

**DEVELOPMENT AND VALIDATION  
OF READING COMPREHENSION TEST FOR  
YEAR 4 ESL STUDENTS  
BY USING GDINA MODEL**

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**UNIVERSITI SAINS MALAYSIA**

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by

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## LIST OF ABBREVIATIONS

A-CDM	Additive Cognitive Diagnostic Model
AHM	Attribute Hierarchy Method
CDA	Cognitive Diagnostic Assessment
CDM	Cognitive Diagnostic Model
CFA	Conceptual Assessment Framework
CEFR	Common European Framework for References
C-RUM	Compensatory Reparameterized Unified Model
CTT	Classic Test Theory
DINA	Deterministic Input, Noisy ‘And’ Gate
DINO	Deterministic Input, Noisy ‘Or’ Gate
ECD	Evidence-Centered Design
ELT	English Language Teaching
GCDM	General Cognitive Diagnostic Model
GDINA	Generalized Deterministic Input, Noisy ‘And’ Gate
GDM	General Diagnostic Model
HCDM	Hierarchical Cognitive Diagnostic Model
IDI	Item Discrimination Indices
IELTS	International English Language Language Testing and system
IRT	Item Response Theory
KPM	Kementerian Pendidikan Malaysia
KR-20	Kuder-Richardson Formulae 20
LCDM	Log-Linear Cognitive Diagnostic Model
MCQ	Multiple Choice Question
MELAB	Michigan English Language Assess

MOE	Ministry of Education
NC-RUM	Non-Compensatory Reparameterized Unified Model
OEDC	Organization for Economic CO-operation and Development
PISA	Program for International Student Assessment
RUM	Reparameterized Unified Model
SBA	School-Based Assessment
SBELC	Standard Based English Language Curriculum
SCPS	Standard Curriculum for Primary Schools
TAP	Test Analysis Program
TOFEL	Test of English as a Foreign language
UPSR	<i>Ujian Penilaian Sekolah Rendah</i>

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**PEMBANGUNAN DAN PENGESAHAN UJIAN KEFAHAMAN MEMBACA  
UNTUK MURID ESL TAHUN 4 DENGAN MENGGUNAKAN  
MODEL GDINA**

**ABSTRAK**

Kajian ini bertujuan untuk membangunkan penilaian diagnostik kognitif (CDA) untuk penilaian kefahaman bacaan peringkat rendah. CDA boleh menilai kekuatan dan kelemahan pembelajaran kognitif pelajar dan membantu mengenal pasti kawasan intervensi yang berpotensi untuk pelajar yang menghadapi cabaran pembelajaran. Kajian ini melibatkan lima orang guru Bahasa Inggeris sekolah rendah berpengalaman dan 900 orang murid Tahun 4 sekolah rendah. Data kualitatif dikumpul melalui sesi temu bual berfikir dengan kuat, dan data kuantitatif dikumpul melalui ujian kertas dan pensel. Tiga fasa terlibat dalam membangunkan CDA, Fasa I: pengenalpastian atribut, pembangunan hierarki atribut, dan reka bentuk item. Sementara itu, Fasa II melibatkan dua peringkat: pentadbiran penilaian dan analisis statistik data yang dikumpul menggunakan model GDINA. Panel guru Bahasa Inggeris menyemak objektif dan hasil pembelajaran yang dinyatakan dalam Spesifikasi Kurikulum Bahasa Inggeris Tahun 4, peperiksaan berkepentingan tinggi (UPSR) dan item buku teks untuk mengenal pasti dan menerangkan atribut kognitif yang berkaitan dan hierarkinya serta membangunkan model pemrosesan kognitif. Model ini telah disahkan dengan menggunakan laporan lisan 12 orang murid Tahun 4 dan respons ujian daripada sampel 80 orang murid Tahun 4. Matriks Q telah dibangunkan berdasarkan model pemrosesan kognitif untuk menentukan hubungan item-keatribut. Sementara itu, model GDINA digunakan untuk menilai kecukupan dan ketepatan matriks Q. Penemuan disahkan bahawa pelajar terlibat dalam proses kognitif selaras

dengan ramalan panel, di mana semua atribut yang dinyatakan dalam setiap profil atribut diperlukan untuk menyelesaikan item dengan betul. Kebarangkalian penguasaan atribut mendedahkan bahawa atribut A5 diikuti oleh atribut A4 adalah atribut yang paling sukar untuk dikuasai dalam pemahaman bacaan, dan atribut A1 adalah prasyarat untuk dikuasai. Pengesahan matriks Q dianggap tinggi kerana nilai  $p$  terlaras Bonferroni menunjukkan melebihi 0.05. Penilaian kesesuaian model untuk kedua-dua aspek kesesuaian relatif dan indeks kesesuaian mutlak mendedahkan bahawa model GDINA adalah model terbaik berbanding DINA, ACDM dan RRUM kerana ia sesuai dengan data dengan baik kerana ia membenarkan hubungan pampasan dan bukan pampasan antara atribut, yang bermanfaat untuk ujian bahasa. Oleh itu, CDA yang menggabungkan model GDINA adalah teknik penilaian praktikal untuk guru menilai murid mereka untuk meningkatkan kualiti pengajaran dan pembelajaran bilik darjah

