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RESEARCH ARTICLE

Antibiotic knowledge assessment questionnaire in undergraduate pharmacy students: A Rasch analysis of validity evidence

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Abstract

Background: Antibiotic knowledge is crucial for undergraduate pharmacy students who are future healthcare professionals. However, a valid and reliable instrument to assess their knowledge is scarce. This study aimed to develop and validate an Antibiotic Knowledge Assessment Questionnaire (AKAQ). **Methods:** The AKAQ had three domains and 29 items, encompassing general antibiotic knowledge, antibiotic resistance, and antibiotic stewardship. Rasch analysis was used to assess psychometric properties, including validity parameters (item and person fit and structural validity), reliability (person and item reliability, Cronbach's Alpha value), item-person interaction, and item bias, using differential item functioning (DIF) based on tems. **Results:** This study included 500 undergraduate pharmacy students from 90 Indonesian universities. The validity of the questionnaire was demonstrated, except for one item. Person means infit and outfit for MNSQ were 1.02 and 0.95, whereas ZSTD were 0.11 and 0.08, respectively. Items means infit and outfit for MNSQ were 1.01 and 0.96, while ZSTD were 0.11 and -0.23. Item and person reliabilities were acceptable at 0.99 and 0.68. Cronbach's alpha reliability was acceptable at 0.71. Two items were biased by term. **Conclusion:** The AKAQ is a valid, reliable, and standard instrument for assessing the antibiotic knowledge levels of undergraduate pharmacy students.

Introduction

Antimicrobial resistance (AMR) is a global health issue (O'Neill, 2014), directly responsible for 1.27 million deaths in 2019, as estimated by a recent global analysis (Murray *et al.,* 2022). The impact of AMR is particularly pronounced in low-middle-income countries (O'Neill, 2014) compared to middle- or high-income countries due to weak laboratory capacity, inadequate governance of health systems, limited health information systems, and constrained resources (Iskandar *et al.,* 2021). Notably, Indonesia ranked 70th of 76 countries in the total amount of antibiotic consumption measured in DDD/1000 inhabitants per day, according to the pharmaceutical sales data between 2000 and 2015 (Klein *et al.,* 2018).

Recognising the critical role of proper education and training in addressing AMR, this work focuses on pharmacy students as future healthcare professionals. Some studies suggest that enhancing pharmacy students' knowledge of AMR and stewardship programmes can influence the broader population's behaviour towards responsible antibiotic use (Bond,

2005; Smith & Olin, 2010; Burns *et al.,* 2020). However, research data on antibiotic knowledge and antibiotic stewardship among pharmacy students is scarce; in developing countries, it is limited to Pakistan (Hayat *et al.,* 2021), Saudi Arabia (Kandasamy *et al.,* 2020), Uganda, Kenya, and Tanzania (Lubwama *et al.,* 2021), Sri Lanka (Sakeena *et al.,* 2018), and Malaysia (Rajiah *et al.,* 2015). Moreover, recent studies measured knowledge levels of antibiotics among the general population in Indonesia (Widayati *et al.,* 2012; Karuniawati *et al.,* 2021; Yunita *et al.,* 2022; Sinuraya *et al.,* 2023). Importantly, this research gap has not been addressed in the Indonesian context, where Rasch analysis was utilised. Unlike the commonly used factor analysis (Liu *et al.,* 2019; Karuniawati *et al.,* 2022; Tohan *et al.,* 2023), Rasch offers distinct advantages in evaluating structural validity (Mallah *et al.,* 2020). Factor analysis has drawbacks, such as the parametric basis of component analysis and the formation of "*difficulty factors*", which may falsely suggest multidimensionality with ordinal scales (Nunnally & Bernstein, 1994). In contrast, Rasch's analysis comprehensively assesses item function, differential item functioning, and local item dependencies (Bond *et al.,* 2020; Linacre, 2021). Rasch generates an ordered item collection, tests unidimensionality, ensures generalisability, considers the potential variability in how respondents perceive the distances between different response options, and identifies poorly functioning items through unexpected replies, providing valuable advantages (Bond *et al.,* 2020).

This study aimed to develop a valid and reliable instrument to measure Indonesian undergraduate pharmacy students' general knowledge of antibiotics, antibiotic resistance, and antibiotic stewardship.

Methods

Study design, participants, and setting

A web-based cross-sectional quantitative study was performed in Indonesia from February to May 2022 using the Antibiotic Knowledge Assessment Questionnaire (AKAQ), a self-administered instrument created on Google Forms. The questionnaire was distributed to Indonesian undergraduate bachelor of pharmacy students (an education programme before professional pharmacist education) from different terms and universities.

