Sri Lankan Adaptation of Metacognitive Awareness Inventory For Students: A Validity and Reliability Study

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ABSTRACT

Metacognitive awareness is closely tied to success in mathematics, yet Sri Lanka has had no validated Sinhala-language instrument for measuring it in school students. This study adapted Schraw and Dennison's (1994) Metacognitive Awareness Inventory (MAI) for Sri Lankan Grade 8 students and examined its structural validity and internal consistency. The Sinhala version, the Metacognitive Awareness Inventory for Students (MAIS), was produced through translation, back-translation, and pilot testing, and was administered on a four-point agreement scale to 470 Grade 8 students (264 male, 206 female) from schools in the Central Province. Confirmatory factor analysis (CFA) was conducted separately for the knowledge component (Metacognitive Knowledge Questions, MKQ; declarative, procedural, and conditional knowledge) and the regulation component (Metacognitive Regulation Questions, MRQ; planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation). Three items (Q9, Q34, and Q48) were removed during model refinement, leaving 49 of the original 52 items. The refined MKQ model fitted well, $\chi^2(111) = 156.581$, CFI = .948, TLI = .936, RMSEA = .030. The refined MRQ model showed a close fit (RMSEA = .035) but only a marginal incremental fit, $\chi^2(454) = 721.878$, CFI = .885, TLI = .875. Cronbach's alpha was .76 for the MKQ, .88 for the MRQ, and .91 for the full inventory. The results support the MAIS as a reliable instrument with sound structural evidence for the knowledge component and acceptable but improvable evidence for the regulation component. Further validation with larger, more varied samples, standardised parameter estimates, tests of discriminant validity and measurement invariance is recommended.

Keywords: Metacognition; Metacognitive Awareness Inventory; Confirmatory Factor Analysis; Mathematics Education; Sri Lanka

INTRODUCTION

Metacognition has been a central construct in educational psychology since Flavell (1976, 1979) described it as knowledge about one's own cognitive processes and the regulation of those processes. Hacker (1998) later broadened the definition to include knowledge of cognitive and affective states and the deliberate monitoring and regulation of them. Most accounts divide metacognitive awareness into two components. Metacognitive knowledge covers what learners know about themselves as learners (declarative knowledge), about strategies (procedural knowledge) and about when and why to use them (conditional knowledge). Metacognitive regulation covers the activities learners use to control their learning, such as planning, monitoring and evaluating (Brown, 1987; Schraw & Dennison, 1994; Schraw & Moshman, 1995).

The link between metacognition and mathematics learning is well documented. Schoenfeld (1985, 1987) showed that expert problem solvers plan, monitor and review their work in ways novices rarely do, and later reviews have confirmed that metacognitive skills contribute to mathematical achievement in children and adolescents (Schneider & Artelt, 2010; Veenman et al., 2006). Meta-analytic evidence also indicates that teaching learners to plan, monitor and evaluate improves their academic performance (Dignath & Büttner, 2008; Donker et al., 2014). Any programme that tries to build these skills needs a way to measure students' metacognitive awareness

before and after instruction. Self-report inventories are the most practical option for classroom-sized and school-level samples, although they capture what students believe about their own practices rather than direct observations of those practices (Veenman et al., 2006).

The most widely used self-report measure of general metacognitive awareness is Schraw and Dennison's (1994) 52-item Metacognitive Awareness Inventory (MAI). It has been translated and examined in several languages, but its internal structure has produced mixed evidence (Akin et al., 2007; Harrison & Vallin, 2018; Teo & Lee, 2012). Evidence of this kind must be gathered again whenever an instrument is translated into a new language and school system, because translation can change the meaning of items and because the same construct may be organised differently across populations.

Mathematics Education in Sri Lanka

Mathematics is taught from Grade 1 to Grade 13 in Sri Lankan schools and is compulsory up to Grade 11, and a pass in mathematics at the G.C.E. (Ordinary Level) examination is required to enter the Advanced Level programme. First-attempt pass rates for school candidates rose by about 18% between 2012 and 2023 (Table 1), yet roughly 30% of candidates still fail the subject (Department of Examinations, Sri Lanka, 2012-2023). In 2017, 53.68% of the 366,923 candidates scored 40 marks or fewer in mathematics (Department of Examinations, Sri Lanka, 2019). The weakness appears early. In the 2014 national assessment of Grade 8 students, the largest share of students (19.4%) scored between 31 and 40 marks (Ministry of Education & National Education Research and Evaluation Centre, 2015). These figures suggest that gaps in understanding are present at the junior secondary level, before students begin the two-year Ordinary Level course.

Table 1: School candidates (first attempt) - Results by grades in Mathematics

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Pass percentage	55.35	57.23	56.7	55.18	62.81	67.24	68.3	71.08	70.52	70.03	73.36	73.16

Source: Performance of Candidates (2012-2021) published by Research & Development Branch, National Evaluation and Testing Service, Department of Examinations, Sri Lanka

One explanation worth testing is that students who attend to the processes of learning, and not only to answers, solve problems more successfully. Researching that explanation in Sri Lanka requires a measure of students' metacognitive awareness that is available in Sinhala, has been checked for cultural and linguistic fit, and has documented psychometric properties. To the authors' knowledge, no such instrument has been reported for Sri Lankan school students.

Metacognitive Inventories for Students

This paper is the student counterpart of an earlier adaptation for Sri Lankan mathematics teachers, the Metacognitive Awareness Inventory for Mathematics Teachers (MAIMT), which was based on Balcikanli's (2011) Metacognitive Awareness Inventory for Teachers (MAIT) and validated with 61 Grade 8 mathematics teachers (Wijethunga, 2026). The two studies share a procedure (Sinhala translation, back-translation, pilot testing and CFA) but differ in four respects. First, the respondents are learners reporting on how they study and learn, not teachers reporting on how they teach. Second, the source instrument is the original MAI, not the MAIT, so the student inventory retains all eight MAI subscales, including information management strategies and debugging strategies, which the six-subscale teacher inventory does not include. Third, the sample is much larger (470 students versus 61 teachers), which enables more rigorous model testing. Fourth, the items are worded in terms of learning and studying in general, so the scores reflect students' general metacognitive awareness as reported by Grade 8 students who are also mathematics learners, rather than mathematics-specific awareness.

Objectives

The study aimed to:

1. Examine whether the factor structure of the Sinhala adaptation of the Metacognitive Awareness Inventory for Students (MAIS) is consistent with the two-component, eight-subscale theoretical framework underlying the original Metacognitive Awareness Inventory (MAI).
2. Assess the internal consistency reliability of the Sinhala-adapted MAIS when administered to Grade 8 students in the Central Province of Sri Lanka.

LITERATURE REVIEW

Theoretical framework

The MAI rests on the distinction between knowledge of cognition and regulation of cognition (Brown, 1987; Flavell, 1979; Schraw & Moshman, 1995). Schraw and Dennison (1994) operationalised the distinction in 52 items. Seventeen items measure knowledge of cognition, grouped into declarative, procedural and conditional knowledge. Thirty-five items measure regulation of cognition, grouped into planning, information management strategies, comprehension monitoring, debugging strategies and evaluation. Table 2 lists the eight subscales, their definitions, and the number of items retained in the Sinhala student version.

