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Review Paper

Cognitive Diagnostic Assessment in Educational Testing: A Score Strategy-Based Evaluation

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Abstract: Cognitive diagnostic assessment (CDA) represents an innovative approach in educational testing, utilizing cognitive diagnosis models (CDMs) to uncover specific cognitive attributes that influence students' responses to assessment items. Unlike traditional assessments, CDA offers detailed, actionable insights into individual learning processes, enabling more targeted and personalized educational interventions. However, the implementation of CDA is still underexplored compared to other psychometric theories, especially in Malaysia. Therefore, this study seeks to describe the application of CDA in Malaysia through the SCORE analysis model method. The SCORE model of CDA is evaluated across five key elements: Strengths (S), Challenges (C), Options (O), Responses (R), and Effectiveness (E) by analyzing past literature sourced from reputable databases such as Google Scholar, SCOPUS, and Web of Science. The findings indicate that CDA offers strengths like granular feedback, enhanced validity, and data-driven decisions, but faces challenges in complex implementation and resource demands. Its effectiveness hinges on efficient implementation and appropriacy, while exploring opportunities, managing risks, and considering stakeholders' responses help optimize its transformational and commercial value. The findings provide educators with a framework for utilizing CDA to enhance instructional strategies and tailor interventions to meet individual student needs. For policymakers, the implications of the strengths, challenges, and opportunities of CDA emphasize the importance of supporting its implementation through professional development, infrastructure investment, and policy alignment. Future studies are recommended to explore the long-term impacts of CDA on student achievement and educational equity, scalability across educational levels, and development of user-friendly tools to enhance accessibility for educators.

Keywords: Cognitive diagnostic model; SCORE model; strategy-based evaluation; educational assessment; psychometrics

Introduction

Cognitive diagnostic assessment (CDA) is a cutting-edge technique in educational testing that leverages specialized statistical models, known as cognitive diagnosis models (CDMs), to uncover the specific cognitive attributes that influence how students respond to assessment items (Shi et al., 2024). These models are used to provide detailed insights into the specific attributes or skills that examinees possess or lack, offering a more granular understanding of their cognitive processes compared to traditional summative assessments (Nájera et al., 2023). The significance of CDAs lies in their ability to provide valuable diagnostic feedback that can guide educational interventions, tailoring instruction to meet the specific needs of students (Maas et al., 2024).

This diagnostic information is crucial for improving learning outcomes, as it enables educators to identify not only what students know but how they think, facilitating targeted remediation. In educational contexts, especially large-scale testing, the application of CDMs has become increasingly important to address the limitations of traditional testing methods, which often fail to provide detailed diagnostic information (Ma et al., 2020).

Recent advancements in CDA have seen the application of CDMs in various educational assessments, including large-scale international tests like Trends in International Mathematics and Science Study (TIMSS) (Zhu, 2023) and Program for International Student Assessment (PISA) (Qin & Guo, 2024). The use of CDMs in these contexts has led to richer diagnostic data that informs curriculum development and teaching strategies. In Malaysia, very few studies have applied CDA principles to the development of new assessment items; that are either in language assessment (Nallasamy & Khairani, 2022a) and the other in mathematics (Mohd Noor & Lian, 2022), highlighting the scarcity of research in this area.

Despite the potential benefits of CDAs, there are ongoing debates about the validity and reliability of retrofitting CDMs to data collected from traditional assessments, which were not originally designed for diagnostic purposes (Akbay, 2021). This practice, while common, raises concerns about the accuracy of the diagnostic information obtained. Furthermore, challenges such as the impact of item ordering on test results and the appropriate construction of Q-matrices to accurately reflect the cognitive processes being measured remain critical issues in the field (Mohd Noh & Mohd Matore, 2024).

Particularly in Malaysia's education system, traditional assessments often emphasize summative evaluations that provide limited feedback on students' cognitive processes, focusing primarily on overall performance rather than specific skill deficits or learning pathways (Awang Hidup & Mohd Matore, 2024). This approach falls short in identifying the cognitive challenges students face, leading to a lack of targeted interventions and personalized instruction. In contrast, CDA has the potential to overcome these limitations by offering detailed insights into the underlying skills and attributes that influence student responses, enabling more precise pedagogical planning and remediation (Guo et al., 2024).

