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# Validation of principal's innovation leadership scale using factor analysis in Malaysian school context

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**ABSTRACT**

This study addresses the need for a standardized tool to assess innovation leadership in secondary education. Despite its importance, no established instrument exists for evaluating and developing innovation leadership among school administrators. The principal innovation leadership scale (PILS) was developed and validated to bridge this gap. The process involved a literature review, expert consultations, and an initial 58-item pool. Exploratory and confirmatory factor analysis (CFA) refined the scale to 18 items across five dimensions, demonstrating strong model fit (comparative fit index (CFI)=0.957, root mean square error of approximation (RMSEA)=0.080, incremental fit index (IFI)=0.958, normed fit index (NFI)=0.947, Tucker-Lewis's index (TLI)=0.90). The fitted model indicated a satisfactory fit, confirming that the five latent constructs effectively measure the observed variables in the questionnaire. The PILS offers a standardized tool for assessing innovative leadership among school leaders, enabling targeted improvement strategies and informing professional development programs. This study significantly contributes to the discourse on innovation leadership in education by providing a valuable instrument for evaluating and enhancing school leadership practices.



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## 1. INTRODUCTION

The Malaysian Ministry of Education's (MOE) efforts to modernize its education system through technology-based initiatives are reflected in the Malaysian Education Plan Annual Performance Report 2017 [1]. The report highlights the significant allocation of resources to improve the efficiency and effectiveness of the ministry's system, which encompasses management and administration as well as teaching and learning. However, despite these efforts, some challenges must be addressed to ensure these technological initiatives can be fully implemented. One of these challenges is the weak skills of administrators, who may need more competencies to deal effectively with the latest technology [1]. In addition, the duplication of software functions, individual software development and the incremental implementation of projects hinder this improvement. While it is important to point out that innovation in education can occur without technology, there is no denying that technological advances have played an essential role in promoting innovation in education. Therefore, the MOE's focus on implementing technology-based initiatives as part of its plan to

transform education is a step in the right direction. However, the above challenges must be addressed to ensure these initiatives can be effectively implemented and sustained.

This education system reform is the most important innovation that all education leaders must address, including teachers, principals, district education councils, civil servants, and the Malaysian MOE [1]. The role of school leaders is critical in driving change in schools [2], fostering innovation [3], and building capacity for innovation [4]. They are responsible for making decisions, setting direction and ensuring the quality of education in schools by creating an environment conducive to innovation [4], [5]. Their effective leadership skills can significantly influence innovation in school management. However, school leaders often need help understanding their role in school innovation and collaboration processes [4]. Teachers need guidance and mentorship from their school leaders to help them develop innovative ideas [5]. While there are many studies on innovation in other fields, more research needs to be done on innovation in education. Furthermore, effective leadership for school leaders in one school may not work in another setting [6]. This is due to the complexity of the innovation, as well as non-linearity and uncertainty.

Innovation is a multi-faceted construct encompassing different types, such as radical and incremental, revolutions and breakthroughs, management, technology, processes and products, and idea generation and implementation [7]. The complexity of innovation has led to conflicting results in previous studies on leadership and innovation. Previous research has shown that different leadership styles can affect innovation differently [8], [9]. Innovation leadership is complicated and constantly changing due to the multi-layered nature of innovation, and there is no one-size-fits-all approach. This complexity arises from the different types, degrees and phases of innovation implementation. Different understandings of leadership also contribute. Leaders must tailor their strategies to the particular type, degree and phase of innovation. For example, fostering product innovation requires motivating teams, overcoming challenges and setting measurable goals [10]. In contrast, systems innovation requires a practical leadership style focusing on vision, relationships and critical planning [11]. Leadership tactics can even evolve within a project. Kesting *et al.* [12] suggest starting with an enabling style to foster creativity and moving to directive leadership in later stages. This adaptability creates a balance between leadership and innovation. These studies show how important it is to be flexible to drive innovation. By combining and adapting different leadership styles as needed, leaders create an innovative culture that fosters creativity, risk-taking and teamwork.

Despite the complicated nature of the innovation itself, the theories underlying the innovation phase and type also varied. Some studies have focused on a single leadership theory for leading innovation [13]. However, recent research has found that a single leadership theory may not effectively lead to innovation. Researchers have found that traditional leadership theories, such as transformational and transactional leadership, are insufficient to explain the dynamic behaviors of innovation because they were not developed with innovation in mind. Such inflexible theories are less effective in supporting innovation implementation processes that require a wide range of knowledge and skills. Instead, combining multiple leadership styles can support innovation more effectively [13].

Thus, innovation's complicated and multi-layered nature challenges education leaders to cultivate it in educational institutions. School leaders must have the knowledge and skills to encourage and facilitate innovation and create an environment conducive to growth. However, previous research on the relationship between leadership and innovation has produced divergent and contradictory results, highlighting the complicated nature of the innovation process. There is a need to combine contemporary leadership theories with traditional methods to cultivate innovative behavior effectively. Research should identify theories of school leadership that are suitable for innovation leadership in educational institutions. Furthermore, an in-depth study of successful school leaders' characteristics and leadership styles in the field of organizational innovation in schools is warranted.