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**ABSTRACT**

This study aims to develop a cognitive diagnostic assessment (CDA) for the primary-level reading comprehension assessment. The CDA can evaluate students' cognitive learning strengths and weaknesses and help identify potential intervention areas for students with learning challenges. This study involved five experienced primary English teachers and 900 Year 4 primary school pupils. Qualitative data was collected via a think-aloud interview session, and quantitative data was collected through paper and pencil tests. Three phases were involved in developing CDA, Phase I: identification of attributes, development of attribute hierarchy, and item design. Meanwhile, Phase II involved two stages: assessment administration and statistical analysis of the data collected using the GDINA model. The panel of English teachers reviewed the learning objectives and outcomes specified in the English Year 4 Curriculum Specifications, the high-stake examination (UPSR) and textbook items to identify and describe the relevant cognitive attributes and their hierarchy and developed the cognitive processing model. This model was validated using verbal reports of 12 Year 4 students and test responses from a sample of 80 Year 4 students. *Q-matrix* was developed based on the cognitive processing model to specify the item-to-attributes relations. Meanwhile, the GDINA model was used to evaluate the adequacy and accuracy of the *Q-matrix*. Findings verified that students engaged in cognitive processes consistent with the panel's prediction, where all attribute(s) specified in each attribute profile are required to solve the items correctly. Attribute

mastery probability revealed that attribute A5, followed by attribute A4, are the most difficult attributes to master in reading comprehension, and attribute A1 is a prerequisite to be mastered. The *Q-matrix* validation is considered high as the Bonferroni adjusted p-value shows above 0.05. The evaluation of model fit for both aspect relative fit and absolute fit indices reveals that the GDINA model is the best model compared to DINA, ACDM and RRUM as it fits the data well and allows both compensatory and non-compensatory relationships between the attributes, which is beneficial to language testing. Therefore, the CDA incorporating the GDINA model is a practical assessment technique for teachers to assess their pupils to improve classroom teaching and learning quality.

# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction

Assessment plays a crucial role in the educational setting, significantly facilitating effective teaching and learning processes. White (2007) explained that assessment is making judgments about students' achievements, needs, abilities, and strengths by gathering evidence. Even Stiggins (2008) noted that assessment is the systematic procedure of collecting data on students' educational progress to utilise the acquired information for instructional planning. Weeden et al. (2002) added that educators could incorporate the data from the assessment outcomes for future lesson plans. Hence, assessment holds significant importance in the realm of education, as it enables educators to gauge the strengths and weaknesses of their students (Popham, 1999). In other words, there is an interaction between teaching, learning, and assessment.

Well-designed assessments can identify students' cognitive strengths and weaknesses, patterns of mastery or non-mastery of sub-skills within a learning domain, and the diagnostic power of test items. Therefore, researchers are continually developing new approaches to improve educational assessment, from the assessment of learning to the assessment for learning (Black & William, 1998a; Stiggins, 2002). The current emphasis lies in identifying an individual's mastery and non-mastery within specific subskills of a targeted domain (Leighton & Gierl, 2007; Rupp et al., 2010). This approach aims to capture the individual's actual ability instead of large-scale assessments that primarily measure general ability. Even Che Noraini et al. (2013) and Ong (2010) have stated that the assessment of learning does not deliver

sufficient information about students' cognitive strengths and weaknesses. Furthermore, this might potentially create a situation where educators are forced to generate students who perform well in the assessments. In short, teachers are deprived of comprehensive information regarding students' performance and have no detailed information about their performance.

In general, educational assessment instruments require a design that facilitates the provision of comprehensive insights into a student's areas of proficiency and areas for improvement while highlighting the precise cognitive sub-skills that require enhancement (Gibbs & Simpson, 2004). Therefore, to improve the teaching and learning process, researchers have proposed an assessment design that is more cognitively informed (Pellegrino et al., 1999; National Research Council [NRC], 2001). Hence, there is a need for cognitive diagnostic assessments (CDAs), which combine educational measurement and cognitive psychology to provide feedback with valuable diagnostic information. CDAs are necessary as they can help teachers gain insight into students' learning progress (Ketterlin-Geller & Yovanoff, 2009; Roberts et al., 2014).

## **1.2 Background of Study**

Over time, the Malaysian education system has undergone multiple revisions to align with the increasing global demand for educational standards. The Primary School Standard-Based Curriculum, also referred to as KSSR (Kurikulum Standard Sekolah Rendah), was introduced by the Malaysian Ministry of Education in 2011. The implementation of this curriculum was carried out progressively, commencing with Year One students. The Primary School Standard Curriculum was developed to cultivate Malaysian individuals with a strong foundation of knowledge, competence,

and exemplary moral values. To elucidate further, the aim is to comprehensively prepare younger generations for their achievements in the 21st century.