While the application of CDA in educational assessment has been accepted across many fields such as language testing, computer adaptive testing and mathematics, there is significant lacunae in understanding the strengths, challenges, options, responses and effectiveness of the approach and how these factors influence its implementation and adoption in various educational contexts. The current use of CDA in Malaysia is minimal, and the benefits of its diagnostic capacity have not been fully leveraged to inform teaching strategies and policy decisions (Nallasamy & Khairani, 2022b). The existing gap lies in a comprehensive understanding of CDA’s strengths, challenges, and practical implications for effective implementation across different educational contexts. This gap highlights the need for a comprehensive analysis that not only evaluates the current state of CDA but also explores its potential to address emerging challenges and leverage new opportunities in the evolving landscape of educational assessment. This study addresses this gap by employing a SCORE-based evaluation to systematically analyze the factors influencing CDA's effectiveness and scalability, aiming to provide a clear framework for its integration into Malaysia's educational system. A SCORE-based evaluation is particularly crucial as it enables a multi-faceted analysis of CDA, assessing its potential to address the current limitations in assessment practices while exploring how to maximize its diagnostic benefits for improved learning outcomes. Thus, the current study seeks to describe cognitive diagnostic assessment based on SCORE strategy-based evaluation.

Methodology

This research utilizes the SCORE model method as a strategic planning tool to evaluate and refine organizational strategies. The model aids in the systematic assessment of an organization’s current approach, facilitating informed decision-making for future planning. The SCORE model was chosen due to its effectiveness as an alternative to traditional evaluation tools like SWOT analysis, offering a more positive and holistic perspective for decision-making (Neal, 2024). The model is a strategic planning tool designed to assist organizations in assessing and refining their strategies. It guides organizations through evaluating their current approach and making well-informed decisions for future planning. As an effective alternative to other

evaluation tool such as SWOT analysis, the SCORE model is a crucial tool that offers a positive perspective for any party aiming to make informed decisions (Neal, 2024). Its success lies in its thorough and systematic approach, enabling decision-makers to leverage strengths and opportunities while addressing challenges. The SCORE model is commonly applied in corporate and business environments. However, it also holds great potential for use in education, particularly in assessing strengths. The SCORE analysis is an invaluable tool for companies, offering a thorough and systematic approach to business evaluation that aids decision-makers in making well-informed choices. By focusing on both internal and external factors, it provides a holistic understanding of the organization's current status, as well as the opportunities and challenges ahead. Consequently, the SCORE analysis empowers businesses to leverage their strengths, address challenges, seize opportunities, and formulate appropriate actions to achieve the organization's objectives. This model has been used recently by previous researchers to review the practice of particular strategies within educational settings and their impact on overall performance including special education and coaching competency (Azeman et al., 2024; Ishak et al., 2024).

Figure 1 outlines the components of the SCORE model, which serves as a strategy-based evaluation framework. The acronym SCORE stands for the five key elements: Strengths (S), Challenges (C), Options (O), Responses (R), and Effectiveness (E) (Neal, 2023).

