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Article

# A Kaleidoscope Model to address the Construction 4.0 policy changes in Malaysia

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**Abstract:** The current era of Industry 4.0, driven by advanced technologies, holds immense potential for revolutionising various industries and fostering substantial economic growth. However, comprehending intricate processes of policy change poses difficulties, impeding necessary adaptations. Public apprehensions are growing about the inertia and efficacy of policy changes, given the influential role of policy environments in shaping development amidst resource constraints. To address these concerns, the study introduces the Kaleidoscope Model of policy change, serving as a roadmap for policymakers to enact effective changes. The study investigates the mediating impact of cultural change within the framework of the Kaleidoscope Model. The study delves into cultural influences by incorporating the Behavior Change Wheel (BCW) Theory. The methodology involves questionnaires survey, analysing using Structural Equation Modelling (SEM). The findings reveal that only the Policy Adoption and Policy Implementation components significantly affect the assessment of the effectiveness of the Construction 4.0 policy. Intriguingly, the final model demonstrates no discernible connection between the Kaleidoscope Model and the cultural influences. This study makes a noteworthy contribution to the realm of political science by furnishing a comprehensive framework and directives for the successful implementation of the Construction 4.0 policy.

**Keywords:** Construction 4.0; construction industry; Kaleidoscope Model; Malaysia; policy changes

## 1. Introduction

The Malaysian Ministry of Works has launched a 5-year short-term plan, known as the Construction 4.0 Strategic Plan (2021–2025), to coincide with the Industry 4.0 initiative (CIDB, 2020). The plan aims to provide a platform to advocate discussions between multiple stakeholders in the construction industry to transform Malaysia's built environment industry using advanced technologies. In addition, the plan emphasizes the transformation of construction into the right technologies for the industry. However, the policy change process can be hard to comprehend, making it difficult to foster the needed change. The policy change inertia and the effectiveness of policy implementation increasingly concern the public, given the importance of policy environments in shaping development outcomes and the growing need to achieve development impact with scarce resources. To address these questions, this study introduces the Kaleidoscope Model of policy change and explores the policy cultural influences. This is to scrutinize the relationship of cultural influences and policy implementation of a country that is economically robust and socially inclusive.

The Kaleidoscope Model (KM) is a practical framework for policy reforms in relation to a country's underlying political, economic, and institutional criteria. The model is a method to help the change agent decide on how change should be implemented. The Kaleidoscope Model proposes several components to identify the policy-emerging elements and implementation conditions that aid in developing strategies for later implementation. This study tests the model empirically in Malaysia by evaluating the effectiveness of Construction 4.0 Strategic Plan (2021–2025).

Changing policy is a significantly more intricate process than previously acknowledged. The traditional literature addressing the "policy-implementation gap" (Gunn, 1978; Høiland, 2018; Tsoi et al., 2021) has seen recent supplementation through the lens of complex systems thinking, integrating concepts of unpredictability, nonlinearity, and adaptability (Braithwaite et al., 2018). The potential for gaps between policy intentions and actual outcomes has been emphasized (Buchy and Shakya, 2023). In this perspective, the factors influencing implementation are perceived as intricate (Abdullahi and Othman, 2020), exhibiting multifaceted and multileveled characteristics. Public policies often resemble "wicked problems," resisting change, presenting multiple potential causes, and offering solutions that vary based on local contexts and temporal considerations (Rittel and Webber, 1973; Tisdall et al., 2023).

Recognizing these complexities becomes paramount, as the factors influencing effective policy implementation are varied and intricate. Policies, in essence, embody "wicked problems," and understanding the intricacies of their implementation is crucial for addressing the pervasive policy implementation gap (Guo, 2023) that persists throughout the country. This understanding necessitates a nuanced examination of the interplay between intentions, actions, and outcomes within the dynamic and adaptive nature of policy implementation. Therefore, the objective of this research is to assess the effectiveness of Construction 4.0 implementation in the Malaysian construction industry, employing the Kaleidoscope Model as a conceptual framework. Addressing the policy implementation gaps is essential for offering authorities an overarching perspective on adoption, assisting them in focusing on selected agendas rooted in social, economic, and political consensus.

## 2. Review of Literature

### 2.1. Malaysian Construction 4.0 related policies

Construction 4.0-related policies involve utilising advanced technologies and digitalisation to enhance the construction industry's productivity, safety, sustainability, and efficiency. Consequently, authorities have launched policies to support and incentivise the adoption of Construction 4.0 practices in Malaysia. A summary of the Malaysian Construction 4.0 related policies is tabulated in **Table 1**.

## 2.2. Kaleidoscope Model (KM)

The Kaleidoscope Model (KM) is employed in this study to investigate the shifts in construction-related policies in Malaysia. The goal is to uncover the underlying drivers, factors, and strategies behind Construction 4.0 policies within the KM framework. Utilising the KM is anticipated to enhance comprehension of the structure and processes underlying Construction 4.0 policies. As a result, this will offer policy partners a more effective entry point for the execution of associated policies (Haggblade and Babu, 2017).

The Kaleidoscope Model, proposed by Resnick et al. in 2018, emphasises five key policymaking stages: (i) agenda setting, (ii) policy design, (iii) policy adoption, (iv) policy implementation, and (v) evaluation and reform. Notably, cultural influences hold equal significance, as emphasised in the Behavior Change Wheel (BCW) and applied in various sectors such as healthcare, energy, and finance policymaking. Consequently, this study takes the initiative to introduce cultural influences as the sixth stage in the Kaleidoscope Model, as elaborated in the subsequent section.

**(1) Agenda Setting (AS)**

Agenda setting (AS) involves three fundamental elements: (i) addressing pertinent issues, (ii) the emergence of a focusing event, and (iii) the presence of influential advocates. Within the context of the Kaleidoscope Model's agenda setting, addressing relevant problems represents the initial phase of KM's policymaking procedures. In setting the policy agenda, identifying the potential problems allows the policymakers to address the issues by developing solutions (Lemos & Rood, 2010). The occurrence of a focal event pertains to an exceptional incident such as a natural disaster, economic downturn, price crisis, or governmental transition, events that are infrequent in nature (Resnick et al., 2015). Furthermore, the influential advocates in the agenda-setting encompass authorities, civil society representatives, private sector entities, research institutes, investors, donor organisations, and others who contribute either directly or indirectly to the policymaking processes. The summary of the agenda setting is shown in **Table 2**.

**(2) Policy Design (PD)**

Policy advocates present alternatives to address the policy challenge during the design stage (Salvesen et al., 2008; Resnick et al., 2018). There are twelve drivers discussed in policy design based on the three elements as shown in **Table 2**.

The dissemination of empirical research and knowledge within policy advocate communities yields authoritative evidence for policy development (Resnick et al., 2018). These advocates scrutinize data amassed from agenda settings, converting this information into a coherent format. Norms, biases, ideologies, and beliefs are distinct, yet interconnected factors that influence policy advocates during the policy design phase. Critically evaluating secondary perspectives concerning a policy's design components, underlying conceptions of human nature, established norms, and socialization proves to be challenging (Resnick et al., 2018). The element of cost-benefit is invariably linked to ideas and beliefs. The underlying rationale for policy development is to safeguard the public interest, which, unfortunately, can result in the neglect of minority group interests. Policy designs or ideologies that hold significant influence during the planning stage might fail to attain the predetermined goals and transforming into policy outcomes during implementation (Banister and Hickman, 2013).

