specific challenges in technical and vocational education.

Recommendation

From the findings gathered, some recommendations can be suggested. It was found that the syllabus cannot be formulated very easily or effectively. One of the objectives is to determine the relationship between Six Sigma DMAIC and TVET performance at Pasir Gudang Johor. It can be seen that that Six Sigma DMAIC did have an effect toward TVET performance. Therefore, it is recommended to implement DMAIC approach in course syllabus development as well as for other organizations particularly related to education institution.

This approach significantly contributes to enhancing student knowledge, reducing program development time, and increasing productivity. For instance, implementing systems like DMAIC or Failure Mode and Effects Analysis (FMEA) can help improve efficiency. Therefore, other educational institutions, particularly those involved in TVET program development, should consider adopting this approach to reap its benefits.

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Conflict of Interest

The authors declare no conflict of interest.

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