Table 2: Subscales of the Metacognitive Awareness Inventory and the items retained in the Sinhala student version (MAIS)

Measurement Scale	Subscale	What it captures	Number of Items in MAIS
Metacognitive Knowledge (MKQ)	Declarative knowledge	Knowing one's strengths, weaknesses and what is worth learning	8
	Procedural knowledge	Knowing how to use learning strategies	4
	Conditional knowledge	Knowing when and why a strategy is useful	5
Metacognitive Regulation (MRQ)	Planning	Setting goals and organising time and resources before a task	7
	Information management strategies	Organising, elaborating and summarising information while learning	8
	Comprehension monitoring	Checking understanding and progress during a task	6
	Debugging strategies	Correcting comprehension and performance errors	5
	Evaluation	Appraising outcomes and strategy efficiency after a task	6

The distinction between the two components matters for mathematics. A student with strong knowledge of cognition may know that diagrams help with geometry, while a student with strong regulation will check whether a solution step is consistent with the problem. Zimmerman's (2002) model of self-regulated learning treats the same activities as phases of a cycle (forethought, performance, and self-reflection), linking the MAI's regulation subscales to a broader account of how learners manage their own work.

Measuring metacognition

Metacognition cannot be observed directly, and researchers measure it through self-reports, interviews, think-aloud protocols and observation (Akturk & Sahin, 2011; Veenman et al., 2006). Self-report questionnaires are inexpensive and can be administered to whole classes. Their limits are well known: respondents may not understand all items, may be unwilling to describe their practices, or may not be able to report processes that run automatically (Veenman et al., 2006). Several inventories have grown out of the MAI, including the Junior

Metacognitive Awareness Inventory for younger learners (Sperling et al., 2002), the Metacognitive Awareness of Reading Strategies Inventory (Mokhtari & Reichard, 2002), and the Metacognitive Awareness Inventory for Teachers (Balcikanli, 2011). The teacher inventory reduced the MAI to 24 items across six dimensions: declarative, procedural, and conditional knowledge; planning; monitoring and evaluating.

Evidence on the internal structure of the MAI

Internal structure is one source of validity evidence for the inferences drawn from a scale's scores (American Educational Research Association et al., 2014; Messick, 1995). For the MAI, most of the structural work has been done on the translated versions. Akin et al. (2007) reported an eight-factor solution for a Turkish version of the instrument from exploratory factor analysis, without a confirmatory test. Teo and Lee (2012) combined exploratory and confirmatory analyses in an Asian sample and proposed a three-factor model that kept 21 of the 52 items. Harrison and Vallin (2018) concluded that the internal structure of the MAI needed further study. Taken together, these studies leave open the question of whether the two-component and eight-subscale models hold across populations, and they show that item reduction is a common outcome of adaptation.

Evaluating factor models

CFA tests whether the relationships between observed items and latent factors match a model specified in advance (Brown, 2015; Kline, 2016). The chi-square statistic tests exact fit but rejects even small misfits in large samples, so it is read together with the comparative fit index (CFI; Bentler, 1990), the Tucker-Lewis index (TLI; Tucker & Lewis, 1973) and the root mean square error of approximation (RMSEA; Browne & Cudeck, 1993). Conventionally, CFI and TLI of at least .90 indicate acceptable fit and at least .95 good fit, and RMSEA of .08 or less indicates reasonable fit and .05 or less close fit (Browne & Cudeck, 1993; Hu & Bentler, 1999; Marsh et al., 1996). A chi-square-to-degrees-of-freedom ratio of 3 or less is also commonly used (Schreiber et al., 2006). These cut-offs are guides, not rules. In models with many items, CFI and TLI tend to fall while RMSEA tends to improve (Kenny & McCoach, 2003), so disagreement among the indices is common in inventories of this length and has to be interpreted explicitly.

When a model fits poorly, a model-generating approach is accepted provided that modifications are theoretically defensible and not made only to improve fit indices (Byrne, 2016; Hair et al., 2019). Two kinds of modification matter here: allowing error terms of items within the same factor to covary, which acknowledges shared wording or content, and removing items that behave poorly.

Reliability is usually reported as Cronbach's (1951) alpha. Alpha increases with the number of items and relies on restrictive assumptions of equal loadings, so it is best treated as a summary of internal consistency rather than as proof of unidimensionality (Sijtsma, 2009). Values of .70 or higher are generally preferred (Nunnally & Bernstein, 1994).

Research gap

The MAI has been adapted in several languages, but no Sinhala version with reported structural and reliability evidence is available for Sri Lankan students, and the existing validation evidence for the MAI is inconsistent across populations. The present study addresses both points. It reports item-level and model-level evidence for a Sinhala adaptation and presents that evidence alongside the teacher version so the two instruments can be used together in studies of classroom metacognition.

Research Methodology

Design and ethical approval

The study is a cross-sectional instrument adaptation and validation study. Ethical approval was obtained from the Postgraduate Institute of Humanities and Social Sciences, University of Peradeniya. Permission to conduct research in schools was then granted by the Department of Education of the Central Province and by the relevant Zonal Education Offices, and school principals gave consent for their schools to take part. Students and teachers

received information on the purpose of the study, the voluntary nature of participation and the confidentiality and anonymity of their responses, and informed consent was obtained before data collection.

Participants

Participants were Grade 8 students from schools in the Central Province, selected to represent geographic location and school size. The sample for analysis comprised 470 students after data screening. Of these, 264 (56%) were male, and 206 (44%) were female. By school type, 197 students (42%) attended Type 1AB (national) schools, 154 (33%) attended Type 2 schools and 119 (25%) attended Type 1C schools (Table 3). Students were therefore drawn from three school categories that differ in access to academic resources and curricula.

Table 3: Profile of the student sample (N = 470)

Characteristic	Category	n	%
Gender	Male	264	56
	Female	206	44
School type	Type 1AB (national schools)	197	42
	Type 2	154	33
	Type 1C	119	25

Instrument: the Metacognitive Awareness Inventory for Students (MAIS)

The MAIS-49 (Appendix 2) is a Sinhala adaptation of the 52-item MAI (Appendix 1) (Schraw & Dennison, 1994). It has two parts: a short demographic section (age, gender and basic mathematics achievement data) and the inventory itself. Items are statements about how respondents learn and study, for example, "I understand my intellectual strengths and weaknesses" (declarative knowledge) and "I ask others for help when I don't understand something" (debugging strategies). Students rate each statement on a four-point scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree). The inventory has two components. The Metacognitive Knowledge Questions (MKQ) contain 17 items in three subscales, and the Metacognitive Regulation Questions (MRQ) contain 32 items in five subscales (Table 2). Subscale scores are item means, so they range from 1 to 4.