**(3) Policy Adoption (PA)**

Two factors assume significant roles in policy adoption: (i) the relative power balance between opponents and proponents, and (ii) the involvement of government veto players. The foremost and most crucial predictor of acceptance is the relative power balance between opponents and proponents. The emergence of opponents and supporters might occur after the finalization of policy design once the potential "winners" and "losers" of a policy reform have become evident (Resnick et al., 2018). In this case, the strategies of the supporters and government are sought to engage with the opponents and influence the policy change (Werners et al., 2010). The second influential component affecting policy adoption is the presence of government veto actors. These can be individual or collective players whose agreement is requisite for policy adoption, or conversely, whose lack of agreement proves fatal to adoption (Resnick et al., 2018; Jayasena et al., 2021). Government veto players also bear responsibilities in the financial and political realms to promote the policy (Wang & Zhang, 2023), underscoring their vital roles in the policy adoption stage.

**(4) Policy Implementation (PI)**

The policy implementation stages emphasise four major elements: (i) the requisite budget, (ii) institutional capacity, (iii) implementing stage veto players, and (iv) the commitment of policy champions. A necessary budget stands out as a fundamental requirement in policy implementation. Delays in distributing resources can lead to corresponding delays in executing policies (Resnick et al., 2018). In this phase, industry experts should determine the resources required to ensure they are sufficient to promote effective policy implementation. The engagement with stakeholders serves as a mechanism through which policymakers can discern the diverse needs, concerns, and priorities of different groups, ensuring a comprehensive understanding and integration of their interests into the policy framework (Pröbstl et al., 2023).

Those responsible for policy implementation or expansion must also exhibit a certain level of institutional capacity. This encompasses both technical and administrative capabilities, including infrastructure, education, and skills (Resnick et al., 2018). The extent of required capability is determined by factors such as the policy's complexity, its frequency of modification, and the potential necessity to adhere to international standards dictating specific capacity levels. Given global agreements, the implementation of national policies and the cultivation of public awareness regarding the necessity of adopting policy implementation strategies are equally imperative (Khanam & Reiner, 2022).

Identifying the veto players during the implementation stage is essential (Resnick, 2018). Typically, players from the public and private sectors are reluctant to execute government policies that jeopardise their profitability or competitive advantage. Equally crucial is the dedication of policy champions who can overcome obstacles through incentives, resources, and capacity. These champions are often high-ranking bureaucrats or politicians who persistently promote policy implementation, despite conflicting interests (Resnick et al., 2018). A total of sixteen strategies pertaining to policy implementation (PI) are depicted in **Table 2**.

**(5) Evaluation and Reformation (ER)**

Most policies are susceptible to minor adjustments or complete structural revisions. The evaluation and reform of policies encompasses three elements: (i) alterations in information and beliefs, (ii) changes in material conditions, and (iii) the emergence of shifts in the institutional landscape. Within the evaluation and reform phase, changes in information could prompt modifications to the plan, particularly concerning the efficacy of the initial goals outlined (Resnick et al., 2018). The second element involves the alteration of material conditions. At this stage, material circumstances undergo significant changes when the primary issue that initially motivated the policy has been resolved (Resnick et al., 2018). The third aspect pertains to shifts in institutional settings, such as a reshuffling of the parliament, which could potentially lead to plan modifications (Resnick et al., 2018; Abdullahi & Othman, 2020). These changes bring forth a fresh set of influential individuals with the authority to veto decisions. They may aim to create their own impact and set a different direction (Kowalczyk et al., 2017). There exist twelve factors that could potentially instigate evaluation or reform, as illustrated in **Table 2**.

**Table 1.** Construction 4.0 related policies in Malaysia.

| | Policy 1 | Policy 2 | Policy 3 | Policy 4 | Policy 5 | Policy 6 | Policy 7 | Policy 8 | Policy 9 |
|---|---|---|---|---|---|---|---|---|---|
| | Construction Industry Transformation Programme (CITP) 2016–2020 | National Policy on Industry 4.0—Industry4WRD | Malaysia Smart City Framework | Malaysia Digital Economy Blueprint | Shared Prosperity Vision (SPV) 2030 | Construction 4.0 Strategic Plan (2021-2025) | National Internet of Things (IoT) Strategic Roadmap | Twelfth Malaysia Plan | National Construction Policy (NCP2030) |
| Date | September 2015 | October 2018 | September 2019 | October 2019 | October 2019 | November 2020 | February 2021 | September 2021 | November 2021 |
| Aim | To build a sustainable construction industry in Malaysia. | To guarantee the smooth integration of Industry 4.0 technologies and equitable accessibility for small and medium-sized enterprises (SMEs). | Devise and formulate policies, strategies, and an action plan with meticulous attention to detail and inclusivity, aimed at implementing a smart city framework comprehensively. | Enhancing focus on key areas, elevating overall efficiency and accountability, which ultimately pave the way for transformative change across the entire nation. | To offer adequate standard of living to all Malaysians by 2030. | Offering a route to steer the Malaysian construction sector into the next industrial revolution involves crafting a series of comprehensive Strategic Plans and Strategic Thrusts. | Aiming to materialize Malaysia's aspiration of becoming the foremost regional hub for IoT development. | To increase export markets by enhancing market efficiency, enabling the role of industry players, and enhancing trade facilitation. | To stimulate more holistic and constructive ways of doing business |
| Function | Standards and guidelines | Funding | Technology integration | To enhance the adoption of technology | Fiscal sustainability | People | To transform the IoT development | Developing Future Talent | Strengthen quality and safety in project performance |
| | Collaboration and incentives | Skills and talents | Open and centralized data | To broaden the HRDF claimable program | Financial capital | Integrated technology | To align with existing initiatives through pilot projects | Accelerating technology adoption and innovation | Embrace sustainable built environment |
| | Capability and capacity | Technology | Triple helix approach | To intensify efforts | Effective institutional delivery | Economy | To form IoT Malaysia | Enhancing connectivity and transport infrastructure | Improve construction productivity |
| | National BIM object library | | Connectivity | To introduce an enhanced mechanism | Governance and Integrity | Governance | To develop open innovation framework | Strengthening the public service | Strengthen infrastructure maintenance |
| | Legal issues | | Cybersecurity | | TVET | | To establish open community data framework | | Firming internationalization and competitiveness |
| | Special interest groups (SIGs) | | Legal framework | | Big data | | | | Increasing good governance and adoption of best practices |
| | Research and development | | Funding and financing | | Sustainability | | | | |
| | | | Research and innovation | | Enlightened society | | | | |

Copyright:
1. Policy 1: Construction Industry Development Board Malaysia (CIDB)
2. Policy 2: Ministry of International Trade and Industry
3. Policy 3: Department for International Trade
4. Policy 4: Economic Planning Unit, Prime Minister’s Department
5. Policy 5: Ministry of Economic Affairs, Malaysia
6. Policy 6: Construction Industry Development Board Malaysia (CIDB)
7. Policy 7: Malaysian Institute of Microeconomic Systems (MIMOS) Berhad
8. Policy 8: Economic Planning Unit, Prime Minister’s Department, Malaysia
9. Policy 9: Ministry of Works, Malaysia