Additionally, it should be noted that the Primary School Standard-Based Curriculum aligns with the second National Key Result Area (NKRA) announced by the Prime Minister of Malaysia (Ministry of Education, 2012). The implementation of the Primary School Standard Curriculum marks a shift in the assessment methods for students. In addition to the Primary School Achievement Examination (UPSR), commonly referred to as UPSR in Malay, students' overall performance and engagement in classroom instruction will now be considered. The new curriculum emphasizes six pedagogical principles: a return to fundamental concepts, the incorporation of enjoyable elements, the promotion of meaningful and purposeful learning, a focus on learner-centred teaching and learning, the integration of relevant new technology, the use of assessment for learning, and the inclusion of character-building components (Ministry of Education, 2015). The fundamental objective of the new curriculum is to address the issue of illiteracy among students in primary schools and improve the overall quality of teaching and learning (Curriculum Development Division, 2011).

There are no exceptions within the English Language Teaching (ELT) domain. The implementation of the KSSR has led to the development of the Standard-Based English Language Curricular (SBELC), which encompasses substantial modifications in curricular documents and organizational structure. The newly established SBELC is to facilitate students in acquiring and applying language skills in their everyday lives, as well as for their academic pursuits and future professional endeavours (Curriculum Development Division, 2011). The primary objective of this curriculum is to equip students at the primary level with fundamental language abilities, including

listening, speaking, reading, and writing. These skills are intended to enhance their ability to effectively communicate in diverse settings that are appropriate for their developmental stage (Curriculum Development Division, 2011).

In 2016, a revision was made to the Standards-Based English Language Curriculum (SBELC) in order to ensure its alignment with the Common European Framework of References (CEFR). The SBELC document encompasses the process of aligning the English Language Content and Learning Standards with pedagogical approaches that are in accordance with the CEFR. This method places a greater emphasis on action-oriented strategies, leading to modifications in teaching, learning, and assessment practices, encompassing an inventive School-Based Assessment (SBA) system. There has been a transition from the conventional approach to assessment for learning in order to address the efficacy of evaluating students' capabilities within the contemporary education system (Little, 2013). In alternative terms, the School-Based Assessment (SBA) is implemented. The implementation of the School-Based Assessment (SBA) is being carried out simultaneously with the introduction of the new Primary School Standard Curriculum. This is due to a significant demand for a transformation in student evaluation methods. There is a need for a change in how students' learning assessments are conducted, focusing on actively engaging students in their learning process. This shift aims to facilitate a deeper comprehension of the subject matter and motivate students to apply their acquired skills and knowledge. Therefore, it is necessary to comprehend and enhance the learning processes and the assessment system.

Hence, the newly developed CEFR-aligned School-Based English Language Curriculum (SBELC) integrates formative and summative assessments inside the educational institution. This integration aims to enhance the effectiveness of the

teaching and learning process, as well as provide teachers with the means to monitor and chart students' progress in terms of learning and achievement (Sulaiman et al., 2015). It has been recognized by experts in the field of education that assessment plays a crucial role in the facilitation of the teaching and learning process. According to Darling-Hammond (2012), assessment serves as a metric for assessing students' academic achievements and progress. According to Redecker and Johannessen (2013), there has been a shift in 21st-century classrooms from a focus on assessment of learning to assessment for learning and assessment as learning. The traditional assessment technique evaluates students' performance concerning predetermined expectations and criteria to assign them a rank or grade. In contrast, it is essential to note that assessment for learning is a continuous process that takes place during the teaching and learning journey. This process provides valuable insights to both the teacher and student regarding the student's areas of proficiency, the constraints of the learning experience, and strategies for enhancement (Nicole & Macfarlane-Dick, 2007). This approach utilises empirical data on students' knowledge, knowledge acquisition, and skill development to provide teachers with valuable insights and inform their instructional practices.

Unfortunately, the findings indicated that teachers were unable to offer valuable feedback on assessments that corresponded to the performance standards of the revised CEFR-aligned SBELC. This limitation will hinder the efficacy of implementing CEFR-aligned school-based assessments (Sidhu et al., 2018). Despite the incorporation of the CEFR levels as a framework for curriculum development, teaching and learning, and assessments in the SBELC reform, it is observed that the assessments are limited in their ability to offer comprehensive insights into students' strengths and weaknesses. Consequently, these assessments may not effectively

support students in enhancing their skills or aid teachers in instructional planning. Furthermore, they may not be reliable teaching practice guidelines (Lim et al., 2018). Both summative and formative assessments are graded holistically without offering detailed insights into the student's individual mastery and weaknesses in a particular skill set. According to Jang (2005), the process of assessing students, as well as comprehending and interpreting the significance of their scores and grades, is a complex undertaking. Therefore, using the cognitive diagnostic model (CDM) in cognitive diagnostic assessment is essential for obtaining comprehensive insights into students' strengths and weaknesses. This approach facilitates assessment for learning and enhances the learning process by equipping teachers with the necessary information to adapt instruction and learning strategies within the classroom (Jang, 2008).