Table 4 presents the student inventory alongside the teacher inventory from the earlier study, as the two are meant to be used together but are not interchangeable.

Table 4: Characteristics of the Metacognitive Awareness Inventory for Students (MAIS)

Feature	Description
Respondents	Grade 8 students
Source instrument	Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994), 52 items
Theoretical structure	8 subscales (3 knowledge of cognition and 5 regulation of cognition)
Item content	Metacognitive awareness related to learning and studying in general
Response scale	4-point Likert scale
Analysed sample	470 students
Items removed during CFA	3 (Q9, Q34 and Q48)
Final inventory	49 items across 8 subscales

Adaptation procedure

The adaptation followed the three-step procedure used for the teacher inventory, which is consistent with common guidance on cross-cultural adaptation of self-report measures (Beaton et al., 2000; Brislin, 1970).

1. **Forward translation.** The researcher prepared Sinhala versions of each item and combined them into one version. An experienced Sinhala language teacher then checked the items for language and clarity.

2. **Back-translation.** Two competent English language teachers translated the Sinhala version back into English to check that concepts and phrases carried over correctly in both directions. The final version incorporated modifications suggested by the researcher and an English language lecturer.

3. **Pilot testing.** The revised Sinhala version was tried out following the procedure used for the teacher inventory. Respondents were asked to pay particular attention to unfamiliar concepts and vague statements.

The Sinhala wording of the items refers to the learner's own studying and learning. Items were not reworded to refer to mathematics, so the MAIS measures general metacognitive awareness in a sample of mathematics learners.

Procedure

A paper-based questionnaire, with a consent form attached to the front page, was administered in classrooms on dates agreed with school principals and class teachers, so that regular lessons were disrupted as little as possible. Before the survey, students were told that responses would be used only for research and that no individual would be identified at any stage.

Data screening

Responses were checked for missing values and for patterned or careless responding. Seven cases with systematically missing data or clearly patterned responses were removed by listwise deletion, leaving 470 valid cases. Randomly missing values were handled by multiple imputation (Rubin, 1987), which produced five imputed data sets whose results were averaged (Enders, 2010; Graham, 2009). Codes and values were verified before analysis, and item distributions were inspected for normality. Skewness and kurtosis were judged against the limits of absolute skewness below 2 and absolute kurtosis below 7 proposed by West et al. (1995).

Data Analysis

Descriptive statistics and reliability coefficients were computed in IBM SPSS Statistics 26, and the CFA models were estimated in IBM SPSS AMOS 26. Following the two-component structure of the MAI and the procedure used for the teacher inventory, the MKQ and the MRQ were analysed in separate CFAs. In each analysis, items were assigned a priori to their subscales, subscale factors were allowed to correlate, and the first model (M1) had no correlated errors. Where M1 fitted poorly, later models allowed error terms of items within the same subscale to covary and then removed items whose deletion improved fit, one at a time. Model fit was judged by the chi-square test, the ratio of chi-square to degrees of freedom (three or less preferred), CFI and TLI (.90 acceptable, .95 good) and RMSEA (.08 acceptable, .05 close) as set out in the Literature Review (Hu & Bentler, 1999; Marsh et al., 1996; Schreiber et al., 2006). Because the chi-square test is sensitive to sample size, the incremental and absolute indices carried more weight in the decisions. Internal consistency was estimated with Cronbach's alpha for the MKQ, the MRQ and the whole inventory, with .70 as the preferred minimum (Nunnally & Bernstein, 1994).

RESULTS

Descriptive statistics

Item-level means, standard deviations, skewness and kurtosis for the 52 original items are given in Appendix 1, and subscale summaries are in Table 5. Item means ranged from 2.59 (Q16, "I know what the teacher expects me to learn") to 3.68 (Q25, "I ask others for help when I don't understand something"). The highest-rated items after Q25 were Q42 (M = 3.65, reading instructions carefully) and Q13 (M = 3.59, focusing attention on important information). Apart from Q16, the lowest-rated items were Q24 (M = 2.70, summarising what has

been learned), Q48 (M = 2.75), Q37 (M = 2.80, drawing diagrams) and Q9 (M = 2.81). At the subscale level, debugging strategies had the highest average mean (3.35) and information management strategies the lowest (3.04).

Table 5: Subscale descriptive statistics (N = 470)

Component	Subscale	Items in original MAI	Items retained in MAIS	Mean	SD	Skewness	Kurtosis
MKQ	Declarative knowledge	8	8	3.17	0.83	−0.91	0.40
	Procedural knowledge	4	4	3.19	0.85	−0.92	0.32
	Conditional knowledge	5	5	3.26	0.86	−1.11	0.78
MRQ	Planning	7	7	3.30	0.82	−1.16	1.00
	Information management strategies	10	8	3.04	0.91	−0.77	−0.07
	Comprehension monitoring	7	6	3.10	0.86	−0.77	−0.01
	Debugging strategies	5	5	3.35	0.82	−1.32	1.44
	Evaluation	6	6	3.08	0.91	−0.83	0.00

Note. Values are averages of the item statistics within each subscale. For information management strategies and comprehension monitoring, averages were computed across all original items, including those later removed (Q9, Q48, and Q34).

Responses were negatively skewed, as expected when most respondents agree with most statements on a four-point scale. All kurtosis values were below 7 (maximum 5.29, Q25). Absolute skewness stayed below 2 for all items except Q25 (−2.30) and Q42 (−2.15), which exceeded it modestly. Inter-item correlations within subscales were mostly weak to moderate, with the great majority ranging from about .00 to .30.

Structural validity of the knowledge component (MKQ)

The MKQ contains 17 items in three subscales: declarative knowledge (8 items), procedural knowledge (4 items) and conditional knowledge (5 items). The initial model (M1) was close to acceptable, $\chi^2(116) = 209.697$, $p < .001$, $\chi^2/df = 1.81$, CFI = .893, TLI = .874, RMSEA = .041, with CFI and TLI slightly under .90. Allowing five pairs of error terms within the declarative knowledge subscale to covary (M2) reduced chi-square by 53.12 on 5 degrees of freedom ($p < .001$). The final model fitted well on every index, $\chi^2(111) = 156.581$, $p = .003$, $\chi^2/df = 1.41$, CFI = .948, TLI = .936, RMSEA = .030 (Table 6). CFI fell just short of the .95 criterion for good fit but exceeded .90, and RMSEA was below .05. No items were removed from the MKQ.

Table 6: Goodness-of-fit statistics for the Metacognitive Knowledge Questions (MKQ)

Model	Description	χ^2	df	CFI	TLI	RMSEA
M1	Completely free	209.697	116	.893	.874	.041
M2	Error terms connected within declarative knowledge	156.581	111	.948	.936	.030

Note. χ^2 = chi-square; df = degrees of freedom; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation.

Figure 1 gives the unstandardised factor loadings of the final MKQ model, with the first item of each subscale fixed to 1.00 to set the scale of the latent variable.