Ethics approval and informed consent

The study received ethical approval from the Health Research Ethics Committee of Universitas Harapan Bangsa before it was conducted (Reference No. B-LPPM-UHB/726/02/2022). The respondents were informed online about the nature of this study; they consented to participate by starting the AKAQ. The anonymity of the students was assured to protect their identification.

Sample size and recruitment

Comrey and Lee have categorised the quality of sample size for questionnaire validation based on the number of samples, i.e. the sample size of 50, 100, 200, 300, 500, and ≥1000 should be regarded as very poor, poor, fair, good, very good, and superb, respectively (Comrey & Lee, 2013). Therefore, the sample size was set to 500 participants to achieve an adequate level. This study applied a random sampling method to choose participants from Indonesian universities. Lecturers were approached from different universities to distribute the AKAQ to their students from different years of the bachelor programme. Data were transformed from the Google Form database into Statistical Package for the Social Sciences version 26.0 (IBM, 2019) to be exported into Winsteps version 5.2.1.0 software (Linacre, 2022). Rasch analysis was conducted, which is a psychometric analytic method that analysed participant responses to the AKAQ questionnaire to determine instrument validity and scale functioning. A Rasch model was used to analyse sum scores from these ordinal responses due to the dichotomous response structure to calculate interval-level estimates that represent person locations (i.e. person ability) and item locations (i.e. the difficulty of a specific question (item) to provide a correct or positive response) on a linear scale that represents the latent variable (logit scale) (Laliyo *et al*., 2022).

Instrument development

The four steps for developing the questionnaire consisted of framework development, item (question) generation, item screening, and pre-testing (Boateng *et al.,* 2018).

Framework development

Established questionnaires (Jamshed *et al.,* 2014; Inácio *et al.,* 2017; Lubwama *et al.,* 2021; Park *et al.,* 2021) and antimicrobial stewardship guidelines (World Health Organization, 2019; World Health Organization, 2021) were used for the framework development phase.

Item generation

Building upon the framework, the AKAQ was categorised into two parts. The first part is intended to collect information about participants' demographic

characteristics such as sex, age, and term. The second part assessed participants' knowledge of antibiotics and included three domains evaluating general antibiotic knowledge (Inácio *et al.,* 2017; Katzung & Vanderah, 2020), antibiotic resistance (Jamshed *et al.,* 2014; Lubwama *et al.,* 2021), and antibiotic stewardship (World Health Organization, 2019; Park *et al.,* 2021; World Health Organization, 2021). It comprised close-ended questions with the options of "*agree*," "*do not agree*," or "*do not know*." The scales were dichotomised, with true and false answers scored 1 and 0, respectively. Similar to wrong answers, the "*do not know*" option was graded 0.

Item screening

Item screening involved four experts (pharmacists with experience in teaching antibiotic-related topics to pharmacy students) who checked the relevance of the items. This process focused on establishing the content validity of the AKAQ items and entailed the exclusion of some questions that did not meet the predetermined criteria. The content validity of the AKAQ was assessed through the content validity index (CVI) approach. Excellent content validity should be composed of Item-CVI (I-CVI) to measure expert agreement on individual item's relevance, Scale-level CVI/Universal Agreement (S-CVI/UA) to gauge unanimous expert agreement on item relevance, and Scale-level CVI/Average (S-CVI/Ave), an average score indicating the degree of expert agreement on item relevance and appropriateness at the scale or questionnaire level, with threshold values of ≥0.78, ≥0.8, and ≥0.9, respectively (Shi *et al.,* 2012). The content of all the AKAQ items achieved the validity parameters. Finally, a questionnaire was constructed in Indonesian and comprised 29 items distributed over three domains, i.e. general knowledge (9 items), AMR (10 items), and antimicrobial stewardship (10 items) (Appendix A).

Pre-testing

The final stage of instrument development involved a pre-testing (face validity test) to examine the clarity of the items. Previous research suggested 30 people for pre-testing (Perneger *et al*., 2015). The AKAQ was distributed to 30 pharmacy students to confirm questionnaire readability and content before collecting data on a larger sample size. Questionnaire item correction and amendment were addressed according to their feedback. The latest version of the polished pre-testing question was utilised as the final questionnaire for validation (Appendix B).