As mentioned earlier, the revised SBELC curriculum encompasses four key elements: listening, speaking, reading, and writing. In accordance with this curriculum, teachers are responsible for designing assessments or instruments, evaluating, documenting, and reporting students' proficiency levels. These assessments, including summative and formative evaluations, are aligned with the Standards-Based Curriculum and Assessment Document (DSKP). These resources provide teachers with a reference point for assessing students' proficiency in the four language skills. Teachers can employ precise descriptors to assess the proficiency level of their students across several language competencies. Again, Malaysian teachers are finding it challenging to assess the reading comprehension component (Lim et al., 2018) as this study focuses on reading comprehension. Generally, most assessments carried out by teachers are merely to classify students' overall performance according to the specific subjects (Eng et al., 2016) but are insufficient to accurately indicate the

students' proficiency level according to the skills stated in each subject. Despite the teachers' sincere efforts to support their students' academic performance, foster success, and cultivate strong reading skills, they find themselves in a state of limited effectiveness. This is primarily due to the inadequacy of data and information derived from reading comprehension assessments, which hinders their ability to provide targeted assistance to students individually, class-wide, or school-wide.

Reading comprehension skills are widely recognized as an essential aspect of language acquisition, which students must proficiently acquire to engage with and acquire knowledge effectively (Eng et al., 2016). It is a fundamental skill that enables individuals to extract meaning from written text. It is not merely the ability to decode words, but rather the capacity to integrate reading with thinking and reasoning, a complex process that requires the activation of numerous cognitive skills. Proficient reading comprehension is crucial for academic success, as it forms the basis for learning across all subjects. Students who effectively comprehend texts are better equipped to acquire new knowledge, analyse information, and engage in critical thinking. (Kissau & Hiller, 2013) Furthermore, reading comprehension skills extend beyond the classroom, playing a vital role in professional development and lifelong learning. (Kraal et al., 2019) The ability to understand and interpret written materials is essential for navigating the complexities of the modern workplace and engaging in informed decision-making. Therefore, fostering strong reading comprehension skills in students is a critical educational objective with far-reaching implications for their future success.

However, many students grapple with proficient reading comprehension skills, which can lead to academic challenges across disciplines (Davoudi & Yousefi, 2015). Existing research indicates that reading comprehension is a critical ability that students

must develop, as it not only enhances the enjoyment and effectiveness of reading, but also supports performance in all other subject areas and students' personal lives (Manggasang, 2021). Moreover, Phantharakphong and Pothita (2014) have noted that students often struggle to understand written text due to their limited mastery of reading comprehension. This difficulty may stem from the complex linguistic nature of text, encompassing vocabulary, grammar, and lexical forms, which can pose significant obstacles for students to acquire, despite having been taught reading skills from an early stage (Samad et al., 2017). Davoudi and Yousefi (2015) have listed number of students reading comprehension difficulties and problems such as deficits in vocabulary knowledge and background knowledge, problems understanding linguistic complexity including lexical and syntactic knowledge, language inaccessibility, poor reading skills and lack of schemata.

Therefore, it is imperative to thoroughly analyse reading comprehension skills to gain a deeper understanding of these skills and identify the associated challenges language students face. By identifying areas of challenge in reading comprehension skills, giving feedback on that particular area can enhance the learning process and compensate for students' weaknesses.

For that reason, Cognitive Diagnosis Models (CDMs) have been primarily designed for cognitive diagnostic assessment (CDA), aiming to evaluate students' competence levels on a comprehensive range of specific skills. These models are particularly valuable as they offer more precise and detailed information in the form of score profiles. Cognitive diagnostic models (CDMs) are psychometric models primarily designed for the purpose of evaluating students' proficiency in a specific set of skills or attributes. In addition, it has been suggested that CDMS has the capacity to offer a more extensive range of information through score profiles. This feature allows

teachers to assess students' learning and development accurately, hence facilitating the creation of more effective instructional strategies tailored to individual student requirements (de la Torre, 2009; 2011). Thus, the present work employs the Generalised Deterministic Input, Noise, and Gate model (GDINA) to conduct a cognitive assessment of reading comprehension assessments. The Generalized DINA model (GDINA) is a comprehensive cognitive diagnostic model that offers a valuable framework for investigating the intricate connections between reading comprehension skills. By providing detailed feedback, the GDINA model enhances the effectiveness of classroom instruction, aids in constructing remedial courses, and supports the creation of instructional materials. Additionally, this model can offer diagnostic information by generating reports on the student's mastery profiles, which outline the student's areas of strength and weakness concerning a predetermined set of skills.

### **1.3 Problem Statement**

The English language serves as a widely adopted "lingua franca" for global communication. Based on the findings of Reddy and Mahavidyalaya (2016), the global population of native English speakers is estimated to be around 375 million, while the number of individuals who use English as a second language is approximately 750 million. Frequently, exchanges within the realm of the English language take place in multicultural contexts with individuals who are either native or non-native speakers. This dynamic has a significant influence on the blending of language and culture among those who speak English. The significance of the English language is evident across multiple domains, such as commerce, global politics, and education. Furthermore, the advancement of the internet and information and communication technology (ICT) has further amplified the impact of globalization on this

phenomenon. Therefore, to effectively address the demands posed by the expanding era of globalisation, it is imperative to acquire fluency in English, given its role as the primary medium for the diffusion of knowledge.