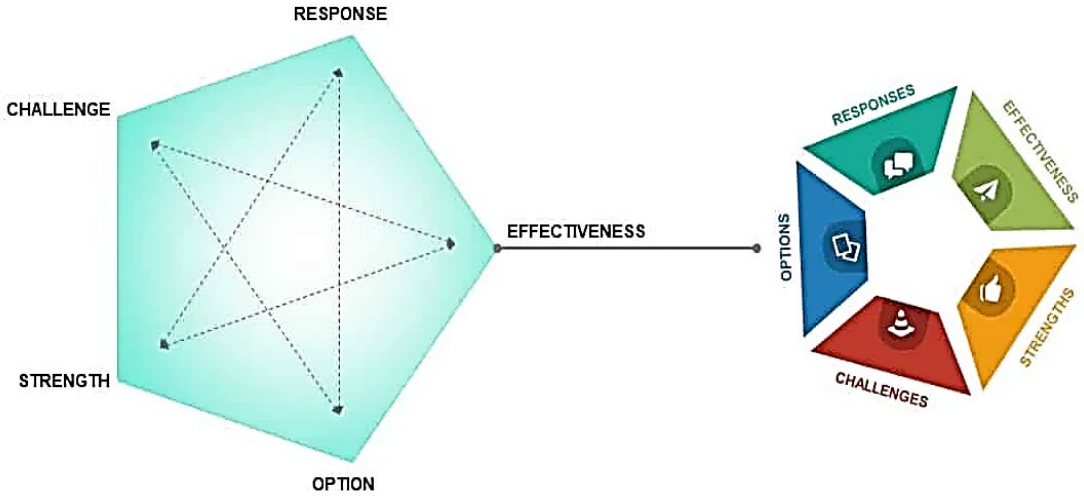

Figure 1. SCORE strategy-based evaluation model

Figure 2 presents the SCORE framework of questions for analyzing various elements of a topic, including strengths, challenges, options, responses, and effectiveness. Each element provides specific questions to explore the key dimensions: the unique advantages (Strengths), limitations and potential obstacles (Challenges), emerging opportunities (Options), stakeholder engagement and strategic actions (Responses), and the efficient use of resources and actionable insights (Effectiveness). The SCORE model is particularly useful for fostering a people-first company culture, as it encourages teams to evaluate the organization's strengths, challenges, opportunities, partnerships, and activities. While similar to SWOT analysis, the SCORE model also provides insight into colleague and stakeholder interactions, as well as the effort employees contribute (Palazzo & Micozzi, 2024). This framework guides a comprehensive evaluation of CDA implementation to assess its impact, feasibility, and potential for improvement, particularly in educational testing context.

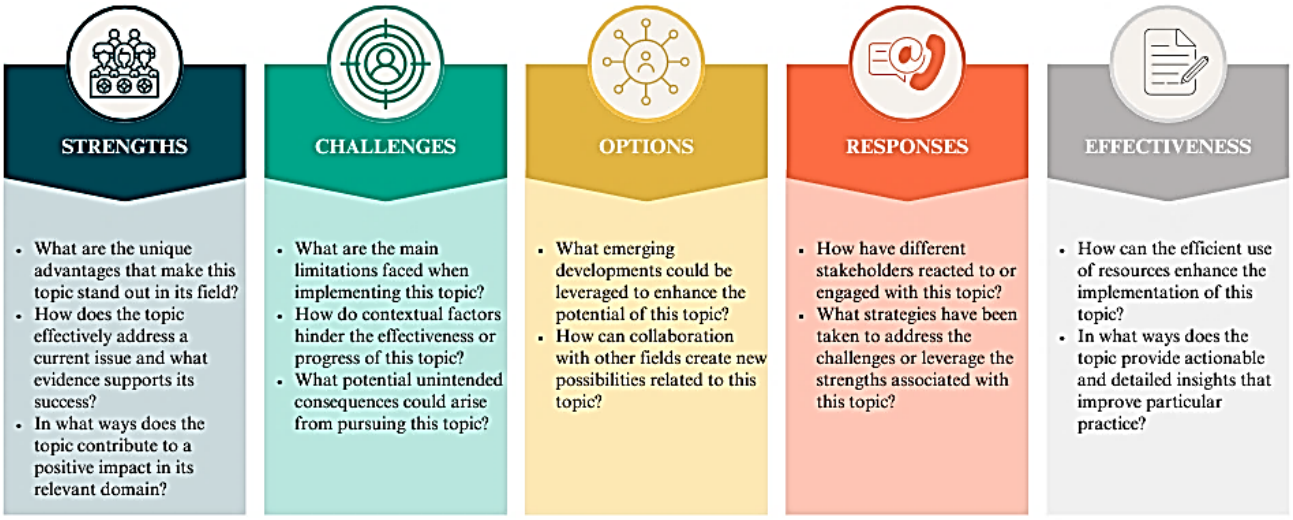

Figure 2. SCORE framework of questions for analyzing various aspects of a topic

The study was conducted by analyzing the current literature found in reputable databases, including Google Scholar, SCOPUS, and Web of Science. The use of reputable databases is crucial for ensuring the credibility and reliability of the information gathered. These databases have been extensively utilized in previous research to conduct thorough literature reviews, validate findings, and build a robust theoretical framework for diverse research topics (Jiang et al., 2024; Rijeng et al., 2024). The research utilized keywords such as "*cognitive diagnostic assessment*," "*cognitive diagnostic model*," and "*diagnostic classification model*" to ensure a comprehensive review of relevant studies. This approach allowed the researchers to identify and evaluate existing knowledge, theories, and applications of CDA and its integration within educational settings. The articles were then screened based on two criteria as shown on Table 1. The selection criteria included only publications on empirical studies, excluding those using simulation data, conceptual studies, and reviews, and limited to publications in the English language. The process proceeded by filtering out irrelevant and recurring articles through a review of their titles and abstracts. This was followed by a thorough analysis of the remaining articles, closely examining their content to confirm their alignment with the study's requirements. Once the literature selection was finalized, the subsequent step entailed a detailed examination of the findings, discussion, and conclusions of each article to identify the strengths, challenges, options, responses, and effectiveness of CDA.