The loadings within declarative and procedural knowledge were of similar size. In conditional knowledge, the four items other than Q15 loaded 2.55 to 3.14 times as strongly as the reference item. This pattern, together with the factor variance of .02, shows that Q15 ("I learn best when I know something about the topic") was a weak indicator of conditional knowledge: its error variance (1.18) was almost as large as its observed variance (SD = 1.09, so variance = 1.19).

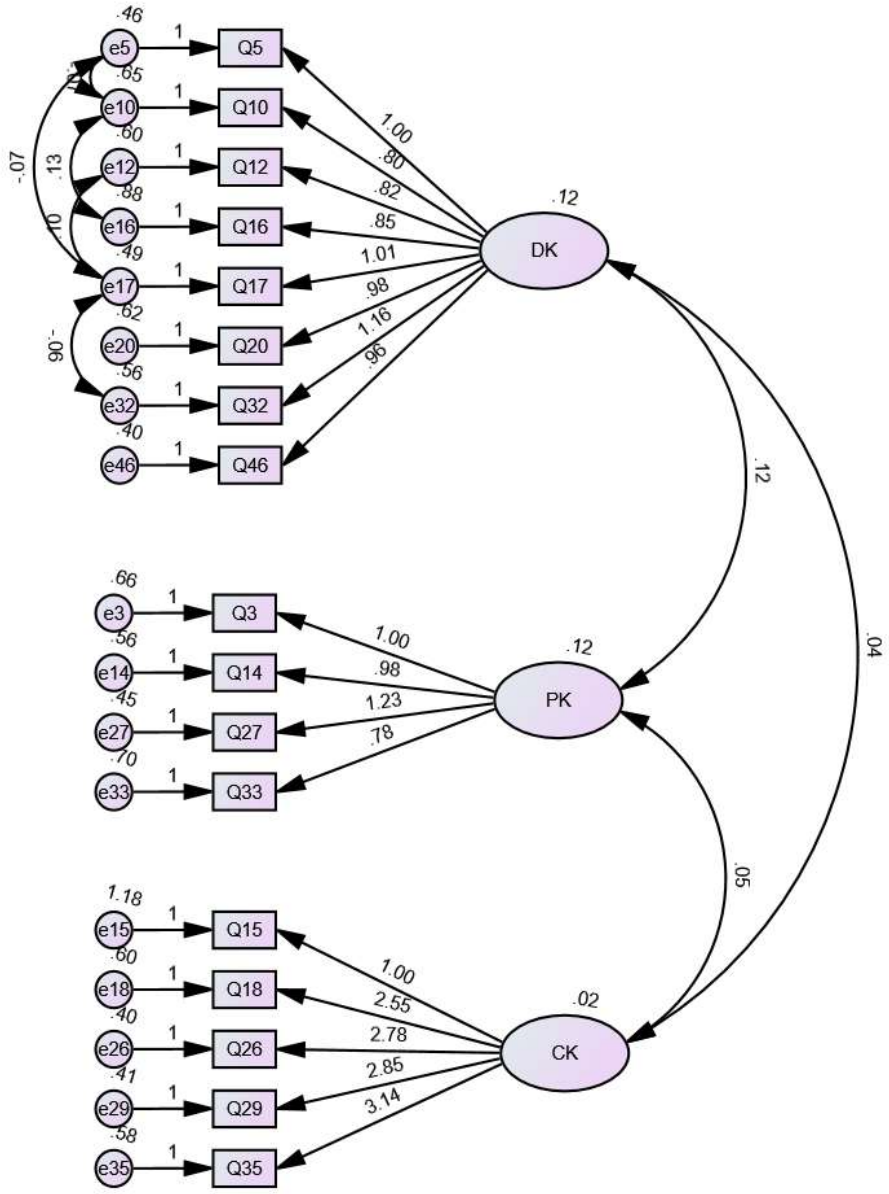


Figure 1: Factorial structure of the variables of the MKQ with factor loadings
Note: DK = Declarative Knowledge, PK = Procedural Knowledge, CK = Conditional Knoweldge

Structural validity of the regulation component (MRQ)

The MRQ contains 35 items in five subscales: planning (7), information management strategies (10), comprehension monitoring (7), debugging strategies (5) and evaluation (6). Table 7 traces the five models. The initial model fitted poorly on the incremental indices, $\chi^2(550) = 945.504$, $p < .001$, $\chi^2/df = 1.72$, CFI = .844, TLI = .831, although RMSEA was already .039. Allowing two pairs of error terms within information management strategies to covary (M2) produced only a small gain (CFI = .853, TLI = .840). Three items were then removed one at a time: Q48 ("I focus on overall meaning rather than specifics"; M3), Q9 ("I slow down when I encounter important information"; M4) and Q34 ("I find myself pausing regularly to check my comprehension"; M5). Both Q48 and Q9 belong to information management strategies, and Q34 to comprehension monitoring.

Table 7: Goodness-of-fit statistics for the Metacognitive Regulation Questions (MRQ)

Model	Description	χ^2	df	CFI	TLI	RMSEA
M1	Completely free	945.504	550	.844	.831	.039

M2	Error terms connected within information management strategies	920.959	548	.853	.840	.038
M3	Q48 removed	874.178	517	.855	.843	.038
M4	Q9 removed	770.723	485	.881	.870	.035
M5	Q34 removed	721.878	454	.885	.875	.035

Note. χ^2 *= chi-square; df = degrees of freedom; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation.*

The final MRQ model (M5) gave $\chi^2(454) = 721.878$, $p < .001$, $\chi^2/df = 1.59$, CFI = .885, TLI = .875 and RMSEA = .035. The RMSEA and the chi-square ratio meet the criteria for close fit and for acceptable fit, respectively, but CFI and TLI remain below the .90 criterion. The MRQ model is therefore best described as showing a close absolute fit with marginal incremental fit, rather than as fully confirmed. Removing the three items brought the retained MAIS to 49 items: 17 in the MKQ and 32 in the MRQ.