In the Malaysian educational system, a child begins learning the English language in preschool when they are between the ages of 5 and 6 and continues as a compulsory subject in primary and secondary school. The significance of acquiring proficiency in the English language has been emphasized within the educational framework in order to address the increasing demands in Science and Technology (ICT) and the Fourth Industrial Revolution. This demands Malaysian students to possess a high level of competence in English in order to effectively compete on the global level. Furthermore, as part of the Malaysian Education Reformation outlined in the Malaysian Education Blueprint (2013-2025), Shift 2 places significant emphasis on the crucial need for students to possess multilingual proficiency in both Malay and English languages, hence enabling effective communication. The acquisition of English language skills encompasses various components, including listening, speaking, reading, writing, and grammar. In the primary classroom setting, an instructional approach known as the modular method is employed to impart these skills, wherein each lesson centres on the development of a certain skill. Consequently, upon completion of the 6-year primary education curriculum, students are anticipated to possess fundamental language skills that empower them to effectively engage in confident and appropriate communication with both their peers and adults in both formal and informal contexts. Additionally, they should be able to comprehend and derive information from a variety of English texts, thereby deriving both informational and pleasurable experiences from their reading endeavours. In addition, students must be capable of writing through proper language and style.

For that reason, the acquisition of reading skill plays an important part in language acquisition, exerting a significant influence on an individual's linguistic growth (Krashen & Brown, 2007; Kiew & Shah, 2020). This is due to its potential to enhance total language competency. Reading proficiency requires learners to not only articulate words accurately but also to understand the meanings of the vocabulary and the semantic structures of the English language. According to Al-Fassi (2004), there is agreement on the importance of reading skill in language acquisition and learning. This is because reading includes a multifaceted cognitive process that entails the integration of memory and building meaning to comprehend and gather information effectively. In a similar vein, Lim et al. (2018) asserted that the process of comprehending written text requires active cognitive involvement with the material being read. The development of reading skill necessitates that students accurately pronounce words and possess a comprehensive understanding of the semantic patterns inherent in the English language. In other words, reading skill requires learners to not only articulate words accurately but also comprehend both the meanings of the vocabulary and the semantic structures of the English language. Therefore, mastery of reading comprehension skills is essential for successful academic performance among learners (Bernhardt, 2011).

A primary goal of reading is to understand the text. Some researchers contend that comprehension is essential for reading to occur. According to Randi et al. (2010), reading involves both decoding and comprehension. Kang (2015) similarly pointed out that a reader will struggle to understand the text if one of these components is missing. This view is further supported by Panigrahi (2010), who described reading as a process of constructing meaning from the text. Koda (2007) added that reading comprehension happens when readers connect new information from the text with

their prior knowledge. Likewise, Grabe and Stoller (2002) argued that reading is the ability to derive meaning from written material and interpret the information correctly. Pollard et al. (2014) emphasized that reading involves not just decoding letters but also extracting meaning from the text. Hence, reading comprehension is a complex process that incorporates various cognitive functions, as noted by Cain et al. (2004). Li and Kirby (2014) also stated reading comprehension is challenging yet necessary for academic achievement.

Due to the complexity of language, which includes vocabulary, grammar, and lexical structures, young learners in primary schools often struggle to acquire reading comprehension, even though they have been taught reading skills from an early age (Kiew & Shah, 2020 ; Chuah & Sulaiman, 2021). This is supported by a report from the New Straits Time (2016) cited in Kamarundzaman (2014), which stated that 162,000 students in Malaysia's primary and secondary schools were illiterate, with 120,000 of them being in primary schools. Additionally, Fong's (2012) research found that only 27.2% of learners in Malaysia had basic English literacy. These statistics highlight a serious concern for the education system, as despite English being a compulsory subject from Year 1, students continue to struggle to achieve proficiency in reading. This is because understanding language goes beyond just grasping individual words; it involves the ability to actively engage with the content and form a mental representation (Rashid, 2012). However, it is crucial to investigate the factors that contribute to poor reading comprehension at the primary school level in order to effectively apply the recommended strategies (Iqbal et al., 2015; Chuah & Sulaiman, 2021). According to Mansor (2017), governments, educators, and other stakeholders in the education sector are deeply concerned about promoting reading habits, recognizing that this skill is essential for academic success.

Nevertheless, many Malaysian students struggle to attain proficiency in this skill despite its crucial role in achieving high academic performance (Nezami, 2012; Eng et al., 2016; Chandran & M. Shah, 2019; Samat et al., 2019; Edward et al. 2021). In a study conducted by Husna Abidin and Mohamad (2019), it was found that the education system in Malaysia is facing challenges in addressing the issue of reading incompetency among students, namely in the area of reading comprehension. Stephanie and Parilah (2019) emphasise that Malaysian students in primary school encounter challenges in acquiring reading comprehension skills despite receiving instruction in reading from an early stage of their education. These difficulties can be attributed to the intricate aspects of language, such as vocabulary, grammar, and linguistic form. According to Lin et al. (2016), the assessment system currently employed in Malaysian primary schools focuses solely on testing students' comprehension using outmoded and imprecise instruments. These instruments only provide information about the students' test scores and do not offer any more insights. The current test scores do not adequately provide teachers with accurate analytical data regarding students' competency levels, which hinders their ability to design customised reading comprehension teaching for their students.