Therefore, this study seeks to integrate conventional leadership, particularly transformational leadership, with other theoretical frameworks such as ambidextrous leadership, Gliddon's innovation leader competency model, Vlok's profile competency model, and Swart's innovation leader competency model. This study addresses the pressing need to enhance innovative leadership within the Malaysian education system by examining the complex relationship between leadership styles and innovation outcomes; the study aims to provide insights into effective leadership approaches for fostering innovation within secondary schools in Malaysia. Furthermore, integrating conventional and contemporary leadership theories to develop an integrated approach to innovation leadership assessment tailored to the educational context is essential for addressing education leaders' multifaceted challenges. Thus, this study attempts to answer these questions:

- How do different leadership styles impact the effectiveness of innovation implementation within educational institutions, particularly in the context of technology-driven initiatives in the Malaysian education system?
- What are successful school leaders' key competencies and characteristics in fostering innovation and driving change within educational institutions?

This innovation leadership model is based on a systematic literature review. It integrates concepts from transformational leadership theory, ambidextrous leadership theory, and innovation leadership competency models. Table 1 presents the proposed dimensions of school leaders' innovation leadership.

Table 1. Dimension of principals innovation leadership scale

| Dimension | Theories background |
|---|---|
| Creative behaviors | Gliddon [14] innovation leader competency model, model profile competence Vlok [15], Swart [16] innovation leader competency model, Bass and Avolio [17] transformation leadership theory. |
| Ideal influence | Bass and Avolio [17] transformation leadership theory. |
| Effective communication | Gliddon [14] innovation leader competency model, model profile competence Vlok [15], Swart [16] innovation leader competency model, Bass and Avolio [17] transformation leadership theory. |
| Empowerment | Gliddon [14] innovation leader competency model, model profile competence Vlok [15], Swart [16] innovation leader competency model, Bass and Avolio [17] transformation leadership theory. |
| Technical skills | Swart [16] innovation leader competency model. |
| Entrepreneurship | Model profile competence Vlok [15], Swart [16] innovation leader competency model. |
| Opening behaviors | Rosing *et al*. [9] |
| Closing behaviors | Rosing *et al*. [9] |

## 2. METHOD

The study aimed to investigate secondary school teachers in national secondary schools in Sabah, Malaysia. Multistage stratified random sampling was used for the study to ensure that the sample was representative and generalizable to the population [18]. This sampling procedure involved two levels of sampling. At the district level, a sample of teachers was randomly selected from 33 schools in each district. This technique ensured that the sample was representative of the teacher population in each district. At the school level, 605 teachers were selected from the 33 identified schools using systematic random sampling. This ensures that the sample is representative of the teacher population in each school. There are 105 teachers participated in exploratory factor analysis (EFA), a statistical technique to identify the underlying factor structure of a set of variables. Meanwhile, 500 teachers participated in confirmatory factor analysis (CFA), a statistical technique to confirm the factor structure identified in EFA. This sample size is adequate for the studies conducted. It can provide reliable results that can be generalized to the population of secondary school teachers in government secondary schools in Sabah State.

Operational definitions and existing questionnaires were used as guidelines in developing the questionnaire to measure each dimension of school leaders' innovation leadership. Table 2 provides the detailed items developed from the literature review to measure each dimension. Items were developed for each dimension to assess the specific construct. These items were derived based on the operational definitions and adapted from the existing questionnaires where necessary. The items were worded clearly and concisely to ensure that respondents understood the intent of the questions. The questionnaire was then pilot-tested to ensure it was understandable and reliable. Feedback from the pilot study was used to refine and improve the clarity of the questions. The final questionnaire was then distributed to the sample population of Malaysian secondary school teachers in government secondary schools in Sabah State, where the teacher sample was randomly selected using a multistage stratified sampling technique. Using operational definitions and existing questionnaires ensured that the items in the questionnaire were comprehensive and relevant to the study. The rigorous process of item development and pilot testing helped to confirm the validity and reliability of the questionnaire, which ultimately contributed to the overall quality of the study.

Content validity was conducted to ensure that the instruments used in the study could measure the constructs developed [19]. Six experts in the field assessed the instruments' content validity [20]. The instruments achieved a satisfactory content validity index (S-cvi/Ave) of 0.94, indicating high content validity. Ethical considerations are paramount in this study, particularly respecting participants' privacy, ensuring anonymity and guaranteeing confidentiality. The guidelines of Hair *et al*. [21] formed the basis for these ethical considerations. Participation in the study was entirely voluntary, without coercion or pressure. Information was provided to participants to ensure they fully understood the nature and purpose of the study. This information included the purpose of the study, the procedures involved and the possible risks and benefits of participation. Participants were also informed of their right to withdraw from the study at any time and for any reason. Most importantly, the researchers obtained consent from the Malaysian education authorities, the Sabah education authorities and the principals of the selected schools before conducting the study. This ensured that all stakeholders were aware of the study and agreed to have it conducted in their schools. By adhering to these ethical considerations, the researchers were able to maintain the integrity of the study and ensure that the rights and welfare of the participants were protected.

In this study, 500 questionnaires were distributed to secondary school teachers in Sabah, Malaysia. A high % response rate of 98% was achieved with a return rate of 490 questionnaires. After data cleaning, 478 questionnaires were deemed suitable for final analysis. The demographic characteristics of the respondents are shown in Table 3. This table overviews the respondents' age, gender, teaching experience, academic qualifications and other relevant demographic variables. It is essential to consider these characteristics when interpreting the study findings, as they may have implications for how teachers perceive the innovative leadership practices of school leaders.