Table 1. Inclusion and exclusion criteria

No.	Criteria	Inclusion criteria	Rejection criteria
1.	Types of publication	Empirical studies with real data	Other than empirical studies with real data - empirical studies using simulation data, conceptual papers, review papers, method reviews
2.	Language	English	Other than English - publications reported in other than English language

Findings and Discussion

The findings of this study provide valuable insights into the application of cognitive diagnostic assessment across diverse educational settings. Figure 3 presents the SCORE analysis, focusing on the five key components of CDA, which will be elaborated upon in the following sections. Each component is summarized with three core aspects that highlight its significance and role in the overall effectiveness of CDA. These aspects provide a clear framework for understanding how each component contributes to achieving the desired educational outcomes through CDA.

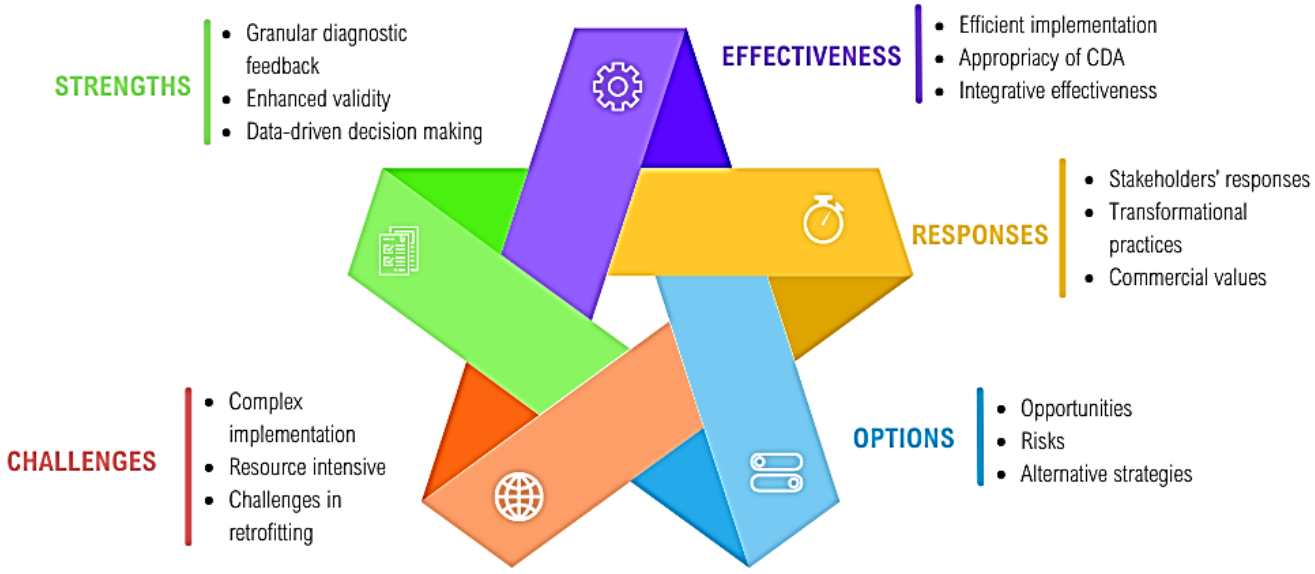

Figure 3. SCORE analysis of cognitive diagnostic assessment

1. Strengths of Cognitive Diagnostic Assessment

Granular Diagnostic Feedback

A key strength of CDA compared to conventional assessment approaches is its ability to generate detailed fine-grained diagnostic feedback for individual students (Maas et al., 2024). The implementation of assessment has long relied on psychometrics perspective that mainly aim at discriminating students based on their holistic performance. Such practice usually arranges students according to their ability levels from the most achieving students to the least achieving ones (Ma et al., 2020). In contrast, CDA offers in-depth insights into specific cognitive skills and knowledge areas based on students' mastery because it divides students into mastery and non-mastery classes. CDA can provide reports on the mastery of attributes among students and profiling students' mastery of the assessed attributes. This level of granularity benefits not only teachers but also students and other stakeholders involved in the educational process. For teachers, the diagnostic reports can inform pedagogical decisions, enhance remedial interventions, and assist in planning future lessons. On the other hand, students benefit from the feedback by empowering them to take an active role in their learning journey. CDA studies classify candidates into mastery categories based on the number of cognitive attributes they have mastered, placing each student into a specific class according to their level of attribute mastery.