The report for PISA (2022) shows Malaysian students scored lower than the Organisation for Economic Co-operation and Development (OECD) average in reading assessment (OECD, 2022). This assessment attempts to analyse the students' reading comprehension skills as defined by PISA. This shows that lower and upper-secondary-level students displayed incompetence in handling and mastering reading comprehension skills. Moreover, according to Nezami (2012) and Edward et al. (2021), a significant challenge educators encounter in higher education is students' inadequate reading comprehension skills, subsequently impacting their academic

achievements. This scenario happens because teachers neglect to identify students' mastery level of cognitive skills from the beginning of formal education during primary schooling (Mohd Mokhtar Thara et al. 2010).

The existing education system in Malaysian primary schools clearly illustrates this circumstance. At the end of their six-year educational journey, students undergo an official examination known as the *Ujian Pencapaian Sekolah Rendah* (UPSR). This assessment functions as a form of assessment to gauge students' proficiency in many areas, including reading, writing, mathematics, and practical communication skills. English is evaluated in two exams, namely Comprehension and Writing, during the UPSR test. Based on the study conducted for the UPSR 2019 examination, it was found that 14.87% of students enrolled in national schools and 12.94% of students attending national-type schools did not meet the minimum passing grade requirement in the Comprehension paper (KPM, 2019). Despite being exposed to English early, not all students exhibit proficiency in mastering this language.

On the contrary, according to Chin and Ghani (2021), English exhibits the lowest level of academic achievement. The lack of awareness among teachers of the challenges encountered by students in reading comprehension assessments is a notable observation. In order to effectively address these challenges, it is imperative to get an understanding of the underlying causes (Nurjanah, 2018). Moreover, it is evident that these students lack a comprehensive understanding of their personal strengths and weaknesses. This issue becomes particularly significant as these students transition into secondary schools, where teachers are unable to conduct thorough assessments or implement remedial measures to address their deficiencies in reading comprehension or other areas of need. The situation is exacerbated by the complete disconnection between students' academic performance in primary school and their subsequent

enrolment in secondary schools. This disconnection arises from the practice of secondary school teachers grading and segregating students solely based on their UPSR results without having knowledge of the students' actual weaknesses. This gap between primary and secondary schools further contributes to the issue.

In addition to this, the present School-Based English Language Curriculum (SBELC) has implemented school-based assessment (SBA), which entails gathering data on students' academic development inside the classroom setting that uses both formative and summative assessment methods. The ongoing assessment is systematically designed, executed, and documented by the subject teachers in order to evaluate the students' level of mastery. Indeed, assessment plays a beneficial role in the learning process by furnishing valuable insights into students' skills enabling teachers to effectively strategize their instructional approaches. Furthermore, it is widely acknowledged by teachers that the most effective method of assessing students' progress in a particular area of study is through the process of assessment (Huang & Wu, 2013). In addition, educators require an assessment instrument to acquire precise insights into students' latent cognitive strengths and weaknesses in their cognitive processes and educational development. Nevertheless, the existing classroom assessment demonstrates a lack of effective integration with instructional methods. The primary emphasis lies in the determination of a student's level of competency, the selection of applicants for a programme or scholarship, as well as the admission process for colleges while also distinguishing between passing and non-passing outcomes (de la Torre & Minchen, 2014). However, in the absence of the students' mastery profiles, the teacher is unable to customise instruction for individual learners by taking into account their specific strengths and weaknesses. In contrast, the educators will engage in predominantly remedial exercises that provide limited

outcomes. According to Mohamed et al. (2010), the existing assessment method in Malaysia is deemed undesirable due to the fact that test scores or grades serve as comprehensive representations of all skills evaluated inside a single examination.

Commonly, assessments' specifications only specify content requirements and neglect to consider the cognitive skills that underlie a curriculum. Even O'Neil et al. (2004) noted in their research that cognitive skills are not explicitly taken into account while developing items or questions for an evaluation. Moreover, it is worth noting that the results of the examination may not accurately represent the extent of the students' knowledge and skill (Huff & Goodman, 2007; Lim et al., 2018) due to the limited inclusion of the reading comprehension component within the assessment framework. Thus, it is difficult for teachers to identify which comprehension skills students face difficulties in mastering. Even Lin et al. (2016) believe the assessment scores offer minimal information on learners' reading ability levels. Hence, to address the issues related to reading comprehension among Malaysian students, it is much needed to identify issues faced by students at the early stage.

Many underlying cognitive skills are required for understanding and mastering the reading comprehension in the assessment, making it a complex process (e.g., vocabulary, identifying explicit information, interpretation and explanation, and evaluation and comment). Hence, numerous research in applied linguistics, education, and psychology have been conducted (Cohen & Upton, 2006). Despite the extensive research on reading comprehension, it is difficult to interpret the significance of reading comprehension test scores in terms of students' abilities and skills (Leighton & Gierl, 2007; Snyder et al., 2005).