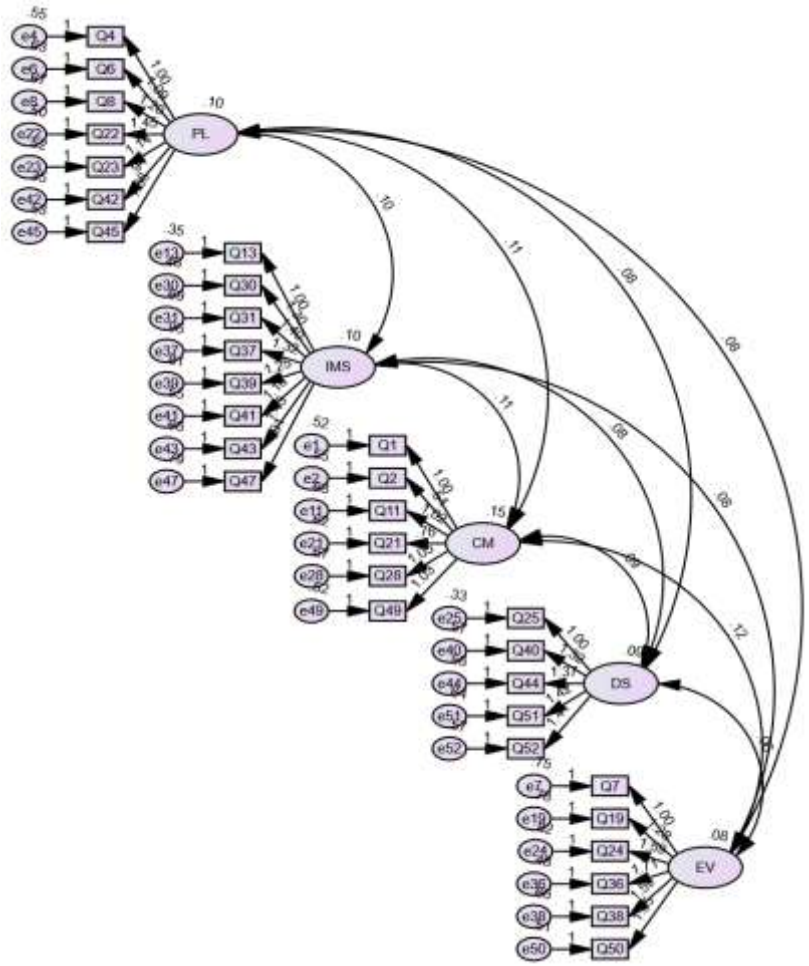


Figure 2: Factorial structure of the variables of the MRQ with factor loadings
Note: PL = Planning, IMS = Information Management Strategies, CM= Comprehension Monitoring, DS = Debugging Strategies, EV = Evaluation

Table 8 presents the goodness-of-fit statistics for the refined model of the Metacognitive Awareness Inventory for Students (MAIS), combining the constructs of the Metacognitive Knowledge Questions (MKQ) and the Metacognitive Regulation Questions (MRQ). Items Q48, Q9, and Q34 were removed in a prior CFA conducted for the MRQ and MKQ to address misfit issues and improve overall model performance. The current analysis reflects these adjustments, yielding a chi-square value of $\chi^2 = 945.504$ with 550 degrees of freedom (df), which indicates reasonable alignment with the data.

Table 8: Goodness of Fit Statistics for Metacognitive Awareness Inventory for Students

Model	Model Description	$chi - squared$	df	CFI	TLI	RMSEA
M1	Q48, Q9, Q34 removed model	945.504	550	0.844	.831	0.039

Note. χ^2 = chi-square; df = degrees of freedom; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation.

The Comparative Fit Index (CFI = 0.844) and Tucker-Lewis Index (TLI = 0.831) indicate a moderate model fit, though they fall slightly below the 0.90 threshold. However, the Root Mean Square Error of Approximation (RMSEA = 0.039) is well within the acceptable range, signifying a close fit between the refined model and the observed data (Browne & Cudeck, 1993). These findings indicate that the prior item removals effectively enhanced the model's performance, particularly regarding RMSEA, confirming its suitability for assessing Metacognitive Awareness among students.

The structural model presented in Figure 3 illustrates the relationships among the eight latent constructs of Metacognitive Awareness: Planning (PL), Information Management Strategies (IMS), Comprehension Monitoring (CM), Debugging Strategies (DS), Evaluation (EV), Declarative Knowledge (DK), Procedural Knowledge (PK), and Conditional Knowledge (CK), together with their respective observed indicators. The predominantly strong standardised factor loadings indicate that the observed variables adequately represent their corresponding latent constructs. The correlations among the constructs are generally weak to moderate, suggesting that, although the dimensions are conceptually distinct, they remain interconnected. For example, the correlations between DK and PK (0.11) and between PL and IMS (0.10) indicate relatively limited associations. Overall, the model demonstrates the multidimensional nature of Metacognitive Awareness, with its measurement structure supporting the inventory's validity in assessing metacognitive knowledge and regulation.

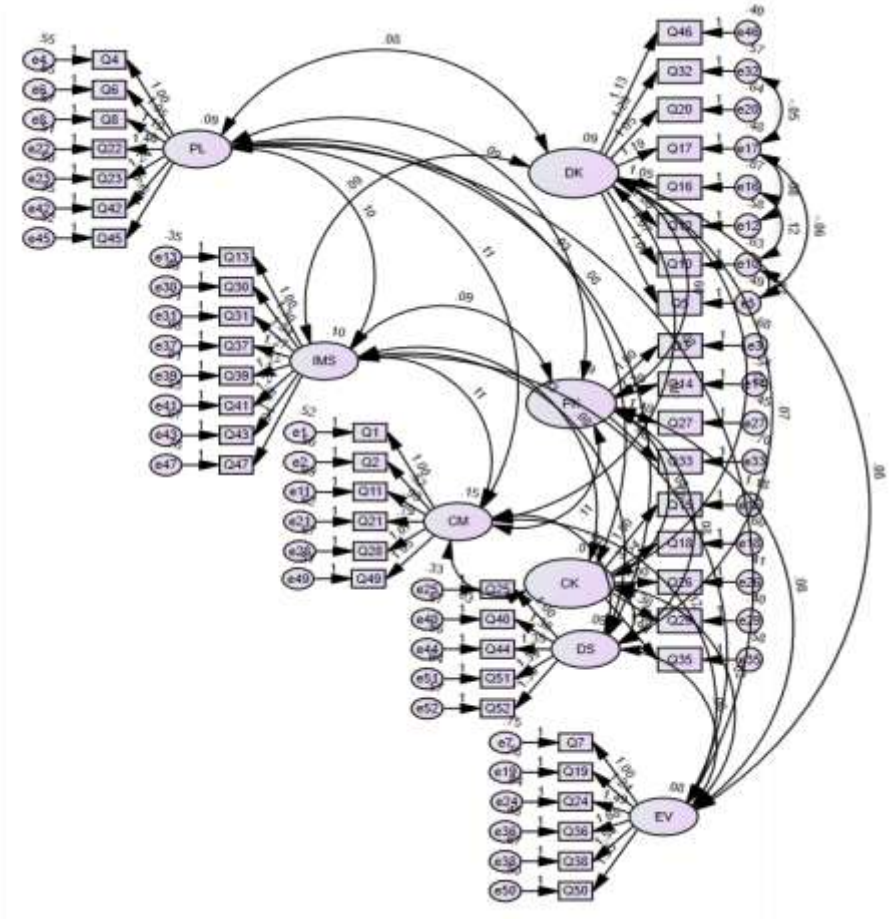


Figure 3: Factorial structure of the variables of the MAIS with factor loadings

Note: DK = Declarative Knowledge, PK = Procedural Knowledge, CK = Conditional Knowledge PL = Planning, IMS = Information Management Strategies, CM= Comprehension Monitoring, DS = Debugging Strategies, EV = Evaluation

Reliability Analysis

Cronbach's alpha was .76 for the MKQ, .88 for the MRQ, and .91 for the whole inventory (Table 9). The MKQ coefficient exceeds the .70 minimum, the MRQ coefficient is in the good range, and the full-scale coefficient is high. Because alpha increases with the number of items, the coefficients for the 17-item MKQ and the 49-item full scale are not directly comparable, and the full-scale value should not be read as evidence of a single dimension (Sijtsma, 2009). Alpha coefficients for the eight individual subscales are not reported.