Within the Malaysian context, Nallasamy & Khairani (2022a) applied CDA principles to develop a reading comprehension assessment for year four primary school students. The study produced individual diagnostic feedback, revealing specific cognitive attributes mastered or lacking among students, and generated latent class profiles that categorized students based on their mastery levels. This approach demonstrated CDA's potential to provide detailed, actionable feedback to enhance learning outcomes by enabling teachers to tailor instruction to meet individual student needs.

Enhanced Validity of Assessments

Another key strength of CDA is it prioritizes the validity of assessment development through an iterative validation process. Previous scholars recommend that the development of CDA items to follow the comprehensive process starting with the design of cognitive model, item development, Q-matrix construction, item validation and diagnostic report generation (Ravand & Baghaei, 2019). Cognitive model specifies the critical attributes to measure the construct designed through inductive process (engagement with experts) or deductive process (literature review). A particularly rigorous aspect of this process is the construction of the Q-matrix, which is pivotal in accurately mapping the relationship between assessment items and the cognitive attributes they are intended to measure (Qin & Guo, 2024). The development of a Q-matrix requires

meticulous attention to detail, as it involves defining the connections between each item and the underlying skills or knowledge areas. This process typically involves multiple iterations of expert review and refinement to ensure that the matrix accurately reflects the cognitive structure of the domain being assessed. Misalignments in the Q-matrix can lead to incorrect diagnoses of students' strengths and weaknesses, which is why this stage is critical to the overall success of a CDA. Furthermore, ongoing validation of the Q-matrix is essential to maintain the reliability and validity of the diagnostic feedback, making it a cornerstone of the CDA methodology.

A number of studies conducted in Malaysia have shown that the iterative validation process in CDA, particularly in Q-matrix construction, enhances the validity and reliability of assessment results (Chew & Chin, 2024). Not only that, the utilization of expert panels and empirical validation were reported to refine the cognitive model, and assessment items (Nallasamy & Khairani, 2022a).

Data-Driven Decision Making

The rich, fine-grained, detailed data produced by CDA plays a crucial role in supporting data-driven decision-making in curriculum design and instructional strategies (Paulsen & Valdivia, 2021). This comprehensive insight enables educators to pinpoint specific areas where students may be encountering difficulties, allowing for the implementation of targeted interventions that directly address those challenges. By tailoring educational approaches to meet individual learning needs, CDA facilitates a more personalized learning experience, which can significantly improve student outcomes (Zhang et al., 2024). Within classroom contexts, the employment of CDA caters to the variability among students and supports the implementation of formative assessment. Teachers' pedagogical decisions are based on what the students have mastered and what they need to improve their learning trajectory. This approach allows teachers to adjust their instructional strategies in real-time, ensuring that each student's learning needs are met more effectively.

The strengths of CDA include providing granular diagnostic feedback, enhancing the validity of assessments through an iterative development process, and supporting data-driven decision-making for personalized learning. These advantages make CDA a powerful tool for educators; however, its implementation is not without challenges, including issues related to the complexity of item development, resource allocation and challenges in retrofitting method.

2. Challenges of Cognitive Diagnostic Assessment Implementation

Complex Implementation

Despite its strength, CDA presents certain challenges. The application of CDA and CDMs requires specialized knowledge and technical expertise, which can be a barrier for educators, due to the demanding development process, complexity of the models themselves and the intricate statistical analysis involved (Javidanmehr & Sarab, 2017). The development process involves creating and validating diagnostic models that accurately capture the underlying cognitive processes. This complexity is compounded by the need to design items that align with specific cognitive skills and fit the structure of the chosen diagnostic model. The complex process of accurately specifying the item-attribute relationship in a Q-matrix is vital for ensuring precise and valid diagnostic inferences in cognitive diagnostic assessments (Nájera et al., 2020). Furthermore, the statistical analysis required to estimate parameters, such as item difficulty and student ability, often involves advanced techniques like latent class modeling, Bayesian estimation, and item response theory (Yamaguchi et al., 2024). These methods require not only a deep understanding of statistical concepts but also proficiency in specialized software, making the implementation of CDA and CDMs a complex and resource-intensive endeavour.

Resource-Intensive

Apart from that the development of CDA items need to undergo rigorous and comprehensive process that can be time-consuming and costly, requiring significant investment in training, software, and data analysis (Mohd Noh & Mohd Matore, 2024). The iterative process of validation, involving repeated testing, refinement of items, and recalibration of the diagnostic model, further adds to the complexity, demanding continuous

attention to detail and the expertise of professionals to ensure that the assessment accurately measures the intended cognitive attributes. Hence, many CDA studies have been conducted using a retrofitting approach, where items from existing assessment systems are analyzed to produce diagnostic reports (Mei & Chen, 2022).