Table 2. Items generated for each dimension identified through the literature review method

| Theoretical codes | Theoretical codes |
|---|---|
| Dimension 1: Creative behaviors | Dimension 5: Technical skills |
| TLK1 Critical thinking | KT33 Participate in innovation activities |
| TLK2 Different perspectives | KT34 Select ideas that can be implemented |
| TLK3 Different ways of looking at problems | KT35 Know the values of commercialized ideas |
| TLK4 New ways of solving problems | KT36 Be able to interpret market returns |
| TLK5 No criticism of creative ideas | KT37 Develop cross-functional teams |
| TLK6 Creative behavior during the process | Dimension 6: Entrepreneurship |
| TLK7 Solve problems creatively | U38 Entrepreneurship skills |
| TLK8 Give motivation | U39 New ideas from the environment |
| Dimension 2: Ideal influence | U40 Marketing products |
| PI9 Shared mission | U41 Compare products with other competitors |
| PI10 Have pride | U42 Generate new ideas based on current situations |
| PI11 Well-being of the team | U43 Generate new ideas based on school relationships |
| PI12 Idea generation activities | U44 The importance of resources |
| PI13 Help from experts | Dimension 7: Opening behaviors |
| PI14 Adequate time for innovation | TLB45 Open environments |
| PI15 Cross-cutting team between schools | TLB46 Encouraging new ideas |
| PI16 Communicating potential ideas to stakeholders | TLB47 Freedom of thought |
| Dimension 3: Effective communication | TLB48 Questioning the status quo |
| C17 Vision for the future | TLB49 Willingness to take risks |
| C18 Innovation vision | TLB50 Allowing mistakes and learning from them |
| C19 Optimistic | TLB51 High tolerance for failure |
| C20 Full of enthusiasm | Dimension 8: Closing behaviors |
| C21 Confident | TLT52 Monitor and control the achievement of the objectives |
| C22 Appealing vision | TLT53 Establish a routine |
| C23 Commercialization of the innovation | TLT54 Take corrective action |
| C24 Evaluation of the success of the innovation | TLT55 Follow the rules |
| Dimension 4: Empowerment | TLT56 Shared success in tasks |
| PB25 Self-development | TLT57 Do not allow mistakes |
| PB26 Individual actor | TLT58 Follow the original plan |
| PB27 Diverse potential | |
| PB28 Mentoring for teachers | |
| PB29 Ideas-generating activities | |
| PB30 Delivering idea generation | |
| PB31 Avoiding controlled work plans | |
| PB32 Freedom and autonomy | |

The data collected from the questionnaire were analyzed in a two-stage procedure. First, an EFA was conducted. EFA is a technique used to identify underlying factors or dimensions in a set of variables that can then be used to facilitate data analysis. Second, CFA was conducted to confirm the factor structure identified through EFA and assess the measurement model's fit. Both EFA and CFA are standard statistical procedures in psychometric research to assess the validity of measured variables.

A total of 58 items were analyzed using principal component analysis (PCA) and varimax rotation. Standardized factor loading and Cronbach's alpha were used to score the items for each factor extracted. A factor loading cut-off value of 0.55 or higher [21] and a Cronbach's alpha value of 0.70 or higher [22] were considered acceptable. Factors with an eigenvalue greater than 1.0 were considered significant and the total variance explained should be greater than 60% of the total variance [21]. Table 4 was used as a guide for extracting the factors in the EFA.

Following the EFA, CFA was used to test the principal's innovation leadership scale for its convergent and discriminant validity. The instrument's validity refers to its accuracy in measuring the intended construct [21]. Hair *et al*. [21] explain that validity includes convergent, discriminant, and model fit. Convergent validity is when all items within a measurement model are statistically significant, as determined by factor loadings, average variance extracted (AVE) and construct reliability (CR). Factor loadings should be greater than 0.50, AVE greater than 0.50, and composite validity 0.60 or higher. Discriminant validity measures the independence of the items measured. It is fulfilled if the correlation between the constructs is

below 0.90. The heterotrait-monotrait ratio of correlations (HTMT) analysis was conducted to address potential problems with discriminant validity arising from correlations between constructs. The HTMT values should not exceed 0.9. The model fit assessment aims to evaluate the compatibility of the CFA model with the data. Several fit indices were used, including the chi-squared statistic ($\chi 2$), normalized chi-squared ($\chi 2/pdf \leq 5.0$), root mean square error of approximation (RMSEA) ($0.05 \leq RMSEA \leq 0.10$), comparative fit index (CFI≥0.90) and Tucker-Lewis's index (TLI≥0.90). Validation of the principal's innovation leadership scale included checking convergent validity through factor loadings, AVE and CR, ensuring discriminant validity by examining construct correlations and HTMT scores and assessing model fit using several indices, including $\chi 2$, $\chi 2/df$, RMSEA, CFI and TLI.