**Table 2.** Kaleidoscope Model elements.

| | **Kaleidoscope Model (KM) Stages** | | | | |
|---|---|---|---|---|---|
| **Elements** | **Agenda Setting (AS)** | **Policy Design (PD)** | **Policy Adoption (PA)** | **Policy Implementation (PI)** | **Evaluation and Reform (ER)** |
| 1 | Shortage of workers | Provide authoritative evidence of policy development | Assist in “testing the policy to identify the potential issues before implementation | Provide grants | Lack of clearly specified regulatory quality principles |
| 2 | Slow adaptation of emerging technologies | Provide track record and prospects in social relationships | Provide diverse opinions, knowledge, and perspectives from the stakeholders | Provide subsidies | Over ambitious policy design |
| 3 | Low productivity in the construction industry | Provide information about the policy formulation and change | Deep understanding of the comprehensive range of impacts on policy | Provide tax benefits | Emergence of new debates and paradigm |
| 4 | Fluctuation in demand for construction activities | Provide clear and easy understandable information to the public | Information sharing between “experts” and “non-experts” | Proper budget allocation of public resources | Lack of stakeholders’ political interests |
| 5 | Fluctuation of international market | Changing expectations of stakeholders for technology implementation | Study existing policies as a reference for problem-solving and improvement | Recruit talent and expertise | Failure to allocate funding |
| 6 | Instability of global economic infrastructure | Implement the emerging technologies during the project lifecycle | Form a new department or team to implement the policy | Modifying the curriculum in higher education | Failure to achieve outcome of precedence policy |
| 7 | Adverse environmental impacts | Increase the stakeholders’ participation | Accessibility and transparency of policy to the public | Increase understanding of policy knowledge and policy implementation strategies in the industry | Failure to allocate human resources |
| 8 | Competition for limited natural resources | Improve the expectations of the digital workplace | Engage with stakeholders in understanding their needs | Provide appropriate workforce and infrastructure to the stakeholders | Lack of institutional and strategies |
| 9 | Conflicts in policy drafting and decisions | Formation of new lifestyle | | Provide training to the stakeholders | Lack of enforcement powers and mechanisms |
| 10 | Changes in systemic governing coalition | Formation of new industries and production models | | Increase the collaboration among stakeholders | Insufficient focus on monitoring, evaluation, and reporting progress |

**Table 2.** (*Continued*).

| | **Kaleidoscope Model (KM) Stages** | | | | |
|---|---|---|---|---|---|
| **Elements** | **Agenda Setting (AS)** | **Policy Design (PD)** | **Policy Adoption (PA)** | **Policy Implementation (PI)** | **Evaluation and Reform (ER)** |
| 11 | Wish to move forward to desirable future conditions | Increase in the investment of technology | | Stimulate current and future impacts of policy change | Undue pervasive political influence on public bureaucracy |
| 12 | External changes or shock to the political system | Increase the local employment rate | | Conduct an awareness program to the stakeholders | Emergence of new cabinet |
| 13 | | | | Determine the present and future public decisions for the industry | |
| 14 | | | | Effective strong political leadership in leading the policy implementation | |
| 15 | | | | Develop a formal implementation blueprint | |
| 16 | | | | Examine obstacles that constrain the effective implementation of policies | |

### 2.3. Behavior Change Wheel (BCW)

A heightened level of public acceptability for a policy is instrumental in facilitating smoother legislation and implementation processes (Marazi et al., 2022). Acceptability, defined as the positive or negative attitude toward a policy (Moeinaddini and Habibian, 2023), plays a crucial role in the successful execution of policies. Consequently, policymakers should actively strive to attain a high level of public acceptability for the Construction 4.0 policy, ultimately expediting its implementation and enhancing overall policy efficiency.

In this context, the recognition and understanding of cultural influences become imperative for shaping policy effectiveness. The identification of cultural influences can be rooted in the three core elements of the Behavior Change Wheel (BCW) concept: (i) capability (encompassing knowledge and skills), (ii) opportunity (involving expectations from stakeholders), and (iii) motivation (in terms of training and incentives provided by authorities), as illustrated in **Figure 1** (Wilson and Marselle, 2016). Within the BCW framework, these elements—capability, opportunity, and motivation (COM-B)—interact synergistically, giving rise to behaviors that influence policy change.

Utilizing these elements, implementation veto players can delve into stakeholders' behavior, gaining valuable insights to formulate effective policy strategies tailored to the construction industry. By understanding and harnessing the dynamics of capability, opportunity, and motivation, policymakers can navigate cultural influences adeptly, paving the way for robust and successful policy implementation within the construction sector.

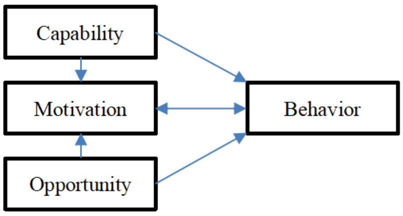


**Figure 1.** The COM-B Model in Behavior Change Wheel (BCW) (Michie et al., 2011).

Behaviour change interventions are pivotal for effective policy transformation since humans are the key participants in policy adoption. 'Behavior change interventions' can be defined as coordinated actions to alter specific behavioural patterns (Michie et al., 2011). Typically, the prevalence or incidence of specific behaviours within groups measures their behavioural trends. Therefore, authorities must comprehend stakeholders' needs and expectations to motivate them, expediting the implementation process (Hwang and Kim, 2023).

Capability refers to an individual's psychological and physical ability to engage in activities (Michie et al., 2011), which requires knowledge and skills (Webb et al., 2016). Construction stakeholders' decisions are influenced by potential profits and project value. They tend to favour the adoption of a more effective and efficient plan that promises greater profitability. Consequently, construction stakeholders need to grasp the information outlined in the Construction 4.0 Strategic Plan (2021–2025) to enhance their capability. Policymakers should establish behavioural rules or principles, enhance knowledge and awareness, and provide guidelines for technology implementation to augment stakeholders' capabilities, as depicted in **Table 3**.

**Table 3.** Cultural influences elements.

| Element | Cultural influences (CI) | Indicators |
|---|---|---|
| 1 | Capability | Establishing rules or principles of behaviors or practices |
| 2 | | Increasing knowledge and awareness |
| 3 | | Providing technology implementation guidelines |
| 4 | Opportunity | Providing a project reference (best practice) to increase the stakeholders |
| 5 | | Understanding the needs of stakeholders' |
| 6 | | Reducing the costs of technologies |
| 7 | Motivation | Rewarding those who are achieved the implementation rate of technologies set by authorities |
| 8 | | Providing education to the stakeholders |
| 9 | | Understanding the stakeholders' behaviorism characteristics |

Opportunity refers to all external factors that enable or trigger a behaviour lying beyond the individual's control (Michie et al., 2011). It encompasses the stakeholders' expectations, which can be enhanced through motivation. This enhancement is particularly crucial because construction stakeholders require encouragement from supportive authorities to implement the policy (Truelove et al., 2020). This encouragement can be achieved by furnishing project references (best practices) to boost stakeholders' confidence, comprehend stakeholders' technological needs, and reduce technology costs.