Challenges in Retrofitting

Retrofitting non-diagnostic assessment items presents significant challenges, including issues with validation, as these items were not originally designed to measure specific cognitive attributes (Akbay, 2021). The original purpose of these assessments often focused on overall performance rather than detailed diagnostic insights, leading to potential misalignment with the cognitive diagnostic model. Additionally, the sufficiency of the items may be inadequate, as they may not comprehensively cover all the necessary attributes, resulting in incomplete or less accurate diagnostic reports (Gierl & Cui, 2008). Moreover, the process of developing appropriate cognitive models for retrofitted assessments is particularly challenging, as it requires careful consideration of the underlying constructs that were not initially accounted for. Finding enough suitable items to accurately assess the targeted attributes can be difficult, further complicating the retrofitting process (Toprak & Cakir, 2021). Ensuring a strong alignment between the cognitive models and the test data is another significant hurdle, as any misalignment can lead to insufficient data for reliable psychometric analysis, ultimately compromising the validity of the diagnostic outcomes.

These challenges reported in previous studies should be addressed through a range of best practices and strategies that have been successfully implemented in other countries and fields. Firstly, investing in capacity-building initiatives, such as training programs and workshops, can enhance educators' technical knowledge and understanding of CDMs, helping them design and validate diagnostic items more effectively. Countries like the United States and China have demonstrated the success of interdisciplinary collaboration (Ghiasian et al., 2024) where psychometricians, subject-matter experts, and software developers work together to streamline the development and analysis of CDA. Additionally, leveraging technological advancements through user-friendly platforms and software specifically designed for CDA applications can reduce complexity; open-source tools like R packages or cloud-based software with CDA capabilities can ease the statistical analysis process (Li et al., 2021). Moreover, establishing a hybrid approach by integrating new diagnostic items with retrofitting, can maximize resource utilization, as done in fields like medicine and engineering, ensuring a more robust set of assessment items that cover the required cognitive skills comprehensively (Xin et al., 2022). Adopting these strategies can help Malaysia address the complexities and resource demands of CDA, enabling more precise and valid diagnostic assessments while optimizing costs and efforts.

The challenges of CDA revolve around its complex implementation, resource-intensive processes, and difficulties in retrofitting non-diagnostic assessments, which require technical expertise and substantial investment. Addressing these challenges through capacity-building, interdisciplinary collaboration, and leveraging technology can enhance the effective use of CDA. Despite these challenges, there are also promising options for CDA to improve educational outcomes and practices, particularly by opportunities in personalised learning, equity risks and alternative strategies.

3. Options for the Implementation of Cognitive Diagnostic Assessment

Opportunities in Personalised Learning

CDA offers a substantial opportunity to transform educational practices by facilitating the development of highly personalized learning experiences (Zhang et al., 2024). By providing detailed insights into individual students' strengths and weaknesses, CDA allows educators to tailor instruction and interventions specifically to each student's needs, ensuring a more targeted and effective approach to learning. This fine-grained diagnostic data empowers educators to implement targeted interventions that directly address areas where students struggle, leading to more meaningful improvements in learning outcomes. Additionally, the comprehensive data generated by CDA informs curriculum design by highlighting the cognitive skills and knowledge areas that require greater emphasis, resulting in more aligned and effective instructional materials.

Collectively, these opportunities position CDA as a powerful tool for enhancing the quality and effectiveness of education.

Equity Risks

Equity concerns arise with the implementation of CDA, as it could potentially widen the gap between students who have access to well-trained educators and those who do not. Disparities in resources and expertise across different schools or regions may lead to uneven application of CDA, exacerbating educational inequalities. Additionally, there is a risk of over-reliance on the diagnostic data provided by CDA, which might result in a narrow focus on the specific cognitive attributes measured, at the expense of other important aspects of learning that are not captured by the assessment. This could limit the holistic development of students by overlooking essential skills and knowledge beyond the scope of CDA.

Alternative Strategies

To maximize the opportunities of CDA while mitigating its risks, several alternative strategic options should be considered. Investing in professional development is essential to equip educators with the skills needed to implement and interpret CDA effectively, addressing equity concerns by ensuring that all students benefit from its insights. A gradual rollout of CDA can help schools build capacity and adjust practices before broader implementation, reducing disparities in resource allocation and expertise. Balancing the use of CDA data with holistic educational approaches ensures that students' overall development is prioritized, preventing an overemphasis on specific attributes. Equitable resource allocation and inclusive curriculum design are critical to maintaining a well-rounded education, while robust data privacy and security measures protect sensitive student information. Engaging a wide range of stakeholders in the implementation process further enhances the effectiveness and equity of CDA.