Table 3. Demographic details of the respondents

| Demographic | Categories | Frequency | Percentage (%) |
|---|---|---|---|
| Gender | Male | 156 | 32.6 |
| | Female | 322 | 67.4 |
| Age | 21-30 | 57 | 11.9 |
| | 31-40 | 216 | 45.2 |
| | 41-50 | 160 | 33.5 |
| | 51-60 | 45 | 9.4 |
| Academic qualification | Certificate/Diploma | 2 | 0.4 |
| | Degree | 387 | 81 |
| | Master | 84 | 17.6 |
| | Doctorate | 5 | 1.0 |
| Years of service | 3–10 | 194 | 40.6 |
| | 11–20 | 214 | 44.8 |
| | 21–30 | 62 | 13.0 |
| | 31–40 | 8 | 1.7 |
| Years of service in the current school | 1-10 | 331 | 69.5 |
| | 11–20 | 118 | 24.7 |
| | 21–30 | 23 | 4.8 |
| | 31–40 | 5 | 1.0 |
| Years of service under the current principals | 1–5 | 402 | 84.1 |
| | 6–10 | 71 | 14.9 |
| | 11–15 | 4 | 0.8 |
| | 16–20 | 1 | 0.2 |

Table 4. EFA fulfilment criteria

| Index for EFA model | Recommended values |
|---|---|
| Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy | >0.50 |
| Bartlett's test of sphericity $\chi 2$ (sig<0.05) | <0.05 |
| Communalities values | ≥0.50 |
| Eigenvalues | >1.00 |
| Factor loading values | ≥0.55 |
| Percentage of variance explained | ≥60% |

## 3. RESULTS AND DISCUSSION

### 3.1. Exploratory factor analysis

PCA with varimax rotation was conducted for the principal's innovation leadership scale items. Before PCA, a preliminary study was conducted to assess the suitability of the data for factor analysis. Data normality was assessed using skewness and kurtosis values, with a critical threshold set at ±1.96 at a 0.05 level of significance [21]. All variables fell within the acceptable range, indicating that the data met the normality assumptions required for further statistical analysis. A multivariate test confirmed the presence of numerous correlation coefficients with values of 0.3 or higher. Each item had a communality value of 0.5 or higher, as shown in Table 5, using the guidelines by Hair *et al.* [21]. Table 5 also shows that the KMO measure of sampling adequacy was more significant at 0.9 than the cut-off value of 0.5 and that Bartlett's test for sphericity was significant at less than 0.05. These preliminary analyses showed that the data met the criteria for conducting a factor analysis.

Eigenvalues and the scree plot were used to determine the number of factors to be extracted. Table 6 gives an overview of the explained variance for the PCA using varimax rotation. This table contains the original eigenvalues, the extraction sums of squared loadings and the rotation sums of squared loadings for the five components. It is noticeable that the principal component has the most significant variance, at 46.319%. The second, third, fourth and fifth components explain 7.584%, 6.163%, 4.899% and 4.539%, respectively. Cumulatively, these five components explain 69.504% of the total variance. Moreover, Table 6

shows eigenvalues ranging from 1.225 to 12.506, while the first five components individually explain variances of 46.319%, 7.584%, 6.163%, 4.899% and 4.539%.

Table 5. KMO test and Bartlett's test of sphericity

| KMO and Bartlett's test | | |
|---|---|---|
| KMO measure of sampling adequacy. | | 0.900 |
| Bartlett's test of sphericity | Approx. Chi-square | 2055.342 |
| | df | 351 |
| | Sig. | 0.000 |

Table 6. Scores of factor components that have been extracted for principals' innovation leadership scale

| The sum of variance explained | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Component | Initial eigenvalues | | | Extraction sums of squared loadings | | | Rotation sums of squared loadings | | |
| | Total | % of variance | Cumulative % | Total | % of variance | Cumulative % | Total | % of variance | Cumulative % |
| 1 | 12.506 | 46.319 | 46.319 | 12.506 | 46.319 | 46.319 | 4.580 | 16.963 | 16.963 |
| 2 | 2.048 | 7.584 | 53.903 | 2.048 | 7.584 | 53.903 | 4.311 | 15.966 | 32.929 |
| 3 | 1.664 | 6.163 | 60.066 | 1.664 | 6.163 | 60.066 | 3.713 | 13.752 | 46.681 |
| 4 | 1.323 | 4.899 | 64.965 | 1.323 | 4.899 | 64.965 | 3.461 | 12.819 | 59.500 |
| 5 | 1.225 | 4.539 | 69.504 | 1.225 | 4.539 | 69.504 | 2.701 | 10.003 | 69.504 |

Table 7 lists the five emergent components of the EFA procedures. The items where the factors overlapped or did not load on any of the components were excluded. To determine the final selection of factor loadings, a threshold was set based on the sample size, which in this case was 105. Following the guidelines of Hair *et al*. [21], a loading factor of 0.55 was chosen. All items with a loading factor value below 0.55 were removed from the final questionnaire. For example, item TLB49 did not reach the threshold value of 0.55 and was therefore removed from the questionnaire before proceeding with the following procedure: factor validation analysis (CFA).