Construct validity

The Rasch measurement analysis was used to investigate the AKAQ validity based on construct validity. This psychometric technique was developed to improve the precision of instrument (questionnaire) constructions, evaluate instrument quality, and investigate respondents' performances (Boone *et al*., 2014). The Rasch analysis accurately and precisely explained the difficulty level of an item (i.e. question), detected the suitability and interaction of items and persons (item-person maps), identified outliers (person misfit), and detected item bias (e.g., differential item functioning (DIF)) to ensure that all items consistently measure the same concept across different term (Boone, 2016; Sumintono & Widhiarso, 2014). Rasch measurement was based on the Joint Maximum Likelihood Estimation equations whereby the raw data were converted to interval data (logits)(Linacre, 1998; Bon, Fox & Lacey, 2020). Psychometric parameters of the AKAQ, which were assessed consisting of validity parameters (item and person fit, structural validity); reliability (person and item reliability, Cronbach's Alpha value; person and item separation); item-person interaction; and item bias using DIF based on term (see Table I).

Table I: Rasch measurement properties and assessment criteria

Rasch measurement	Acceptable range	Definition
Person and item fit analysis	The person and item fit were measured using infit and outfit mean-square (MNSQ) and z-standard (ZSTD). The acceptable range of infit and outfit MNSQ are 0.5–1.5 (Sumintono & Widhiarso, 2015; Bond *et al.,* 2020). The value of 1.6 is accepted if an item has a positive point measure correlation (PTMA) (Sumintono & Widhiarso, 2015; Bond *et al.,* 2020) Meanwhile, the acceptable range for infit and outfit of ZSTD is −2 to +2, even though this threshold can be ignored if the sample size is more than 200 (Azizan *et al.,* 2020)	Person fit analysis was used to determine the validity of the person-response relationship. It can help to identify participants with atypical response patterns (for example by selecting the same answer for all the items). Item fit analysis was conducted to see whether the items in the AKAQ instruments can measure the knowledge about antibiotics in pharmacy undergraduate students. The item should be improved or deleted if a particular item is a misfit. Item fit analysis was displayed on a bubble chart to show measures and fit values graphically.

Rasch measurement	Acceptable range	Definition
Structural validity (unidimensionality)	Raw variances of >30% (Linacre, 1998; Chou & Wang, 2020) Eigen values of <3 (Linacre, 2021)	Structural validity measurement aimed to ascertain whether all items collectively measure the same domain of knowledge trait. The parameters of unidimensionality were assessed to confirm the structural validity of the AKAQ. Unidimensionality was evaluated by raw variances explained by items and unexplained variances in first contrast or Eigen values.
Reliability	Person and item reliability of >0.67 (Fisher, 2007) Cronbach's alpha value of >0.6 (Taber, 2018)	Reliability is measured to indicate the reproducibility of the measure (Linacre, 2021), (Bond & Fox, 2013).
Separation coefficients for individual items and persons	Item separation value is expected as >3 (Linacre, 2021). Person separation values are 1.50 (acceptable), 2.00 (good), and 3.00 (excellent)(Duncan *et al.,* 2003; Canto-Cerdan *et al.,* 2021)	The separation coefficient was measured to explore how well the different items distinguish the participants' ability and how well the individual participants distinguish the items' difficulty levels. The higher the separation values, the better the separation.
Item-person interaction	Item-person interaction is displayed in the Wright map (see Fig. 2 in results) using the same linear scale (logit scale). It was assessed from a distance between the mean (M) value of items' difficulty and participants' ability. The closer the two values, the better, with a difference of 0 between the two values denoting a perfect match between the items' difficulty and participants' ability. A difference of 1> logit indicates a non-matching difficulty level between the question/item and the participants' ability (Cantó-Cerdán *et al.,* 2021)	Wright Map (Item-Person Correlation) is intended to explore how well the distribution of test items' difficulty concerning participants' knowledge levels.
Differential Item Functioning (DIF)	Negligible (|DIF | 0≥0.43 logits); Slight to Moderate (|DIF | ≥0.43 logits) and prob (|DIF| = 0 logits) ≤0.05 (2-sided); Moderate to Large (|DIF | ≥0.64 logits) and prob(|DIF| ≤0.43 logits) ≤0.05 (2-sided) (Zwick *et al.,* 1999)	DIF is conducted to check item bias based on the term in which we assume that students from different terms will have different scores on the AKAQ (Linacre, 2021). Term classification is divided into two groups, i.e. undergraduate pharmacy students in the first to fifth terms and sixth to twelfth terms, but undergraduate pharmacy education in Indonesia should be noted to have a standard study period of 4 years or 8 terms, while students above 8 terms are students who are late in completing their studies.