Motivation encompasses all cognitive processes that activate and guide behaviour, encompassing goals and conscious decision-making, habitual processes, emotional responses, and analytical reasoning (Michie et al., 2011). In this context, policymakers should be well-versed in the norms and beliefs of the plan to encourage stakeholders to become more proactive in adopting the policy. Hence, motivation strategies like rewarding those who achieve the technology implementation targets set by authorities, providing education, and understanding stakeholders' behavioural tendencies are essential to enhance policy implementation.

## 2.4. Evaluation of policy effectiveness

Three criteria are employed to comprehensively assess policy effectiveness: effectiveness (industry contribution), efficiency (cost-effectiveness), and equity or fairness (Axsen and Wolinetz, 2021). The dimension of policy effectiveness delves into its impact on the construction industry, encompassing both short and long-term considerations. In the short term, digitalization propels process acceleration, heightened productivity, and efficiency gains, while technology transformation holds the potential for sustained long-term economic growth.

Efficiency, a pivotal yet challenging aspect to quantify, revolves around the policy's cost-effectiveness. Common efficiency measures span economic growth (Shah and Garg, 2023), consumer well-being, and industry profits. The intricate challenge lies in delineating the tangible impact of these measures on the policy's efficiency.

Policy equity involves discerning the ramifications for the "winners" (proponents) and "losers" (opponents) affected by the policy (Resnick et al., 2018). The opposition, comprised of those proficient in technology, stands in contrast to the proponents, staunch advocates of traditional methods. Technology adoption offers substantial advantages to the opponents, while proponents lean towards adhering to conventional construction methods.

Several key performance indicators (KPIs) serve as tangible metrics to measure policy effectiveness, especially concerning the reduction of the construction process duration. For instance, project completion time can be measured from the initiation of the construction phase to the project's finalization. This KPI serves as a robust tool to evaluate the policy's efficacy in minimizing construction timelines and ensuring adherence to project schedules.

Referencing **Table 4**, twelve factors have been identified to systematically evaluate policy effectiveness, aligning with the three aforementioned criteria. This comprehensive framework aims to holistically gauge the multifaceted impact of policies on the construction industry, ensuring a nuanced and thorough assessment across various dimensions. Evaluating policy effectiveness is essential in fostering resources, facilities, and infrastructure, achieving sustainable growth, addressing social costs, public health, environmental concerns, and barriers (Sun et al., 2014). Therefore, the twelve (12) elements have been selected to evaluate policy effectiveness from various dimensions, including economic, social and others.

**Table 4.** Policy effectiveness elements.

| Element | Policy effectiveness (PE) |
|---|---|
| 1 | Shortening the Construction Process |
| 2 | Increasing Productivity and Efficiency |
| 3 | Reducing Environmental Issues |
| 4 | Reducing Construction Costs |
| 5 | Increasing Collaboration among Stakeholders |
| 6 | Enhancing Economic Growth |
| 7 | Providing Greater Benefits for Stakeholders |
| 8 | Increasing Global Competitiveness |
| 9 | Enhancing Domestic and International Business Partnership |
| 10 | Achieving Policy Outcomes |
| 11 | Increasing Implementation Rate of Emerging Technologies |
| 12 | Increasing the Readiness and Willingness of Stakeholders |

## 2.5. Conceptual model of Kaleidoscope Model in Construction 4.0

The conceptual model of Kaleidoscope Model in Construction 4.0 is developed based on the Kaleidoscope Model theory and BCW as shown in **Figure 2**. It comprises five stages (H1 to H5) that describe the policymaking process, while cultural influences (H6) are the elements that affect policy effectiveness evaluation. The five stages of the KM, adapted from Resnick et al. (2018), are agenda setting, policy design, policy adoption, policy implementation, and evaluation and reform. The cultural influences, identified by the BCW's capability, opportunity, and motivation, are expected to influence policy effectiveness evaluation.

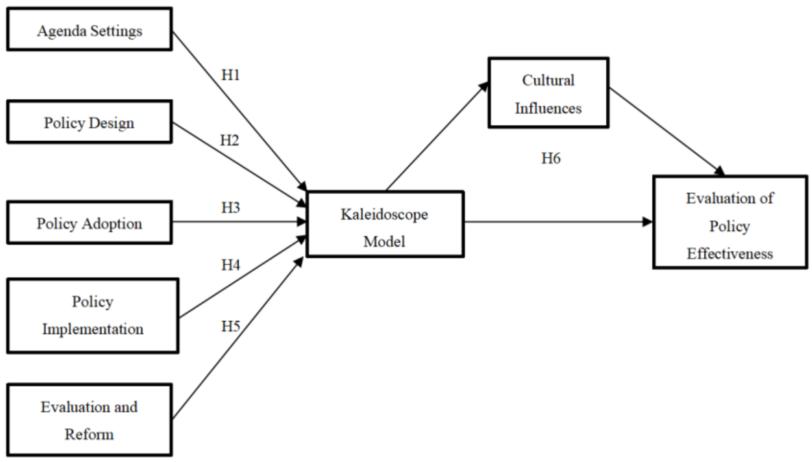


**Figure 2.** Conceptual model of Kaleidoscope Model in Construction 4.0.

## 3. Methodology

**Figure 3** illustrates the comprehensive flow of the research methodology. This study is dedicated to assessing policy effectiveness through the utilization of the Kaleidoscope Model, integrating the mediating factor of cultural influences. To achieve the research objectives, a quantitative research methodology has been employed to build upon insights derived from an extensive literature review.

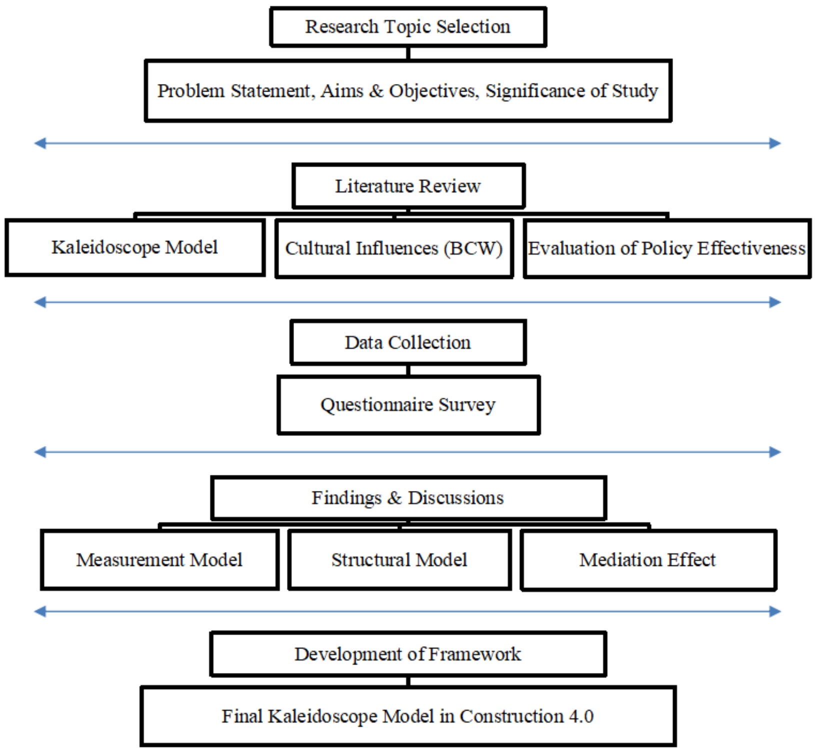


**Figure 3.** Research methodology flow chart.

The quantitative analysis in this research is facilitated by the application of Partial

Least Squares Structural Equation Modelling (PLS-SEM). This advanced statistical approach is utilized to explore and quantify the intricate relationships within the research framework. PLS-SEM offers a robust method to analyse complex models and draw meaningful conclusions from the collected data.