Table 7. Varimax rotation component matrix

| Rotation | | | | | | |
|---|---|---|---|---|---|---|
| Item code | Factors | | | | | Communality |
| | 1 | 2 | 3 | 4 | 5 | |
| C18 | 0.698 | | | | | 0.629 |
| C20 | 0.688 | | | | | 0.565 |
| C19 | 0.664 | | | | | 0.705 |
| PB27 | 0.656 | | | | | 0.752 |
| TLK2 | | 0.830 | | | | 0.785 |
| TLK4 | | 0.786 | | | | 0.738 |
| TLK3 | | 0.760 | | | | 0.695 |
| TLK1 | | 0.733 | | | | 0.653 |
| TLK7 | | 0.630 | | | | 0.634 |
| KT33 | | | 0.779 | | | 0.814 |
| KT35 | | | 0.745 | | | 0.753 |
| KT32 | | | 0.744 | | | 0.700 |
| KT34 | | | 0.738 | | | 0.829 |
| KT31 | | | 0.636 | | | 0.639 |
| TLT53 | | | | 0.806 | | 0.799 |
| TLT55 | | | | 0.768 | | 0.697 |
| TLT52 | | | | 0.712 | | 0.757 |
| TLT57 | | | | 0.699 | | 0.765 |
| TLB49 | | | | 0.456 | | 0.560 |
| TLB45 | | | | | 0.791 | 0.802 |
| TLB46 | | | | | 0.746 | 0.737 |
| TLB44 | | | | | 0.730 | 0.749 |
| | | | | | | Total |
| Eigenvalues | 12.506 | 2.048 | 1.664 | 1.323 | 1.225 | 18.766 |
| The sum of the variance percentage | 46.319 | 7.584 | 6.163 | 4.899 | 4.539 | 69.504 |

After detailed analysis, component one comprises items C18, C19, C20 and PB27, which are jointly assigned to the dimension of effective communication. Component two comprises items TLK1, TLK2, TLK3, TLK4 and TLK7, all classified under the creative behaviors dimension. Component three comprises items KT31, KT32, KT33, KT34 and KT35, grouped under technical skills. Component four comprises items

TLT52, TLT53, TLT55 and TLT57, which are classified under the dimension closed behaviors. Finally, the fifth component consists of items TLB44, TLB45 and TLB46, which are assigned to the open behaviors dimension. Cronbach's alpha values were calculated to ensure the internal consistency of the measurements for the latent constructs. Table 8 shows the internal validity of the individual constructs. All final items met the criteria for internal consistency and achieved a value of 0.879, exceeding the threshold of 0.7 [21].

Table 8. Cronbach's alpha for internal consistency

| Component | Number of items | Cronbach's alpha |
|---|---|---|
| Creative behaviors | 4 | 0.854 |
| Effective communication | 5 | 0.887 |
| Technical skills | 5 | 0.902 |
| Open behaviors | 4 | 0.887 |
| Closed behaviors | 3 | 0.864 |
| Total items | 21 | 0.879 |

### 3.2. Confirmatory factor analysis

After the EFA, only five dimensions were selected for the CFA: creative behaviors (TLK), effective communication (KOM), technical skills (KT), open behaviors (TLB) and closed behaviors (TLT). For the CFA, the factor loadings were first assessed. All factor loadings were above 0.5. Then, model fit was assessed using incremental indices (adjusted goodness of fit index (AGFI), CFI, TLI, normed fit index (NFI)) and absolute indices (Chi-squared, RMSEA, goodness of fit index (GFI)), as recommended by Hair *et al*. [21]. For incremental indices, CFI (0.941), incremental fit index (IFI) (0.942), NFI (0.929) and TLI (0.931) exceeded the threshold of 0.90, but two indices, GFI (0.834) and AGFI (0.786), fell short of this mark. In addition, the relative Chi-square value of 5.477 exceeded the required value 5.0 [23], and the RMSEA value of 0.096 was above the desired value of 0.08 [24]. As these criteria were not met, adjustments to the model were required.

PB27 and TLK7 were removed to improve the fit indices, as they had low factor loadings and insignificant contributions to latent constructs. After this change, the fit of the model was reassessed. The relative Chi-square value decreased to 3.640, now meeting the less than 5.0 requirement, and the RMSEA value improved to 0.080, meeting the less than 0.08 threshold. Other fit indices also improved: CFI (0.957), IFI (0.958), NFI (0.947) and TLI (0.949) were all above 0.90. GFI (0.902) and AGFI (0.855) values also improved. The fitted model showed a satisfactory fit, indicating that the five latent constructs effectively measure the observed variables in the questionnaire, as shown in Figure 1.

To ensure the validity and reliability of the measurement model shown in Figure 1, several criteria must be met, including one-dimensionality, convergent validity, construct validity and discriminant validity. Convergent validity is tested by assessing factor loadings, AVE and CR. One-dimensionality is given if the factor loadings exceed 0.5 and preferably reach 0.7 or more. The AVE value of each construct should be above 0.5. CR values should ideally be 0.7 or higher, although values between 0.6 and 0.7 are also considered acceptable, according to Hair *et al*. [21].

The results in Table 9 show that all items had factor loadings greater than 0.5, with each item exceeding a value of 0.7, indicating the achievement of an optimal factor loading. In addition, the AVE scores for the communication (0.852), creative behaviors (0.760), technical skills (0.874), closed behaviors (0.818) and open behaviors (0.875) components all exceeded the 0.5 threshold. in addition, the scores of CR for the communication (0.945), creative behaviors (0.927), technical skills (0.965), closed behaviors (0.947) and open behaviors (0.954) components all exceeded the minimum threshold of 0.6. This means that the latent constructs of this model meet the requirements for convergent validity and CR.