As mentioned, there are many scientific studies relating to reading comprehension skills. Nevertheless, most research concentrates on comprehending the impact of diverse reading methods on comprehension skills or ascertaining the correlation between reading comprehension and the factors influencing reading (Ozdemir & Akyol, 2019; Chandran & M.Shah, 2019). However, students are still facing difficulties in reading comprehension. In the absence of comprehensive knowledge concerning the cognitive processes employed by students when addressing challenges in reading comprehension, facilitating their mastery of these skills becomes challenging.

Therefore, to identify reading comprehension problems among students, a Cognitive Diagnosis Model, Generalised Deterministic Input, Noisy 'And' Gate, commonly known as GDINA, is used to assess students' mastery and non-mastery of a set of fine-grained skills. The GDINA model, defined by Li et al. (2016), is a saturated model encompassing compensatory and non-compensatory skill relationships. This model is designed to be adaptable and can accommodate many types of relationships. The cognitive diagnosis model (CDM) is a latent variable model explicitly designed for cognitive diagnostic tests. It aims to offer more precise and comprehensive insights into students' learning and growth by generating score profiles. The retrieval of this information involves the first construction of a *Q-matrix*, which represents the skills necessary for each test item inside the reading comprehension assessment. Subsequently, the dataset will be subjected to analysis using the GDINA model, following the methodology proposed by de la Torre and Chiu (2016), utilising a code implemented in the R package CDM (Robitzsch, Kiefer, George, & Uenlue, 2017). Teachers can use the data obtained through analysis to design better instruction or interventions to address individual student and group needs based on the score

profiles (de la Torre, 2009, 2011). To sum up, teachers can identify the student's weaknesses in a specific domain.

#### **1.4 Purpose of Study**

The primary objective of this research is to assess the efficacy of employing the GDINA model in creating diagnostic score reports that precisely represent students' reading comprehension competence levels.

#### **1.5 Research Objectives (RO)**

The primary objective of this research is to employ Cognitive Diagnostic Modelling (CDM) to assess students' proficiency in specific knowledge and skills. The aim is to obtain diagnostic information about their cognitive strengths and weaknesses in acquiring reading comprehension skills. The objectives of this study are to:

- RO1:** To construct an expert-based cognitive processing model and validate through students' verbal reports on the text items to accentuate the cognitive processes involved in answering reading comprehension questions.
- RO2:** To construct a *Q-matrix* for developing test items that measure specific attributes listed in the cognitive processing model.
- RO3:** To identify the quality of the test item through item discrimination indices.
- RO4:** To identify the hierarchy of the attributes' difficulties in mastering reading comprehension.
- RO5:** To estimate students' cognitive strengths and weaknesses for the tested attributes of the reading comprehension assessment.

## 1.6 Research Questions (RQ)

The research questions in this study are as follows:

**RQ1:** Is the expert-based cognitive processing model consistent with the student-based cognitive processing model?

**RQ2:** To what extent the relation between attributes to items specified in the *Q-matrix* is correctly specified?

**RQ3:** What is the quality of the test items in this reading comprehension assessment?

**RQ4:** What is the hierarchy of the attributes of difficulty in mastering reading comprehension?

**RQ5:** What are the students' cognitive strengths and weaknesses for the attributes in reading comprehension?

## 1.7 Significance of Study

This study investigates novel approaches to developing test questions that incorporate the curriculum, instruction, and assessment to examine students' cognitive strengths and weaknesses concerning their proficiency in reading comprehension skills. By recognizing students' cognitive strengths and weaknesses, teachers can better understand students' learning progress. Hence, teachers can modify their pedagogical methods, assess the efficacy of instructional materials, and implement suitable interventions to address students' areas of weakness on time. Besides, the research outcomes will also contribute to the interpretation and classification of students' learning performance. Furthermore, the cognitive diagnostic assessment (CDA) possesses a diagnostic feature that aligns with the criteria outlined by the Malaysian educational system for school assessments.

Additionally, the use of the CDA has the potential to provide teachers with guidance in developing purposeful assignments that evaluate students' comprehension and proficiency levels rather than relying just on achievement evaluations that prioritise numerical numbers. Moreover, this approach allows students to address the underlying factors contributing to the problem more efficiently, thereby motivating them to bridge the disparity between their present level of accomplishment and their desired educational objectives.

Through the implementation of the cognitive diagnostic assessment and under the guidance of teachers, students possess the ability to engage in self-evaluation as a means of enhancing their own personal growth and development. This tool facilitates the identification of students' areas of difficulty, enabling them to proactively address and rectify their learning deficiencies. This strategy indirectly fosters motivation and encourages students to cultivate a self-directed learning mindset, aligning with one of the primary goals of implementing SBA in national schools.

This study investigates novel approaches to the development of test questions that incorporate the curriculum, instruction, and assessment in order to examine the cognitive skills of students in relation to their proficiency in reading comprehension skills. By acknowledging the cognitive strengths and shortcomings of students, teachers can gain a deeper understanding of their learning progression. Hence, teachers have the ability to modify their pedagogical methods, assess the efficacy of instructional materials employed in teaching, and implement suitable interventions to address students' areas of weakness in a timely manner. Additionally, the research findings will make a valuable contribution to the understanding and categorization of students' academic achievements. Furthermore, the cognitive

diagnostic assessment (CDA) possesses a diagnostic feature that aligns with the criteria outlined by the Malaysian educational system for school assessments.