The culmination of the research efforts is the presentation of the Construction 4.0 Kaleidoscope Model. This model is a synthesis of the findings, providing a visual representation of the evaluated data and shedding light on the dynamics of policy effectiveness in the context of Construction 4.0. It serves as a valuable tool for policymakers, industry stakeholders, and researchers aiming to navigate the landscape of policy implementation in the evolving field of Construction 4.0.

This study represents a quantitative research endeavor carried out through a comprehensive questionnaire survey to describe and elucidate observed phenomena based on the feedback of respondents (Sukamolson, 2007). The chosen sampling method is purposive, also known as judgmental, selective, or subjective sampling. The technique employed within this purposive sampling method involves total population sampling, aiming to thoroughly investigate the entire population of construction stakeholders who share common characteristics, such as specific experiences, skills, and knowledge. Purposive sampling encompasses a variety of non-probability sampling techniques, relying on the researcher's judgment to select the units of study, be it individuals, cases/organizations, events, or data points (Rai & Thapa, 2015).

The survey instrument, distributed through SurveyMonkey, targeted a diverse range of construction stakeholders in Malaysia, encompassing developers, contractors, consultants, academicians, and authorities. The rationale behind this approach is to gain a nuanced understanding of the needs and expectations of these stakeholders. By incorporating individuals with varied roles and perspectives within the construction industry, this study aims to gather comprehensive insights that can contribute to expediting the effective implementation of the Construction 4.0 policy in Malaysia (Wilson et al., 2016).

The questions should be short and straightforward to the point. The more structured the questions, the easier it is for the researcher to interpret the quantitative data, which is qualified and numerical information (Marshall, 2005). In this study, the closed question is selected as the question type to carry out the questionnaires. It offers a choice of alternative replies in the questionnaires and uses the Likert Rating Scale to understand respondents' thoughts on this topic. The Likert scale consists of Strongly Disagree (1), Disagree (2), Slightly Disagree (3), Agree (4), and Strongly Agree (5). 5-level scales improve measuring accuracy, and it is used to assess respondents' emotions.

The questionnaire survey has been conducted, consisting of eight sections: background information of respondents (Section A), identification of drivers of policy change (Section B), identification of factors shaping the effectiveness of policy implementation (Section C), identification of policy implementation strategies for Construction 4.0 (Section D), identification of policy evaluation and policy reformation (Section E), evaluation of policy effectiveness (Section F), and open-ended questions.

The questionnaires were distributed to Malaysian construction stakeholders, including academics, architects, engineers, and others, using the SurveyMonkey platform, as outlined in **Table 5**. **Table 5** illustrates the percentage distribution of respondents across various professions within the construction industry. Notably, a significant portion of the participants consisted of quantity surveyors (33.73%) and civil engineers (28.92%). This finding suggests a higher level of receptiveness among quantity surveyors and civil engineers towards understanding the implementation of the Construction 4.0 policy.

**Table 5.** Respondents' Background.

| No | Current Profession | Percentage (%) |
|---|---|---|
| 1 | Academician | 8.43 |
| 2 | Architect | 1.20 |
| 3 | Civil Engineer | 28.92 |
| 4 | Consultant | 3.61 |
| 5 | Mechanical Engineer | 3.61 |
| 6 | Quantity Surveyor | 33.73 |
| 7 | Structural Engineer | 2.41 |
| 8 | Others | 18.10 |
| | Total | 100.00 |

The data collection phase yielded 106 completed questionnaires, resulting in a response rate of 26.5%, which is considered notably high. According to Fellows and Liu (2021), the anticipated response rate for questionnaire surveys typically ranges from 25% to 35%. Of the total distributed questionnaires, 23 sets (5.75%) had incomplete responses. Consequently, 83 sets (20.75%) of questionnaires are deemed valid data suitable for further analysis.

Besides, the study employs Partial Least Squares Structural Equation Modelling (PLS-SEM) using SmartPLS 4.0 software for data analysis. PLS-SEM is recognised for its intricate structure, involving multiple layers of general and latent variables. Structural Equation Modelling (SEM) facilitates assessing intricate cause-and-effect connections within path models featuring latent variables. This approach examines the correlation between observed variables and their underlying latent constructs, where these latent constructs denote unobserved variables identified through their impacts on observable variables (Sarstedt and Cheah, 2019). The weight assigned to an item is the outer loading, representing the correlation coefficient between the observed variable and the latent construct. PLS-SEM encompasses two primary components: the measurement model and the structural model. The measurement model elucidates the connections between the observed data and the latent variables, thus assessing the reliability and validity of the reflective constructs. Conversely, the structural model illustrates the relationships between the latent variables themselves.

## 3.1. Measurement model

The measurement model encompasses the unidirectional predictive connections between each latent construct and the corresponding observed variables. This study employs reflective constructs, considering that the latent constructs influence the observed variables derived from the survey questionnaire. The former includes evaluating construct reliability and validity, establishing convergent validity through the average variance extracted (AVE), assessing discriminant validity, and accounting for the variance inflation factor (VIF) (Hair et al., 2017).

Construct reliability and validity measure the correlation between the underlying observed variables and their associated constructs. For reflective scale measurements, factor average variance extracted (AVE), composite reliability (CR), and outer loadings of the items are assessed. Ideally, outer loadings below 0.4 should be eliminated (Hair et al., 2017). AVE measures the amount of variation captured by the construct relative to the variance due to measurement error, while CR indicates the internal consistency of scale items. Construct reliability and validity are established when composite reliability values fall between 0.60 and 0.70, considered acceptable in exploratory research. Values between 0.70 and 0.90 are considered satisfactory (Hair et al., 2017). Values above 0.95 are undesirable due to the indicators measuring the same phenomenon, leading to inflated composite reliability results (above 0.95) (Hair et al., 2017).

Convergent validity of the constructs is evaluated by considering the outer loadings and average variance extracted (AVE). Indicators with outer loadings between 0.40 and 0.70 should be considered for removal from the scale only when deleting the indicator leads to an increase in composite reliability or the AVE above the suggested threshold value. Indicators with weaker outer loadings may be retained based on their contribution to content validity. Indicators with very low outer loadings (below 0.40) should always be eliminated from the construct (Hair et al., 2017). Convergent validity is statistically established when the Average Variance Extracted (AVE) is > 0.50 or higher (Hair et al., 2017), indicating that the constructs explain more than half of the variance of their indicators.