Statistical analysis

This study used Winsteps version 5.2.1.0 software (Linacre, 2022) and Statistical Package for the Social Sciences (SPSS) version 26 (IBM, 2019) for statistical analysis. Winsteps was used to perform Rasch analysis to check the validity and reliability of the AKAQ and to run a DIF analysis. The SPSS version 26 (IBM, 2019) was used to run the descriptive statistics of participants' characteristics.

Results

Data collection and screening

This study enrolled 500 participants from 90 Indonesian universities (Table II). Of the total sample, 85% were females, 59% were 20-23 years old, and 30.4% were in the fourth term. The majority (69.0%) were from universities in the western region of Indonesia, where most universities are located.

Table II: Demographics of participants (n=500)

Baseline characteristics	Frequency	%
Sex		
Female	425	85%
Male	75	15%
Age		
<20 years old	117	35.4%
20-23 years old	294	58.8%
>23 years old	29	5.8%
Term		
1st – 5th Term	282	56.4%
6th – 12th Term	218	43.6%
University participants		
West Region (69 Univ.)	345	69.0%
Central Region (20 Univ.)	126	25.2%
East Region (1 Univ.)	29	5.8%

AKAQ validity and reliability

The Person and Item Fit Parameters are summarised in Table III. Overall, the means of infit (weight) and outfit (unweight) mean square (MNSQ) for person fit measurements were acceptable, with values of 0.93 and 1.00, respectively. The means of infit and outfit z-standard (ZSTD) were acceptable, with values of 0.03 and 0.06, respectively. However, approximately 11% of participants (n = 56) were misfits (Appendix C) because their infit and outfit MNSQ were outside the acceptable range (lower threshold: 0.5, and upper threshold: 1.6 as long as the value of PTMA is positive) (Sumintono & Widhiarso, 2015; Bond *et al.,* 2020). Thus, the response pattern of those students could not be predicted well by the Rasch model. The misfit persons were excluded; hence, the MNSQ and ZSTD person values after exclusion were acceptable, with values of 0.95 and 1.02 and 0.11 and 0.08, respectively. Some persons were misfits based on the ZSTD threshold (n = 20). However, the number of samples is 444 (>200); therefore, this ZSTD threshold can be ignored (Azizan *et al.,* 2020).

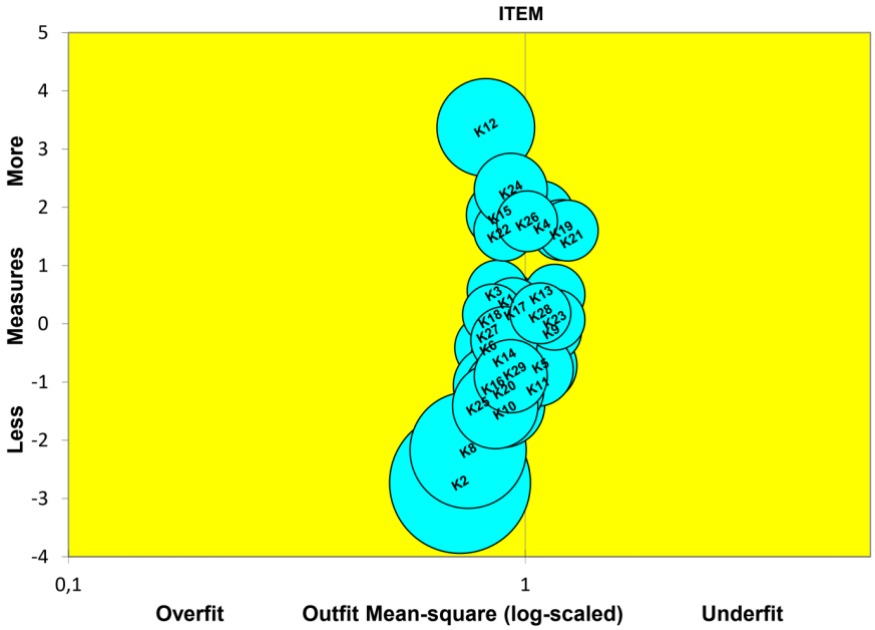
Table III: Summary of Rasch parameters for AKAQ