Additionally, the use of the CDA has the potential to provide teachers with guidance in developing purposeful assignments that evaluate students' comprehension and proficiency levels rather than relying just on achievement evaluations that prioritise numerical numbers. Moreover, this approach offers students the opportunity to address the underlying factors contributing to the problem in a more efficient manner, thereby motivating them to bridge the disparity between their present level of accomplishment and their desired educational objectives.

Through implementing the cognitive diagnostic assessment and under the guidance of teachers, students can engage in self-evaluation to enhance their personal growth and development. This tool facilitates the identification of students' areas of difficulty, enabling them to address and rectify their learning deficiencies proactively. This strategy indirectly fosters motivation and encourages students to cultivate a self-directed learning mindset, aligning with one of the primary goals of implementing SBA in national schools.

In conclusion, this study offers significant resources for researchers in the field who are interested in researching Cognitive Diagnostic Assessment (CDA) and Cognitive Diagnostic Models (CDMs). This study concludes by providing some advice and guidelines for those interested in utilising Cognitive Diagnosis Models (CDMs) to effectively address the present demand for cognitive diagnosis in the context of teaching and learning reading comprehension.

## **1.8 Limitations of the Study**

The current research is subject to many constraints that may restrict the generalizability of the findings. The study sample was restricted to Year Four pupils from 16 Pulau Pinang primary schools due to the prevailing pandemic situation. Therefore, the findings may lack generalizability to the entire population of primary school students in Malaysia.

Secondly, the assessment cannot be conducted in a natural classroom environment. Therefore, students might ask their parents or siblings to help answer the test questions, and there is no seriousness to answer the assessment correctly. Furthermore, they did not have good teaching and learning sessions due to the current COVID-19 situation. The transition from traditional classroom instruction to online learning might present a significantly distinct experience for young students, necessitating their adaptation to this alternative educational format due to the absence of other viable options.

Indeed, the education system and teachers have learned to adopt “Education in Emergency” through many online platforms and are duty-bound to adopt a system they are unprepared for. Due to that, teachers are uncertain about assessing their students as they did not expect to face such a situation. They find it challenging to conduct assessments during this pandemic since learning and teaching sessions were online based.

## **1.9 Operational Definition**

### **1.9.1 Cognitive Diagnostic Assessment**

Cognitive diagnostic assessment (CDA) is a method of assessment that offers insights into students' strengths and weaknesses regarding their knowledge structures and processing skills, commonly referred to as attributes, within the specific topic of study (Lee & Sawaki, 2009; Leighton & Gierl, 2007). Basically, CDA seeks to facilitate the process of assessing student learning and offer diagnostic feedback by providing detailed reports on students' levels of skill mastery. CDA achieves this objective by integrating cognitive theories with statistical models to detect and assess the students' proficiencies and deficiencies in the specific learning domain. In this research, a CDA is developed to measure students' knowledge of reading comprehension.

### **1.9.2 Cognitive Diagnostic Model**

The Cognitive Diagnosis Model (CDM) is a psychometric model explicitly designed for cognitive diagnostic assessments. These assessments aim to evaluate students' level of mastery or non-mastery concerning a comprehensive set of finely differentiated attributes or skills within a particular subject or area (Chen & Chen, 2016). Cognitive diagnostic models (CDMs) can provide precise data regarding students' learning and progress through score profiles. This enables teachers to assess students' performance more effectively and tailor instruction and intervention strategies to meet the specific requirements of individuals and groups (de la Torre, 2009, 2011). The present study utilised the GDINA model, a compensatory cognitive diagnostic model, to categorise the students' proficiency profiles in the domain of reading comprehension.

### **1.9.3 Cognitive Attribute**

The term "cognitive attribute" pertains to the knowledge, procedures, or skills that are required for the successful execution of a task within a specific topic or subject (Gierl et al., 2009). This study examines the cognitive attributes pertaining to students' reading comprehension proficiency. These attributes encompass vocabulary, syntactic knowledge, the ability to comprehend explicit information, to connect and synthesise information, and the aptitude for making inferences.

### **1.9.4 *Q-matrix***

The *Q-matrix* is a two-dimensional matrix representing the logical connection between attributes and test items (Zhao et al., 2020). It allows for identifying students' mastery patterns for these attributes through their responses to the test items. The *Q-matrix* illustrates the associations between individual test items and the cognitive attributes included in the assessment. The link between elements is established using numerical values, specifically 1 and 0, within a *Q-matrix*. The value of 1 signifies that the item necessitates the attributes, whereas the value of 0 indicates that the item in question does not need the attribute.

### **1.9.5 GDINA**

The model referred to as the Generalised Deterministic Input, Noisy 'AND' Gate (GDINA) is a compensatory and saturated Cognitive Diagnostic Model (CDM) described by Javidanmehr and Anani Sarab in 2017. This study used the Generalised DINA model (GDINA) to perform a cognitive diagnostic on reading comprehension assessments, as this model facilitates the examination of the relationships between different skills or attributes associated with reading comprehension. According to