To assess collinearity, the variance inflation factor (VIF) is defined as the reciprocal of the tolerance. In PLS-SEM, a tolerance value of 0.20 or lower and a VIF value of 5 or higher indicate a potential collinearity problem (Hair et al., 2017). A VIF level of 5 for an indicator indicates that 80% of its variance is accounted for by the remaining formative indicators associated with the same construct (Hair et al., 2017). If collinearity is very high, with a VIF value of 5 or higher, consideration should be given to removing one of the corresponding indicators (Hair et al., 2017). However, this should be done while ensuring that the remaining indicators sufficiently capture the construct's content from a theoretical perspective.

Discriminant validity assesses how well-observed variables vary between constructs. Discriminant validity analysis ensures that a reflective construct in the PLS path model has stronger connections with its own constructs in the PLS path model compared to any other construct. Two popular discriminant validity assessments for PLS-SEM are the Fornell-Larcker criterion and cross-loadings (Fornell & Larcker, 1981). In cross-loadings, an indicator's outer loading on the associated construct should be greater than any of its cross-loadings on other constructs (Hair et al., 2017). The results of the measurement model will be explained in Section 4.1, including composite reliability, AVE, VIF, and discriminant validity.

## 3.2. Structural model

After confirming the validity and reliability of the measurement model, the focus shifts to examining the structural model. To assess the significance of path coefficients from the original sample with replacement, the bootstrapping method is utilized. Each bootstrap sample contains an identical number of observations as the original dataset. The number of bootstrap samples should be substantial, but it must be at least equal to the number of valid observations in the dataset. Following the recommendation of Hair et al. (2017), a rule of using 5000 bootstrap samples is adhered to for estimating the PLS path model.

Bootstrapping is a technique that helps determine the significance of coefficients by providing standard errors. These bootstrap errors are then used to compute empirical *T*-values, while critical values from the normal distribution are applied for two-tailed tests. As explained by Hair et al. (2017), commonly used critical values for two-tailed tests are 1.65 (for a significance level of 10%), 1.96 (for a significance level of 5%), and 2.57 (for a significance level of 1%). In this preliminary study, we assume a significance level of 10% (Hair et al., 2017). Additionally, bootstrapping yields *P*-values, which indicate the probability of obtaining an empirical *T*-value as extreme as the observed one, assuming the null hypothesis is true. The significance levels of the *P*-values will be denoted using asterisks (*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$), with the increasing number of asterisks representing the increasing significance of the construct.

The confidence interval in bootstrapping provides additional insights into the stability of coefficient estimates. It indicates the range within which the actual population parameter is likely to lie with a certain level of confidence (e.g., 95%). In addition to evaluating significance through testing, the width of the confidence interval reflects the stability of the estimation. A broader confidence interval suggests reduced stability (Hair et al., 2017). Meanwhile, significance within the structural modelling phase is ascertained by examining significance (*P*-values), path coefficients, and confidence intervals as described in Section 4.2.

## 3.3. Mediator analysis

Mediation comes into play when a third variable, termed the mediator, intercedes between two other interconnected constructs. This mediator variable dictates the character of the relationship between these two constructs. There exist two varieties of mediating effects: direct and indirect effects. A direct effect is depicted by a single arrow, directly connecting two constructs. On the contrary, indirect effects encompass a series of relationships featuring at least one intervening construct. An indirect effect comprises two or more direct effects and is visually represented by multiple arrows (Shmueli et al., 2019).

In order to effectively assess mediation models, all the quality criteria for the measurement models, as discussed earlier, must satisfy the minimum requirements. Once the measurement model's quality criteria have been evaluated, it becomes imperative to consider all the evaluation criteria for the structural model. When examining the mediation model, it is vital to observe the specific effects during the bootstrapping process (Hair et al., 2017). The results of the mediating effect will be illustrated in Section 4.3.

## 4. Findings and discussion

### 4.1. Measurement model

The construct validity, reliability, and R-square of the Kaleidoscope Model (KM) of the conceptual model are evaluated, as shown in **Table 6**. In the measurement model, the composite reliability is 0.926. These results are considered highly reliable. By grouping the five stages in the KM as the latent variable (LV) scores, the AVE value is calculated as 0.534, surpassing the minimum threshold of 0.50 suggested by Fornell and Larcker (1981). Thus, the measures of the KM demonstrate high levels of convergent validity. The R-square value of the research model is 0.887, as depicted in the KM. This indicates that the five stages significantly influence the evaluation of policy effectiveness and account for 88.70% of the variance in the endogenous construct.

**Table 6.** Construct validity, reliability and R-square of KM for policy effectiveness evaluation.

| No | | Composite reliability | Average variance extracted (AVE) | R-square |
|---|---|---|---|---|
| 1 | Policy effectiveness | 0.926 | 0.534 | 0.887 |

**Table 7** presents the results of discriminant validity through cross-loading assessment. According to Hair et al. (2017), the outer loadings of indicators on their associated constructs should be higher than the cross-loadings on other constructs. In **Table 7**, the presence of "Yes" indicates no issue with discriminant validity, while the presence of "No" suggests a problem. Therefore, in this study, the indicators PE05, PE07, and PE08 pose a discriminant validity problem. Referring to **Table 7**, PE05 is facing a discriminant validity problem, as it shows a value of 0.635 in the Policy Effectiveness construct, which is lower than the value in the Kaleidoscope Model construct (0.656). Therefore, it will be eliminated in the construct.

**Table 7.** Discriminant validity for Kaleidoscope Model in Construction 4.0.

| | Kaleidoscope Model | Policy effectiveness | Discriminant validity |
|---|---|---|---|
| LV scores—Agenda Settings | 0.618 | 0.582 | Yes |
| LV scores—Policy Design | 0.753 | 0.709 | Yes |
| LV scores—Policy Adoption | 0.962 | 0.906 | Yes |
| LV scores—Policy Implementation | 0.969 | 0.912 | Yes |
| LV scores—Evaluation and Reformation | 0.926 | 0.872 | Yes |
| PE01—Shortening the Construction Process | 0.541 | 0.588 | Yes |
| PE02—Increasing Productivity and Efficiency | 0.716 | 0.800 | Yes |
| PE03—Reducing Environmental Issues | 0.576 | 0.649 | Yes |
| PE04—Reducing Construction Costs | 0.457 | 0.562 | Yes |
| PE05—Increasing Collaboration among Stakeholders | 0.656 | 0.635 | No |
| PE06—Enhancing Economic Growth | 0.777 | 0.800 | Yes |
| PE07—Providing greater Benefits for Stakeholders | 0.779 | 0.766 | No |

**Table 7.** (*Continued*).

| | Kaleidoscope Model | Policy effectiveness | Discriminant validity |
|---|---|---|---|
| PE08—Increasing Global Competitiveness | 0.697 | 0.666 | No |
| PE09—Enhancing Domestic and International Business Partnership | 0.820 | 0.870 | Yes |
| PE10—Achieving Policy Outcomes | 0.700 | 0.784 | Yes |
| PE11—Increasing Implementation Rate of Emerging Technologies | 0.711 | 0.773 | Yes |
| PE12—Increasing the Readiness and Willingness of Stakeholders | 0.719 | 0.801 | Yes |

The collinearity can be measured by the variance inflation factor (VIF), which is the reciprocal of the tolerance (Hair et al., 2017). A tolerance level above 0.20 or below 5 indicates no issue with collinearity. **Table 8** displays the collinearity results, which indicate no issue with collinearity as the VIF ranges from 1.596 to 4.537 among the indicators.