	Persons	Person (After deletion)	Item (question)	Item (After deletion K7)
N	500	444	29	28
Mean measure	0.78	0.75	0.00	0.16
SD	0.80	0.69	1.61	1.41
SE	0.04	0.04	0.31	0.27
Mean:				
Infit MNSQ	1.00 (Range: 0.43-1.69)	1.02 (Range: 0.61-1.69)	1.00 (Range:0.82-1.16)	1.01 (Range:0.89-1.16)
Infit ZSTD	0.03 (Range: -2,85-2.5)	0.11 (Range: -1.90-2.44)	0.09 (Range:-2.72-4.46)	0.11 (Range:-2.72-4.46)
Outfit MNSQ	0.93 (Range: 0.14- 2.73)	0.95 (Range: 0.50-1.58)	0.93 (Range: 0.17-1.24)	0.96 (Range:0.73-1.24)
Outfit ZSTD	0.06 (Range:-1.33-2.80)	0.08 (Range:-1.13-1.27)	-0.30 (Range:-2.55-2.85)	-0.23 (Range:-2.55-2.85)
Reliability (Rasch)	0.73	0.68	0.99	0.99
Reliability (Cronbach's Alpha)	0.71			
Separation coefficient	1.65	1.44	10.83	11.40
Unidimensionality				
Raw variance by measure	34.9%			
Unexplained variance in 1st contrast	2.84%			

*SD= Standard Deviation, SE= Standard error, MNSQ= mean-square, ZSTD= z-standard, K7= Knowledge Question no.7

The means of infit and outfit were 1.00 and 0.93 for MNSQ and -0.30 and 0.09 for ZSTD, respectively, for the item fit. However, one misfit item was identified based on the MNSQ outfit value (Appendix D), i.e. item K7 (MNSQ: 0.17; ZSTD: −2.18). Thus, this item was removed (Appendix E). The deletion of item K7 was able

to increase MNSQ and ZSTD outfits (Table III). Furthermore, ten misfit items were found (Appendix D) according to the range of ZSTD infit and outfit value (−2–2), but this threshold can be ignored because the sample size is >200 (Azizan *et al.,* 2020). The distribution of item fit orders for the 28 valid items is shown in Figure 1, while the initial item fit order involving item K7 is shown in Appendix E.



The Y axis is the Joint Maximum Likelihood Estimation (item) Measure; the X axis is the Item Fit Mean Square (Linacre, 2021); Overfit (x > 1.50); Outfit (x = 0.50–1.50). Each bubble represents an item whose size is proportional to the standard error of item difficulty calibration. Well-fitting items are close to the central vertical line. Items should preferably be the closest possible to a modelled value of 1 for infit and outfit MNSQ, regardless of plotting the interplay of fit and items and fit and persons (Bond *et al.,* 2020).

Figure 1: Bubble chart of item fit order

Construct validity (unidimensionality)