In Malaysia, CDA has the potential to significantly contribute to national educational goals by fostering a more equitable and effective learning environment. By providing granular insights into individual students' cognitive skills and learning gaps, CDA enables teachers to deliver personalized instruction and interventions, thereby supporting the Ministry of Education's aim to enhance student-centred learning and improve academic performance. For example, if students face challenges in listening and speaking skills, CDA can help design activities that improve these competencies through tailored practice and feedback, ultimately enhancing their overall language abilities. This approach not only boosts individual student achievement but also aligns with the national objective of equipping students with strong communication skills for higher education and future employment. Additionally, CDA can aid in the early identification of struggling students, allowing educators to implement timely interventions and improve overall academic achievement, aligning with Malaysia's goals of raising national student performance as highlighted in the Malaysia Education Blueprint. This data-driven approach can also guide policy adjustments and curriculum enhancements that better meet the diverse needs of Malaysian students, fostering a more inclusive and responsive educational system.

The options presented by CDA for personalized learning can significantly enhance educational outcomes, but these benefits must be balanced with considerations for equity, holistic learning, and strategic implementation to maximize its effectiveness. As Malaysia integrates CDA into its educational framework, careful planning and stakeholder involvement are key to fostering a supportive environment for its successful adoption. To further understand the impact of CDA, it is crucial to explore how various stakeholders respond to its implementation.

4. Responses to Cognitive Diagnostic Assessment

Stakeholders' Responses

Responses towards CDA may vary depending on the types of stakeholders. Internal stakeholders, encompassing those directly involved with the practice of CDA, such as educators, administrators, and students, are likely to focus on the practical implications of its implementation (Chan & Chou, 2020). They

may express interest in how CDA can enhance teaching and learning outcomes but may also have concerns about the additional workload, the need for training, and the potential challenges of data interpretation. Meanwhile, external stakeholders, especially those that do not directly involve themselves in the day-to-day practice of CDA, such as policymakers, parents, competitors, and technology providers, may have a broader perspective (Agnew, 2021). They might focus on issues related to regulatory compliance, data privacy, market competition, and the overall impact on the education system. While some external stakeholders may see CDA as an opportunity for innovation and improved educational outcomes, others might be concerned about the costs, equity implications, or potential disruption to existing educational practices.

Transformational Practices

The implementation of CDA in educational testing, particularly involving educational institutions, could significantly transform current assessment practices by driving a shift towards more personalized and diagnostic forms of evaluation (Fan et al., 2021). Traditional assessments, which typically emphasize broad measures of student achievement, may need to be re-evaluated or supplemented with CDA to offer deeper insights into individual learning processes. This shift could lead to the establishment of new standards and guidelines that integrate cognitive diagnostic methods into existing assessment frameworks, enhancing the precision and relevance of educational testing (C. Li, 2022). Additionally, policymakers might place a strong emphasis on equity and access, ensuring that all schools, especially those in underserved areas, have the necessary resources to effectively implement CDA. This could involve providing targeted funding and support for acquiring the requisite technology, training, and materials, thereby ensuring that all students benefit equally from the advanced insights that CDA offers.

Commercial Values

CDA offers substantial commercial value across the education sector by enabling educational institutions to differentiate themselves through personalized learning experiences that enhance student outcomes, potentially boosting enrolment and retention rates. For educational technology providers, CDA creates opportunities to develop specialized tools and resources, opening new revenue streams and fostering strong partnerships with schools. Additionally, for policymakers, CDA supports data-driven decision-making that can improve educational equity and effectiveness, leading to more efficient resource allocation and better outcomes at scale, ultimately aligning with the broader goal of enhancing the quality of education for all students.

The responses to CDA vary among stakeholders, with internal stakeholders focusing on practical implications and training needs, while external stakeholders weigh its broader impact on innovation, equity, and the educational system. As CDA brings transformational practices and commercial opportunities to education, it is essential to evaluate its overall effectiveness in enhancing learning outcomes, supporting data-driven decisions, and aligning with educational goals.