**Table 8.** Collinearity among indicators.

| Indicators | VIF |
|---|---|
| PE01—Shortening the Construction Process | 1.756 |
| PE02—Increasing Productivity and Efficiency | 4.537 |
| PE03—Reducing Environmental Issues | 1.753 |
| PE04—Reducing Construction Costs | 1.596 |
| PE05—Increasing Collaboration among Stakeholders | 1.778 |
| PE06—Enhancing Economic Growth | 2.982 |
| PE07—Providing greater Benefits for Stakeholders | 2.311 |
| PE08—Increasing Global Competitiveness | 2.112 |
| PE09—Enhancing Domestic and International Business Partnership | 3.598 |
| PE10—Achieving Policy Outcomes | 2.656 |
| PE11—Increasing Implementation Rate of Emerging Technologies | 4.288 |
| PE12—Increasing the Readiness and Willingness of Stakeholders | 3.007 |

## 4.2. Structural model

**Figure 4** shows the structural model results with path coefficient. The results shown that policy effectiveness indicators are significant at $p < 0.01$.

Effective policy implementation strategies provide a structured approach to translating policy objectives into action. With these strategies, policymakers can identify the most effective approaches for achieving desired policy outcomes. For example, stimulating the current and future impacts of the policy (PI11) can increase the readiness and willingness of stakeholders (PE12) to implement technology in the project lifecycle. This is due to the cooperation and active participation required for successful policy implementation. Pingali et al. (2023) support this notion by highlighting that digital readiness refers to an organization's ability to undertake and initiate a transformative process or change to achieve organizational objectives. When stakeholders are ready and willing to embrace and support a policy, they are more likely to engage in its implementation actively (Nasution et al., 2018).

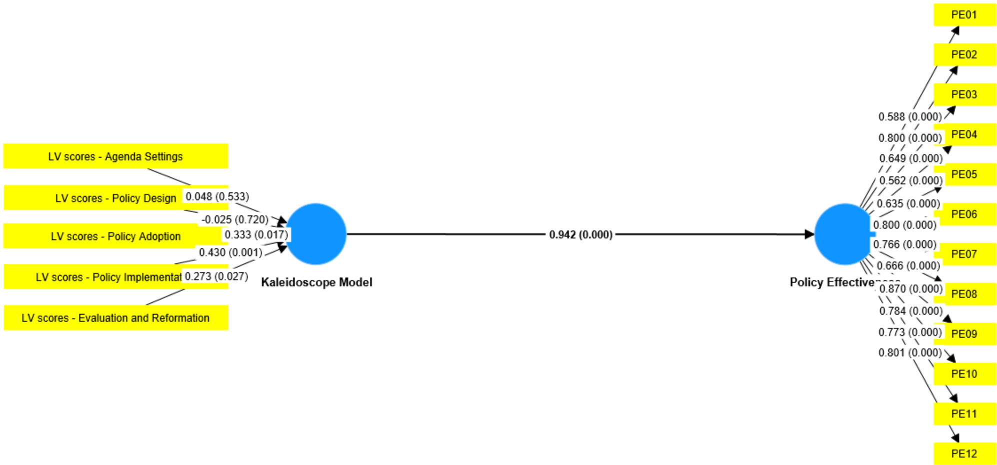


**Figure 4.** Structural model for the Kaleidoscope Model in Construction 4.0.

Referring to **Figure 4**, the outer loadings of policy effectiveness (PE) range from 0.562 to 0.870, with *P*-values below 0.01. This indicates that all the indicators in PE are critical and significant in evaluating the effectiveness of the Construction 4.0 Strategic Plan (2021–2025). The highest outer loading is 0.870 for enhancing domestic and international business partnerships (PE09). Strong domestic and international business partnerships can facilitate successful policy implementation by fostering collaboration, knowledge sharing, and resource mobilisation. When policymakers collaborate with domestic and international businesses, they gain valuable expertise (PI05—recruiting talent and expertise), industry insights (PI15—developing a formal implementation blueprint), and access to resources (PI08—providing appropriate workforce and infrastructure to stakeholders). This collaboration enhances the implementation of policy measures and ensures alignment with the needs and capabilities of the business sector.

In contrast, the lowest outer loading in PE is PE04—reducing construction costs. Reducing construction costs through technology implementation contributes to overall economic efficiency and competitiveness. Lower construction costs attract more investment, stimulate economic growth, and create job opportunities. Evaluating the effectiveness of construction policies in reducing costs provides insights into their impact on the competitiveness of the construction industry and their contribution to broader economic development. However, while reducing construction costs through technology implementation is important for project affordability and efficiency, enhancing domestic and international business partnerships has a more extensive and far-reaching impact on the overall effectiveness of construction policies. Business partnerships contribute to policy outcomes such as market dynamics, resource mobilisation, innovation, and global engagement. Therefore, prioritising and evaluating the effectiveness of these partnerships provides a more comprehensive assessment of construction policy effectiveness.

Based on **Figure 4**, the Kaleidoscope Model (KM) significantly affects policy effectiveness, as evidenced by a path coefficient of 0.942 and a *P*-value of 0.000 ($p <$

0.01). This result indicates an interrelated relationship between the implementation of the KM and policy effectiveness. The KM, proposed by Resnick et al. (2018), plays a crucial role in evaluating policy effectiveness through the five stages. Haggblade and Babu (2017) suggested that adopting the KM can enhance understanding of the structure of Construction 4.0 policies and the policymaking process within the construction industry. It provides a better entry point for policy partners and a deeper understanding among the public, thanks to the different evidence and perspectives from academia and communities. This is supported by Resnick et al. (2018), who mentioned that the Kaleidoscope Model is developed from public administration, political science, and international experiences of actual policy change. Therefore, the framework of the Kaleidoscope Model is able to enhance the effectiveness of the Construction 4.0 policy.

### 4.3. Mediation effect

The mediation analysis went through a similar process described in the previous section: measurement model analysis and structural model analysis. The measurement model, composite reliability of cultural influences and policy effectiveness are 0.902 and 0.927, indicating a highly reliable internal consistency (Shmueli, 2019). Furthermore, the AVE value is calculated as 0.514, surpassing the minimum threshold of 0.50 and represents 51.40% of the overall data. Thus, the measures of the KM demonstrate high levels of convergent validity.

Considering all the structural model evaluation criteria is essential after evaluating the quality criteria of measurement models. **Table 9** shows the structural model results with the path coefficient. The results are converted to their significance level, *P*-values (*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$) as indicated in the model.