Discriminant validity refers to how each construct differs from the other constructs in the measurement model. Some researchers have expressed concern that the traditional methods to assess discriminant validity are limited. Therefore, Byrne [24] suggested using the HTMT method as an alternative. The results of the HTMT analysis are presented in Table 10, and it was found that the HTMT values between components did not exceed 0.90 [25]. It can be concluded that this model meets the required conditions for discriminant validity.

The validation of the principal innovation leadership scale (PILS) involved several steps, including modification of the original model based on the modification index, assessment of one-dimensionality, convergent validity, construct validity and discriminant validity. The evaluation showed that the modified model met the criteria for model fit index, convergent validity and CR. The HTMT method was used to assess discriminant validity, and the results showed that the model met the required discriminant validity. Overall, the PILS was a valid and reliable measure of innovation leadership in secondary schools.

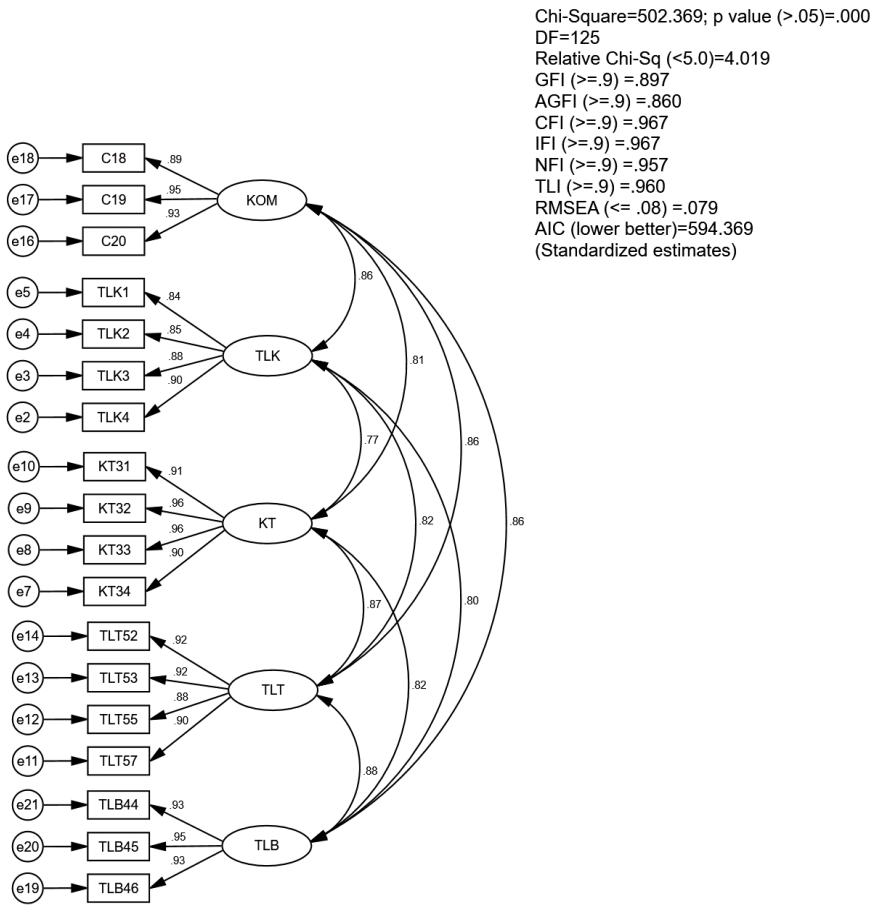


Figure 1. The final model of principal innovation leadership measurement

Table 9. AVE and CR values for principals innovation leadership constructs

| Constructs | Item | Factors loading | CR (Minimum 0.6) | AVE (Minimum 0.5) |
|---|---|---|---|---|
| Effective communication (KOM) | C18 | 0.89 | 0.945 | 0.852 |
| | C19 | 0.95 | | |
| | C20 | 0.93 | | |
| Creative behaviors (TLK) | TLK1 | 0.84 | 0.927 | 0.760 |
| | TLK2 | 0.85 | | |
| | TLK3 | 0.88 | | |
| | TLK4 | 0.90 | | |
| Technical skills (KT) | KT31 | 0.91 | 0.965 | 0.874 |
| | KT32 | 0.96 | | |
| | KT33 | 0.96 | | |
| | KT34 | 0.90 | | |
| Closed behaviors (TLT) | TLT52 | 0.92 | 0.947 | 0.818 |
| | TLT53 | 0.92 | | |
| | TLT55 | 0.88 | | |
| | TLT57 | 0.90 | | |
| Open behaviors (TLB) | TLB44 | 0.93 | 0.954 | 0.875 |
| | TLB45 | 0.95 | | |
| | TLB46 | 0.93 | | |

Table 10. HTMT analysis of principal innovation leadership model

| Components | TLK | KT | TLT | KOM | TLB |
|---|---|---|---|---|---|
| TLK | | | | | |
| KT | 0.783 | | | | |
| TLT | 0.821 | 0.872 | | | |
| KOM | 0.857 | 0.825 | 0.864 | | |
| TLB | 0.802 | 0.826 | 0.884 | 0.869 | |

### 3.3. Discussion

In response to the dynamic landscape of educational innovation, this study delves into the intricate leadership dynamics within secondary schools, particularly in the context of innovation-driven initiatives within the Malaysian education system. Two pivotal questions guide this inquiry: firstly, the impact of various leadership styles on the efficacy of innovation implementation within secondary schools in Malaysia, and secondly, the identification of key competencies and characteristics of successful school leaders in fostering innovation and driving change.