Table 9: Reliability of the MAIS

Scale	Cronbach's alpha
Metacognitive Knowledge Questions (MKQ)	.76
Metacognitive Regulation Questions (MRQ)	.88
Entire questionnaire (MAIS)	.91

DISCUSSION

This study adapted the Metacognitive Awareness Inventory into Sinhala for Grade 8 students and examined its structure and internal consistency in a sample of 470 students. The evidence is strongest for the knowledge component. The MKQ fitted well after allowing correlated errors within declarative knowledge, with CFI = .948, TLI = .936, and RMSEA = .030, and no item had to be removed. The regulation component was less clear. The MRQ showed a close fit on RMSEA (.035) and the chi-square ratio (1.59), but CFI (.885) and TLI (.875) remained below the .90 criterion, but were very close to 0.90 after three items were removed. Internal consistency was good at the component and full-scale levels (α = .76, .88, and .91). Taken together, these results support the use of the MAIS for research with Sri Lankan Grade 8 students and identify the regulation component as the part of the inventory that needs further work.

Only three of the 52 items were removed, which is modest compared with the reductions reported for other adaptations of the MAI (Teo & Lee, 2012) and the four items removed from the teacher version. Two of the three removed items, Q48 ("I focus on overall meaning rather than specifics") and Q9 ("I slow down when I encounter important information"), belong to information management strategies, which also had the lowest subscale mean (3.04). Both removed items were among the lowest-rated items overall (Q48, M = 2.75; Q9, M = 2.81). The third, Q34 ("I find myself pausing regularly to check my comprehension"), belongs to comprehension monitoring. Items about slowing down and pausing describe behaviours that Grade 8 students may not recognise in themselves or may interpret in different ways, and Q48 may be read as contradicting the neighbouring summarising item. These are hypotheses about the cause. Cognitive interviews with students would be needed to test them.

The weak conditional-knowledge indicator Q15 ("I learn best when I know something about the topic") was retained, but its error variance was almost equal to its observed variance, so the wording or its place in the subscale should be reviewed.

Students' average ratings were above the scale midpoint on every subscale (3.04 to 3.35 on a scale from 1 to 4), with negative skew. Strategies that involve working with the material, such as drawing diagrams (Q37, M = 2.80), summarising (Q24, M = 2.70) and creating examples (Q31, M = 2.90), were rated lower than help-seeking (Q25, M = 3.68) and careful reading of instructions (Q42, M = 3.65). In mathematics, diagrams and self-generated examples are central strategies, so this pattern is of practical interest. Because the responses are self-reports on a short agreement scale, they show what students believe about their practices, not what they do, and the high means may partly reflect agreeable responding.

In the wider project from which these data come, MAIS scores were related to students' mathematics achievement and showed no gender differences (Wijethunga, 2026). Those analyses are reported separately and are consistent with the instrument behaving as expected, but they are not a substitute for a dedicated test of criterion-related validity.

CONCLUSION

The Sinhala Metacognitive Awareness Inventory for Students (MAIS) is a 49-item inventory with a knowledge component of 17 items and a regulation component of 32 items. In a sample of 470 Grade 8 students from the Central Province, the knowledge component showed good structural fit and acceptable reliability ($\alpha = .76$). The regulation component showed close absolute fit but marginal incremental fit and good reliability ($\alpha = .88$), and the full inventory was highly consistent ($\alpha = .91$). On this evidence, the MAIS can be used for research and for monitoring programmes that aim to build students' metacognitive awareness, with component scores interpreted more cautiously than subscale scores. Together with the teacher inventory (Wijethunga, 2026), this pair of Sinhala instruments provides Sri Lankan researchers with a means to study metacognition in mathematics classrooms. Replication in a new sample, with standardised estimates, tests of discriminant validity and measurement invariance, and criterion evidence, is needed before the inventory is used to make decisions about individual students.

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Appendix 1: Item-level descriptive statistics for the 52 original items (N = 470)

Subscale	Item	Statement	M	SD	Skewness	Kurtosis
Declarative knowledge	Q5	I understand my intellectual strengths and weaknesses.	3.44	0.76	−1.37	1.54
Declarative knowledge	Q10	I know what kind of information is most important to learn.	3.12	0.85	−0.79	0.05
Declarative knowledge	Q12	I am good at organising information.	3.12	0.83	−0.75	0.10
Declarative knowledge	Q16	I know what the teacher expects me to learn.	2.59	0.99	−0.28	−0.94
Declarative knowledge	Q17	I am good at remembering information.	3.18	0.78	−0.92	0.77
Declarative knowledge	Q20	I have control over how well I learn.	3.18	0.86	−0.94	0.28
Declarative knowledge	Q32	I am a good judge of how well I understand something.	3.26	0.85	−1.05	0.47
Declarative knowledge	Q46	I learn more when I am interested in the topic.	3.47	0.71	−1.21	0.93
Procedural knowledge	Q3	I try to use strategies that have worked in the past.	3.19	0.88	−0.95	0.16
Procedural knowledge	Q14	I have a specific purpose for each strategy I use.	3.24	0.82	−0.99	0.52
Procedural knowledge	Q27	I am aware of what strategies I use when I study.	3.25	0.80	−0.99	0.67
Procedural knowledge	Q33	I find myself using helpful learning strategies automatically.	3.07	0.88	−0.76	−0.09
Conditional knowledge	Q15	I learn best when I know something about the topic.	3.10	1.09	−0.87	−0.65
Conditional knowledge	Q18	I use different learning strategies depending on the situation.	3.20	0.84	−0.94	0.34