5. Effectiveness of Cognitive Diagnostic Assessment

Efficient Implementation

The potentials of CDA can be realized to attain its effectiveness when implemented with the right resources and training. To ensure the efficient implementation of CDA, it is crucial to optimize resource use while minimizing waste. This can be achieved by streamlining key processes, including educator training, cognitive model development, and data interpretation, to ensure that every step is as cost-effective as possible. Regular evaluations should be conducted to identify areas where resources can be better utilized, and unnecessary expenditures can be eliminated. Investing in continuous professional development for educators is essential, ensuring they are well-equipped to use CDA effectively without requiring excessive ongoing support. Additionally, leveraging technology to automate and simplify parts of the assessment process can significantly enhance efficiency, allowing for quicker, more accurate diagnostics with reduced manual effort (Yoon et al., 2024). By focusing on these strategies, the implementation of CDA can be both resource-efficient and highly effective in improving educational outcomes.

Appropriacy of CDA

The appropriacy of CDA is further highlighted by its capacity to provide actionable insights that are directly applicable to classroom instruction. Unlike traditional assessments that often offer only a broad overview of student performance, CDA breaks down learning into specific cognitive skills, allowing educators to identify and address particular areas where students may be struggling. Moreover, the appropriacy of CDA extends to its adaptability across various educational levels and contexts. Whether used in primary education to diagnose foundational learning issues or in higher education to refine advanced cognitive skills, CDA's flexible framework can be tailored to meet the specific demands of different educational settings (Sessoms & Henson, 2018). Additionally, CDA's appropriacy is reinforced by its alignment with contemporary educational policies that emphasize equity and inclusion. By providing detailed insights into each student's learning profile, CDA enables educators to design more inclusive instructional approaches that cater to diverse learning needs.

Integrative Effectiveness

CDA has the potential to achieve integrative effectiveness within existing educational systems by harmonizing with various assessment and instructional practices. When seamlessly integrated, CDA can strengthen and complement other educational initiatives, such as formative assessment and curriculum development, ensuring that all components work cohesively toward the common goal of enhancing student learning outcomes. This integrative approach ensures that CDA not only fits within the broader educational framework but also amplifies the overall effectiveness of the system.

Conclusion

In conclusion, the findings from the SCORE analysis indicate that CDA has the potential to significantly enhance educational practices by providing more detailed and actionable insights into student learning, leading to more targeted and effective interventions. This finding has important implications for the theoretical framework in the field of cognitive assessment by considering how detailed diagnostic insights can be systematically integrated into existing models. By aligning assessments more closely with individual learners' cognitive processes, educators can better identify specific areas of difficulty and address them with targeted interventions. It highlights the need to refine cognitive diagnostic models to better align with the complexities of individual learning processes and underscores the importance of incorporating diagnostic feedback into theoretical constructs that guide educational assessments.

As for practical implications, this finding suggests that educators and policymakers should prioritize the implementation of CDA tools to enhance instructional strategies and support personalized learning. By leveraging the detailed insights provided by CDA, teachers can more effectively identify and address students' specific cognitive strengths and weaknesses, leading to more targeted interventions and improved educational outcomes. To CDA effectively, educators and policymakers should start by providing professional development opportunities to familiarize teachers with CDA principles and tools, ensuring they have the necessary skills to interpret diagnostic data accurately. Policymakers should allocate resources to develop and integrate CDA-friendly technologies within the curriculum, promoting user-friendly platforms that can accommodate varied levels of teacher expertise. Moreover, schools and districts should collaborate to develop a framework for the scalable and equitable implementation of CDA, ensuring all students, regardless of background, benefit from personalized, targeted learning strategies that address their unique needs and enhance overall academic achievement.

However, due to practical constraints, this study cannot provide a comprehensive review of CDA. This study only analyses the application of CDA using the SCORE analysis model to evaluate its strengths, challenges, opportunities, responses, and overall effectiveness within the context of educational testing. Other evaluation tool such as SWOT (strengths, weaknesses, opportunities, threats), SOAR (strengths, opportunities, aspirations, results) and NOISE (needs, opportunities, improvement, strengths, exceptions) can be used to further evaluate CDA by offering different perspectives and additional insights in various educational settings.

Future studies on the current topic are therefore recommended. Further research could extend to exploring the long-term impacts of CDA on student achievement and educational equity. Additionally, future studies could investigate the scalability of CDA across different educational levels and contexts, as well as its effectiveness in diverse populations. For instance, future studies could examine how CDA can be scaled to support both elementary and high school students, adapting the level of cognitive complexity and feedback according to the age group. There is also a need to explore the development of more user-friendly tools and methods for implementing CDA, which could make it more accessible for educators with varying levels of expertise in cognitive diagnostics. An artificial-intelligence-based platform could automatically analyze students' responses in real time, identify cognitive strengths and weaknesses, and provide instant, detailed feedback on specific skill areas that need improvement.

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