**Figure 5** depicts the mediating effect of cultural influences. There are two effects in mediating effects: direct and indirect. The direct effect is from the KM to Policy Effectiveness (PE). Referring to **Figure 5**, the path coefficient for the direct effect is 0.991, with a *P*-value of 0.000, indicating a significant impact of the Kaleidoscope Model on policy effectiveness, as discussed in the previous section. On the other hand, the path coefficient for the indirect effect from the KM to Cultural Influences (CI) is 0.936, with a *P*-value of 0.000. This result indicates that the KM affects cultural influences. Effective policy implementation strategies have the ability to shape and influence behaviour and practices within the construction industry's society or organisation. This is supported by Weiner (2009), who suggests that strategies can create readiness by "unfreezing" existing mindsets and motivating change. However, the path coefficient and *P*-value from cultural influences (CI) to Policy Effectiveness (PE) are −0.063 and 0.695, respectively. This means that CI is not significant in influencing policy effectiveness, as depicted in **Figure 5**. In order to examine the specific effect of the mediator, a structural path Kaleidoscope Model → Cultural influences → Policy effectiveness is evaluated as shown in **Table 10**.

**Table 9.** Structural model with mediating effect.

| | Path Coefficients | *T*-values | *P*-values | Significance Level |
|---|---|---|---|---|
| Cultural influences → Policy Effectiveness | −0.094 | 0.614 | 0.539 | Insignificant |
| Kaleidoscope Model → Cultural Influences | 0.934 | 39.233 | 0.000 | *** |
| Kaleidoscope Model → Policy Effectiveness | 1.026 | 7.255 | 0.000 | *** |

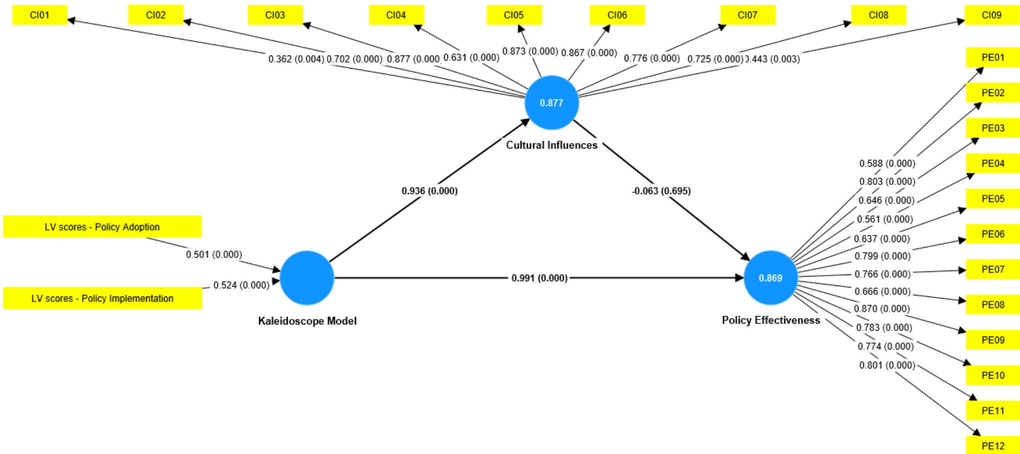


**Figure 5.** Mediating effect for Kaleidoscope Model in Construction 4.0.

**Table 10.** Specific effect for mediator.

| | Path coefficient | *T*-values | *P*-values |
|---|---|---|---|
| Kaleidoscope Model → Cultural Influences → Policy Effectiveness | −0.059 | 0.39 | 0.697 |

It was found that the mediating effect of cultural influences is not significant in affecting policy effectiveness, as shown in **Table 10,** with a *P*-value of 0.697. These results indicated that universal governance principles, efficiency, and effectiveness guide policy implementation. These principles are believed to transcend cultural differences and human behavior patterns, ensuring that policies are executed according to standardized procedures and criteria. Legal frameworks and institutional structures are designed to ensure consistent policy implementation. They are based on established laws, regulations, and administrative procedures, which are expected to be followed regardless of cultural or behavioral considerations. Besides, bureaucratic systems are designed to minimize subjectivity and cultural biases in policy implementation. Standardized protocols and Construction 4.0 guidelines are intended to ensure that decisions are made based on rational and objective criteria, reducing the potential for cultural or behavioral influences to sway the implementation process.

## 5. Conclusion

In the policy evaluation, the implementation of a Kaleidoscope Model in Construction 4.0 has emerged as a pivotal tool for assessing policy effectiveness. This study has culminated in a significant finding: the utilization of the Kaleidoscope

Model exhibits a positive influence on policy effectiveness, even in the absence of cultural influences. The impact of the Kaleidoscope Model (KM) on policy effectiveness is substantial, as indicated by a path coefficient of 0.942 and a $P$-value of 0.000 ($p < 0.01$). The mediating effect of cultural influences was found to be insignificant in affecting policy effectiveness, with a $P$-value of 0.697. This conclusion sheds light on the potential of the Kaleidoscope Model to serve as a robust framework for policy assessment, showcasing its ability to transcend cultural variations and yield favourable outcomes.

The incorporation of the Kaleidoscope Model into policy evaluation practices has yielded noteworthy results. The model's multi-dimensional approach, which considers diverse economic, social, environmental, and technological factors, enables a comprehensive analysis of policy impacts. This holistic perspective provides policymakers and evaluators with a clearer understanding of policy effectiveness across various domains. Importantly, the study has demonstrated that the efficacy of the Kaleidoscope Model persists independently of cultural influences.

This study has bolstered the model's credibility as a universal tool by indicating that cultural factors do not significantly alter the model's positive impact on policy effectiveness. This finding underscores the Kaleidoscope Model's capacity to maintain its integrity and analytical power in diverse socio-cultural contexts. The model's ability to navigate beyond cultural barriers highlights its potential to be employed across different regions and societies without diminishing its efficacy.

While the results emphasise the strengths of the Kaleidoscope Model, it is prudent to acknowledge potential limitations. Cultural influences undoubtedly contribute to the complexity of policy implementation and effectiveness evaluation. Future studies could explore instances where subtle cultural nuances may intersect with the Kaleidoscope Model's assessment process, deepening our comprehension of these interactions.

The limitation arises from the exclusive collection of research findings from construction stakeholders in Malaysia. Notably absent from the research are other significant influencers, specifically the public—the ultimate end users of the final construction products. The omission of the public from the study was primarily due to time constraints. However, it is essential to acknowledge that the behavioral characteristics of the public play a pivotal role in the realm of policy implementation.

The Construction 4.0 policy, with its potential to impact construction costs and induce fluctuations in building prices, introduces complexities and heightened challenges in policy implementation. The behavior of the public becomes particularly crucial in this context, as their perceptions, expectations, and responses to the policy can significantly influence its effectiveness.

To address this limitation, it is recommended to delve into the behavioral characteristics of the public concerning the Construction 4.0 policy. Understanding how the public perceives and reacts to the policy can provide invaluable insights, enabling a more comprehensive and nuanced approach to policy formulation and implementation. By incorporating the perspectives of end users, policymakers can enhance the relevance and efficacy of the Construction 4.0 policy, ensuring a more holistic and inclusive implementation strategy.

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