To address the first question, this study utilizes a comprehensive framework synthesized from notable theories, including transformational leadership, ambidextrous leadership, and various models of innovation leadership competency. Empirical evidence demonstrates that leveraging these theories—such as ambidextrous leadership [9], Gliddon innovation leader's competency model [14], Model profile competence Vlok [15], Swart's leader competency model [16], and Bass and Avolio transformational leadership theory [17], serves as a robust framework for understanding and fostering innovation leadership within secondary schools in Malaysia.

The findings address the second research question through rigorous empirical validation to identify effective school leaders' pivotal competencies and attributes in nurturing innovation and steering organizational change. The empirical evidence highlights five key dimensions as crucial predictors of innovation efficacy: creative behaviors, effective communication, technical proficiency, openness, and closure. These dimensions collectively encompass various aspects of innovation leadership, from fostering creativity and teamwork to ensuring accountability and procedural adherence. However, despite their initial theoretical consideration, dimensions such as ideal influence, empowerment, and entrepreneurship did not withstand empirical scrutiny.

The first dimension, creative behaviors, describes how innovation leaders think outside the box when solving problems, testing assumptions, adopting different perspectives and suggesting new ways to accomplish tasks. Creative behaviors that emphasize learner-centered, collaborative, experimental and adaptive learning experiences are essential for fostering innovative educational practices [26]. Research shows that leaders who prioritize learners' needs, encourage experimentation and stimulate creativity in their employees are likelier to have employees who demonstrate innovative behaviors and entrepreneurial values [27]. Therefore, leaders in educational institutions should create an environment that promotes flexibility, supports creative and analytical thinking in teachers and students, and encourages them to approach problems from different perspectives [28]. In this way, leaders can increase teachers' confidence and reduce their fear of innovation, thus fostering a culture of innovation in the organization.

The second dimension, effective communication, was validated with three specific items: talking optimistically about the future, talking passionately about what needs to be achieved in innovation, and showing confidence in achieving innovation goals. Extensive research [29], [30] consistently emphasizes the importance of effective communication for innovation leaders to drive change among their followers. Through effective communication, innovation leaders can create a shared sense of purpose and vision among team members [30], which fosters collaboration and creativity and leads to successful innovation. Furthermore, effective communication is crucial for creating a culture of trust and openness; as research by Rizki *et al*. [29] argues, it encourages teachers and staff to share their innovative ideas calmly. Optimistic and enthusiastic communication inspires and motivates learners [31]. By talking positively about the future, discussing innovation goals with enthusiasm and showing confidence in achieving them, teachers create a positive and hopeful environment that encourages learners to believe in the potential of innovation.

The study's results also underline the crucial role of technical skills in promoting innovation in schools. The technical skills dimension identified includes various aspects such as providing valuable input for innovation activities, identifying viable ideas, assessing the value and characteristics of ideas that can be commercialized, and interpreting the returns during commercialization. These findings demonstrate that leaders' technical skills foster innovation [32]. Teachers also emphasize the importance of technical support for innovative projects. They need to acquire technical skills that align with these principles to contribute to the education sector's development effectively. Leaders with technical skills are critical at various stages, including developing, evaluating, and commercializing ideas. Leaders with technical skills and experience have better intuition when sorting ideas in the early stages of product development [32].

The fourth dimension of this study confirms the dimension of opening behaviors with three items that encourage individuals to develop their creative ideas, ensure freedom of thought in innovation and promote the improvement of existing situations. This dimension is related to the fifth dimension, closing behaviors, which confirms four items: controlling the achievement of goals, establishing routine behaviors during the innovation process, emphasizing adherence to the rules of the innovation process, and following the original plan of the innovation project. These two dimensions are discussed together as they are derived from the theory of ambidextrous leadership and complement each other. Ambidextrous leaders alternate

between opening and closing behaviors to find new solutions to problems [9]. This dimension suggests that school leaders use open behaviors as a catalyst for innovation. At the same time, however, they also use closed behaviors to control the innovation carried out.

The opening behaviors dimension of the study confirmed that school leaders promote the emergence of creative ideas by encouraging teachers to have the freedom to innovate and improve existing conditions. At the same time, the final behavioral dimension showed that while principals give teachers the freedom to be innovative, they still need to exercise control over achieving innovation goals themselves. Teachers need to engage in routine behaviors during the innovation process, such as following the set timelines for innovation, attending meetings organized by the innovation team, and emphasizing the necessary rules while implementing the innovation while sticking to the original plan for implementing the innovation. This result aligns with the fundamental theories put forward [9]. These theories state that open behaviors fosters an atmosphere where employees can experiment, challenge prevailing norms and develop unbridled ideas as part of the innovation process. Conversely, close behaviors minimize discord within the follower cohort of employees by monitoring goal achievement, initiating corrective action when needed, and providing explicit instructions on meeting goals. This ultimate attitude ensures the timely and efficient achievement of innovation goals. Consequently, teachers are encouraged to follow consistent practices throughout the innovation process. This includes active meeting participation and consistent adherence to established guidelines and regulations.