Conditional knowledge	Q26	I can motivate myself to learn when I need to.	3.49	0.73	−1.57	2.36
Conditional knowledge	Q29	I use my intellectual strengths to compensate for my weaknesses.	3.45	0.74	−1.41	1.82
Conditional knowledge	Q35	I know when each strategy I use will be most effective.	3.09	0.87	−0.78	0.01
Planning	Q4	I pace myself while learning in order to have enough time.	3.31	0.81	−1.11	0.74
Planning	Q6	I think about what I really need to learn before I begin a task.	3.01	0.87	−0.61	−0.27
Planning	Q8	I set specific goals before I begin a task.	3.25	0.90	−1.10	0.40
Planning	Q22	I ask myself questions about the material before I begin.	3.34	0.84	−1.21	0.77
Planning	Q23	I think of several ways to solve a problem and choose the best one.	3.28	0.80	−1.04	0.67
Planning	Q42	I read instructions carefully before I begin a task.	3.65	0.66	−2.15	4.53
Planning	Q45	I organise my time to best accomplish my goals.	3.23	0.85	−0.92	0.18
Information management strategies	Q9†	I slow down when I encounter important information.	2.81	0.99	−0.47	−0.79
Information management strategies	Q13	I consciously focus my attention on important information.	3.59	0.67	−1.75	2.99
Information management strategies	Q30	I focus on the meaning and significance of new information.	3.37	0.79	−1.12	0.61
Information management strategies	Q31	I create my own examples to make information more meaningful.	2.90	0.94	−0.53	−0.60
Information management strategies	Q37	I draw pictures or diagrams to help me understand while learning.	2.80	1.07	−0.43	−1.06
Information management strategies	Q39	I try to translate new information into my own words.	2.96	0.98	−0.67	−0.54
Information management strategies	Q41	I use the organisational structure of the text to help me learn.	3.31	0.83	−1.06	0.46
Information management strategies	Q43	I ask myself if what I'm reading is related to what I already know.	3.02	0.93	−0.74	−0.28
Information management strategies	Q47	I try to break studying down into smaller steps.	2.93	0.94	−0.60	−0.46
Information management strategies	Q48†	I focus on overall meaning rather than specifics.	2.75	1.01	−0.32	−0.99
Comprehension monitoring	Q1	I ask myself periodically if I am meeting my goals.	3.24	0.82	−0.95	0.39

Comprehension monitoring	Q2	I consider several alternatives to a problem before I answer.	3.30	0.78	−1.05	0.83
Comprehension monitoring	Q11	I ask myself if I have considered all options when solving a problem.	3.07	0.92	−0.75	−0.28
Comprehension monitoring	Q21	I periodically review to help me understand important relationships.	3.01	0.85	−0.54	−0.31
Comprehension monitoring	Q28	I find myself analysing the usefulness of strategies while I study.	2.92	0.92	−0.61	−0.37
Comprehension monitoring	Q34†	I find myself pausing regularly to check my comprehension.	2.99	0.94	−0.70	−0.35
Comprehension monitoring	Q49	I ask myself questions about how well I am doing while I am learning something new.	3.15	0.83	−0.76	0.02
Debugging strategies	Q25	I ask others for help when I don't understand something.	3.68	0.65	−2.30	5.29
Debugging strategies	Q40	I change strategies when I fail to understand.	3.23	0.85	−0.96	0.24
Debugging strategies	Q44	I reevaluate my assumptions when I get confused.	3.26	0.85	−0.98	0.24
Debugging strategies	Q51	I stop and go back over new information that is not clear.	3.23	0.90	−0.98	0.06
Debugging strategies	Q52	I stop and reread when I get confused.	3.37	0.86	−1.40	1.35
Evaluation	Q7	I know how well I did once I finish a test.	3.30	0.91	−1.22	0.59
Evaluation	Q19	I ask myself if there was an easier way to do things after I finish a task.	3.08	0.96	−0.87	−0.16
Evaluation	Q24	I summarise what I've learned after I finish.	2.70	1.01	−0.33	−0.97
Evaluation	Q36	I ask myself how well I accomplish my goals once I'm finished.	3.23	0.85	−1.05	0.59
Evaluation	Q38	I ask myself if I have considered all options after I solve a problem.	2.87	0.93	−0.50	−0.58
Evaluation	Q50	I ask myself if I learned as much as I could have once I finish a task.	3.28	0.81	−1.01	0.55

Note. † Item removed during model refinement. Item numbers correspond to the MAIS numbering and differ from the teacher inventory numbering.

Appendix 2: Metacognitive Awareness Sinhala Inventory for Students (MAIS-49)

අධිප්‍රජානන දැනුවත්භාවය පිළිබඳ ප්‍රශ්නාවලිය

		අසත්‍යයි	බොහෝ දුරට අසත්‍යයි	බොහෝ දුරට සත්‍යයි	සත්‍යයි
1.	මගේ ඉගැන්වීමේ ප්‍රබලතා හා දුබලතා මම දනිමි	1	2	3	4
2.	මම අතීතයේ සාර්ථක වූ ඉගැන්වීමේ ක්‍රම භාවිතා කිරීමට උත්සාහ කරමි	1	2	3	4
3.	මගේ ඉගැන්වීමේ දුර්වලතා මගහැරීම සඳහා මම මා සතු ඉගැන්වීමේ ප්‍රබලතා භාවිත කරමි	1	2	3	4
4.	කාලයක ප්‍රමාණවත් ව ලබා ගැනීම සඳහා මම වේගය තීරණය කර ගනිමි	1	2	3	4
5.	මා උගන්වන අතරතුර මගේ ඉගැන්වීමේ අරමුණු සපුරාලන්නේ දැයි මම වරින් වර මගෙන්ම අසමි	1	2	3	4
6.	මා උගන්වා අවසන් වූ පසු මගේ ඉගැන්වීමේ අරමුණු කොතරම් දුරට සාක්ෂාත් වී ඇත්දැයි මම මගෙන්ම අසමි	1	2	3	4
7.	හොඳ ගුරුවරයෙකුවීම සඳහා වඩාත්ම වැදගත් කුසලතා මොනවාදැයි මම දනිමි	1	2	3	4
8.	පන්තියේදී මා භාවිතා කරන සෑම ඉගැන්වීමේ ක්‍රමයක්ම නෝරා ගැනීමට මට නිශ්චිත හේතුවක් තිබේ	1	2	3	4
9.	මට ඇත්තටම ඉගැන්වීමට අවශ්‍ය වූ විට ඒ සඳහා මාවම පෙළඹවිය හැකිය	1	2	3	4
10.	මම ඉගැන්වීම ආරම්භ කිරීමට පෙර මගේම සුවිශේෂ ඉගැන්වීම් අරමුණු තබා ගනිමි	1	2	3	4
11.	මම උගන්වන අතරතුර මගේ ඉගැන්වීමේ ක්‍රම කොතරම් ප්‍රයෝජනවත්දැයි තක්සේරු කරමි	1	2	3	4
12.	සෑම ඉගැන්වීමේ අත්දැකීමකට පසුව, වෙනත් ඉගැන්වීමේ ශිල්පීය ක්‍රමයක් මට භාවිත කරන්නට තිබුණේ දැයි මම මගෙන්ම අසමි	1	2	3	4