The study initially proposed eight dimensions for school leaders' innovation leadership, but only five were identified as effective. In particular, the dimensions of ideal influence, empowerment and entrepreneurship did not contribute to innovation in the selected population. Although the ideal influence dimension was shown to impact innovation significantly in previous studies, it was found not to affect innovation in the population in this study. This finding is supported by Ruhnke and Mulder [33], who found that in transformational leadership, only three dimensions, namely visioning individual judgement and intellectual stimulation, were frequently associated with innovation [34].

The dimension of empowerment also did not influence the innovation introduced. According to Germi and Hasanzadeh [35], the importance of managerial empowerment decreases when opening and closing behaviors are already prevalent in the organization. A study by Lašáková *et al*. [36] on the empowerment of school leaders in Malaysia also showed that the extent of empowerment practiced remains moderate. The empowerment of leaders in the education context is challenging due to the bureaucratic nature of educational organizations. However, this finding differs from the study of Lašáková *et al*. [36] who emphasized the importance of empowering school leaders to implement change in schools. Empowerment can motivate school members to align with strategic priorities, organize group tasks in critical programmers, and provide guidance and support.

In addition to ideal influence and empowerment, the initially proposed dimension of entrepreneurship did not influence school innovation. This result is at odds with previous research by Bagheri *et al.* [37] who found a link between entrepreneurship and innovation in schools. School leaders should recognize the importance of an entrepreneurial mindset in leading their schools and implementing and improving innovation [38]. This trait is more prevalent in innovation leadership in universities and higher education institutions than in schools. This is because universities and higher educational institutions are more exposed to competition for funding, enrollment of students and implementation of high-impact programmers to educate qualified students. The entrepreneurial skills of school principals can be developed through active participation in professional development activities and training in entrepreneurial leadership [38]. Thus, to equip school principals in Malaysia with this trait, it is necessary to conduct courses according to the needs of schools, as well as workshops and training to enhance their entrepreneurial skills in the school environment.

This study empirically proves that innovation cannot be controlled by a single leadership theory alone. Instead, combining several leadership theories is necessary to guide complex innovation [9]. Moreover, different types of leadership are required at various phases, types and stages of innovation. Integrating leadership theories in this study to develop the conceptual framework of innovation leadership contributes to the first empirical research findings in Malaysia's educational innovation context. Using a combination of transformational leadership theory, ambidextrous leadership theory, and the innovation leader model is empirically demonstrated to lead innovation in schools effectively.

## 4. CONCLUSION

The principals' innovation leadership scale was developed based on established leadership theories, identifying five key dimensions essential for fostering innovation in educational institutions: creative behavior, effective communication, technical skills, and opening and closing behaviors. These dimensions were critical in cultivating a culture of innovation among academic leaders. However, the study revealed that

Ideal Influence, Empowerment, and Entrepreneurship did not significantly impact innovation in the schools studied. This suggests these dimensions may play a minor role in this specific context. This finding highlights the importance of contextual factors in shaping the effectiveness of leadership dimensions. It underscores the need to explore their role in innovation leadership within Malaysian schools further. The study contributes to the field by validating an integrated leadership framework, emphasizing the necessity of moving beyond traditional leadership theories to understand complex innovation processes in education.

The study's findings offer valuable implications for policymakers, educational leaders, and researchers aiming to enhance innovation in academic institutions. The validated dimensions of innovation leadership can serve as a foundation for leadership development programs tailored to the Malaysian education system. School leaders can better navigate the complexities of implementing innovation by strengthening competencies in creative behaviors, communication, technical skills, and opening and closing behaviors. Furthermore, integrating multiple leadership theories into the principals' innovation leadership scale provides a novel approach to assessing leadership effectiveness in fostering innovation. However, the study has limitations, including its generalizability beyond Malaysian secondary schools, potential social desirability bias in self-reported data, and the exclusion of specific leadership dimensions, which may have unaccounted influences on innovation leadership. Future research should explore these areas further to refine the conceptual framework and enhance the understanding of leadership's role in driving innovation.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

## CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest regarding the publication of this manuscript. The research was conducted independently, and no financial, personal, or professional relationships could be construed as having influenced the findings or interpretations of this study.

## INFORMED CONSENT

All participants involved in this study provided informed consent before their participation. They were fully informed about the purpose of the research, the procedures involved, their right to withdraw at any time without consequence, and the measures taken to ensure confidentiality and anonymity.

## ETHICAL APPROVAL

This study was conducted following ethical guidelines and principles. Before the commencement of data collection, the Universiti Pendidikan Sultan Idris Human Research Ethics Committee granted ethical approval (Reference number: 2024-0343-01). All procedures involving human participants adhered to the ethical standards of the Declaration of Helsinki and any applicable national regulations.

## DATA AVAILABILITY

The data supporting this study's findings are available upon reasonable request from the corresponding author [DRSMF]. Due to confidentiality considerations, some data may not be publicly accessible.

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