		අසත්‍යයි	බොහෝ දුරට අසත්‍යයි	බොහෝ දුරට සත්‍යයි	සත්‍යයි
11.	තොරතුරු සංවිධානය කිරීමේ මම දක්ෂයෙක් වෙමි	1	2	3	4
12.	මම උවමනාවෙන් ම වැදගත් තොරතුරු කෙරෙහි මගේ අවධානය යොමු කරමි	1	2	3	4
13.	මා භාවිත කරන සෑම උපාය මාර්ගයක් සඳහාම සුවිශේෂ අරමුණක් මට ඇත	1	2	3	4
14.	මා වඩාත් ම හොඳින් ඉගෙන ගන්නේ පාඩම පිළිබඳ ව යමක් මා දැන සිටින විට ය	1	2	3	4
15.	මා විසින් උගත යුතු යැයි ගුරුතුමා/තුමිය අපේක්ෂා කරන දේ මම දනිමි	1	2	3	4
16.	මම තොරතුරු මතක තබා ගැනීමට දක්ෂවෙමි	1	2	3	4
17.	පවතින තත්ත්වයට අනුව මම විවිධ ඉගෙනුම් උපාය මාර්ග භාවිතා කරමි	1	2	3	4
18.	මම කාර්යයක් අවසන් කිරීමෙන් පසු එය සිදු කිරීමට ඊට වඩා පහසු ක්‍රමයක් තිබුණිදැයි මම මගෙන්ම අසමි	1	2	3	4
19.	මා කොතරම් හොඳින් ඉගෙන ගන්නවාද යන්න පිළිබඳ පාලනයක් මට ඇත	1	2	3	4
20.	වැදගත් සම්බන්ධතා තේරුම් ගැනීමට උදව්වක් වීම සඳහා මම වරින් වර සමාලෝචනයේ යෙදෙමි	1	2	3	4
21.	මම යමක් ආරම්භ කිරීමට පෙර, දී ඇති කරුණු පිළිබඳ ව මගෙන්ම ප්‍රශ්න අසමි	1	2	3	4
22.	ගැටලුවක් විසඳීමට සහ හොඳම දේ තෝරා ගැනීමට ක්‍රම කිහිපයක් ගැන මම සිතමි	1	2	3	4

		අසත්‍යයි	බොහෝ දුරට අසත්‍යයි	බොහෝ දුරට සත්‍යයි	සත්‍යයි
23.	මම යම් දෙයක් ඉගෙනගෙන අවසන් වූ පසු ඉගෙන ගත්තේ කුමක්දැයි සාරාංශ කරමි	1	2	3	4
24.	මට යමක් නොතේරෙන විට එය මම තවත් කෙනෙකුගෙන් අසා පැහැදිලි ගැනීමට කටයුතු කරමි	1	2	3	4
25.	මට ඉගෙන ගැනීමට අවශ්‍ය වූ විට ඒ සඳහා මාවම පොලඹවා ගත හැකිය	1	2	3	4
26.	මම ඉගෙන ගන්නා විට කුමන උපාය මාර්ගය භාවිතා කරන්නේ දැයි මම දනිමි	1	2	3	4
27.	මම ඉගෙන ගන්නා අතරතුර ඒ සඳහා යොදා ගන්නා උපායමාර්ගවල ප්‍රයෝජනවත් බව පිළිබඳ ව විශ්ලේෂණය කරමි	1	2	3	4
28.	මගේ දුබලතා මගහරවා ගැනීම සඳහා මා සතු බුද්ධිමය ශක්තිය මම භාවිතා කරමි	1	2	3	4
29.	නව තොරතුරු වල අර්ථය හා වැදගත්කම කෙරෙහි මම අවධානය යොමු කරමි	1	2	3	4
30.	තොරතුරු වඩාත් අර්ථවත් කිරීම සඳහා මම මගේම උදාහරණ නිර්මාණය කරමි	1	2	3	4
31.	මම යමක් හොඳින් තේරුම්ගෙන ඇති ද යන්න පිළිබඳ හොඳ විනිශ්චයකරුවෙක් වෙමි	1	2	3	4
32.	ප්‍රයෝජනවත් ඉගෙනුම් උපාය මාර්ග ඉබේම මෙන් භාවිතා කිරීමට මම පුරුදු වී සිටිමි	1	2	3	4
33.	මා භාවිතා කරන සෑම උපාය මාර්ගයක්ම වඩාත් ඵලදායී වන්නේ කුමන විටකදී ද යන්න මම දනිමි	1	2	3	4

		අසත්‍යයි	බොහෝ දුරට අසත්‍යයි	බොහෝ දුරට සත්‍යයි	සත්‍යයි
34.	මම යමක් අවසන් කළ පසු මගේ අරමුණු කෙතරම් හොඳින් ඉටු වී ඇද්දැයි මම මගෙන්ම අසමි	1	2	3	4
35.	ඉගෙන ගන්නා අතරතුර මට හේරුම් ගැනීමට උදව්වක් ලබා ගැනීම සඳහා මම පිස්තුර හෝ රූප සටහන් ඇඳීමට කටයුතු කරමි	1	2	3	4
36.	ගැටලුවක් විසඳීමෙන් පසු එය විසඳීමට භාවිත කිසියම් ක්‍රම සලකා බැලුවේදැයි මම මගෙන්ම අසමි	1	2	3	4
37.	මම නව තොරතුරු මගේම වචන වලට පරිවර්තනය කිරීමට උත්සාහ කරමි	1	2	3	4
38.	යමක් හේරුම් ගැනීමට අපොහොසත් වූ විට මම උපාය මාර්ග වෙනස් කරමි	1	2	3	4
39.	මට ඉගෙන ගැනීමට උදව්වක් ලෙස දෙන ලද කරුණු සංවිධානය කර ඇති ආකාරය භාවිතා කරමි	1	2	3	4
40.	මම කාර්යයක් ආරම්භ කිරීමට පෙර උපදෙස් හොඳින් කියවා බලමි	1	2	3	4
41.	මා කියවන දේ මා දැනටමත් දන්නා දේ හා සම්බන්ධ දැයි මම මගෙන්ම අසමි	1	2	3	4
42.	කරුණු නොතේරී අවුල් සහගත බවක් ඇති වූ විට මම මගේ උපකල්පන නැවත පරීක්ෂා කරමි	1	2	3	4
43.	මගේ අරමුණු වඩාත් හොඳින් ඉටු කර ගැනීම සඳහා මම මගේ කාලය සංවිධානය කරගනිමි	1	2	3	4
44.	මට පාඩම පිළිබඳ උනන්දුවක් ඇති වූ විට ඒ පිළිබඳ ව වැඩි දුරටත් හදාරමි	1	2	3	4
45.	මම කුඩා පියවර වලට කඩා ඉගෙන ගැනීමට උත්සාහ කරමි	1	2	3	4

		අසත්‍යයි	බොහෝ දුරට අසත්‍යයි	බොහෝ දුරට සත්‍යයි	සත්‍යයි
46.	මම එක් එක් සුවිශේෂ කරුණුවලට වඩා සමස්ත අර්ථය කෙරෙහි අවධානය යොමු කරමි	1	2	3	4
47.	යම් කාර්යයක් අවසන් කළ පසු මා මට හැකි ඉහළම ප්‍රමිතීන් ඉගෙන ගත්තාදැයි මම මගෙන්ම අසමි	1	2	3	4
48.	අපැහැදිලි නව කරුණු හමුවූ විට ඉගෙනීම මදකට නවතා එම කරුණු නැවත පැහැදිලි කර ගනිමි	1	2	3	4
49.	මම යම් කරුණක් පිළිබඳ ව නොපැහැදිලි වූ විට එම කාර්යය මදකට නවතා ඒ පිළිබඳ ව නැවත නැවත කියවමි	1	2	3	4