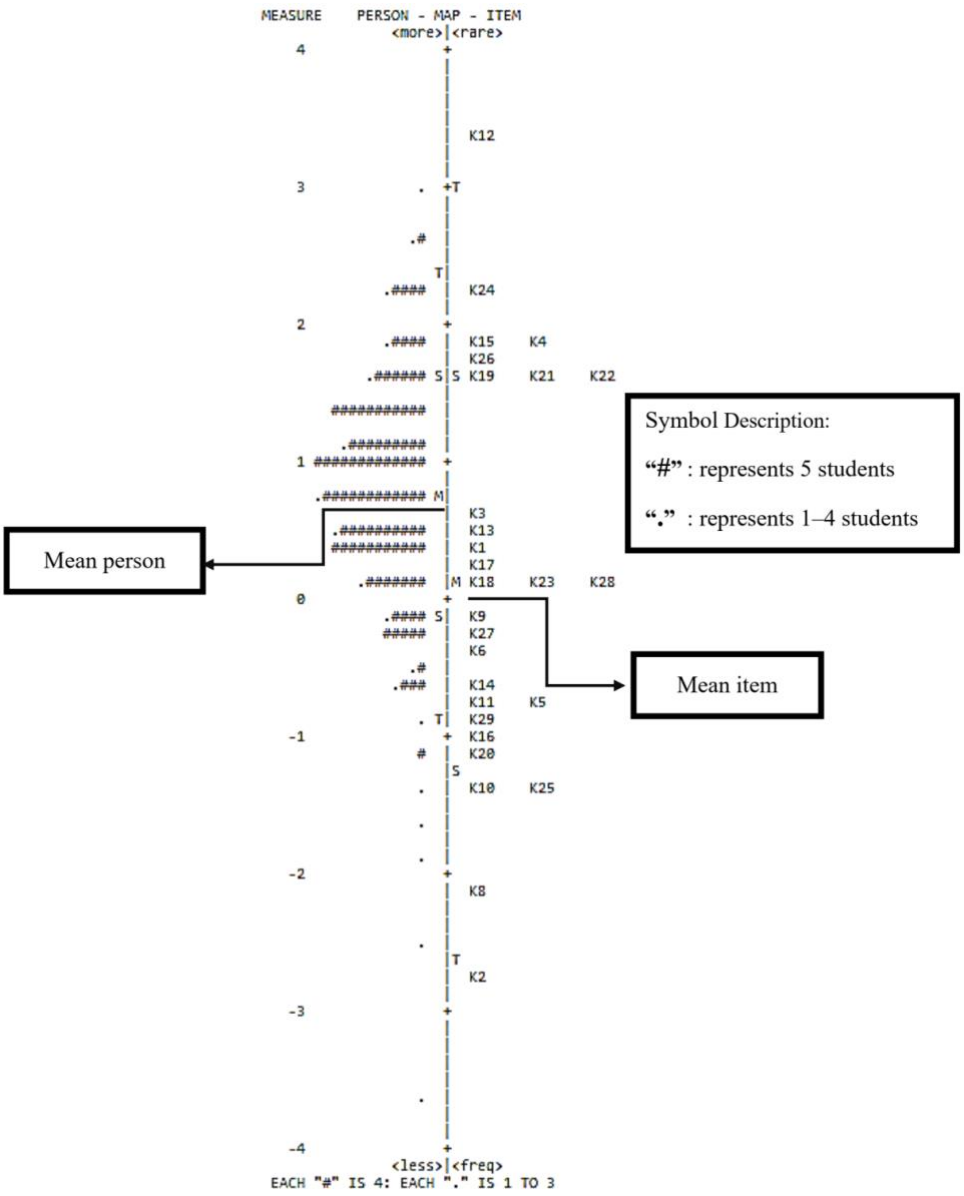
The structural validity of the AKAQ was further examined using unidimensionality. The results reached an acceptable threshold at >30% (Linacre, 1998; Chou & Wang, 2010) (33.4%), indicating that the instrument achieved the unidimensionality criteria. Moreover, the unexplained variance for the first contrasting values was <3% (2.71%). The unexplained variance confirms no random noise in the instrument used in this study.

Reliability

The Rasch parameter generated acceptable criteria for person and item reliabilities, i.e. 0.7 and 0.9, respectively. Additionally, Cronbach's alpha was above the acceptable threshold, i.e. 0.6 (Taber, 2018) (Table III). Overall, the AKAQ exhibited acceptable criteria for the Rasch reliability parameter (Fisher, 2007; Taber, 2018). Moreover, the person and item separations were acceptable, i.e. 1.44 and 20.08, respectively. These values supported the idea of the AKAQ reliability (Wright & Master, 1982; Boone, 2016).

Item-person interaction

The item-person Wright map (Figure 2) was used to check whether the items in the AKAQ were neither too challenging nor too easy for the participants. In this study, the participants' indicators were located higher than the items' indicators, reflecting that pharmacy students had a higher ability than the difficulty level of the test items (Linacre, 2021). However, the difference between the mean person measure and the mean items measure was <1 logit (0.51 logits), which indicates that the difficulty level of the question/item remained suitable with the participants' ability (Linacre, 1998; Linacre, 2021). Hence, item K2 (Bacterial infections can be treated with antibiotics) was identified as the easiest item and item 12 (Beta-lactamases are enzymes produced by bacteria that break open the beta-lactam ring) was the hardest item (Boone, 2016).



The right-hand side shows the 28 items of the questionnaire from the easiest (K2, bottom indicator) to the most difficult one (K12, top indicator); the left-hand side locates the person's ability measured along with the items. The higher the symbol, the better the test results. M in the right- and left-hand sides indicate the mean item difficulty and the mean person ability, respectively (Canto Cerdan *et al*., 2021).

Figure 2: Wright map (Item-Person Correlation)

Moreover, the Wright map shows that students have >50% chance (p = 0.5) of correctly answering an item when their indicator is above the item's indicator. The 50% chance (p = 0.5) occurs when the indicators align, indicating comparable difficulty levels between the item and students' ability. Conversely, students have <50% (p < 0.5) chance to correctly answer the item if the person's indicator is located the item's indicator.

Differential Item Functioning (DIF) analysis

DIF analysis by term (Figure 3) indicated that items K6 (DIF:0.79; Prob:0.0045) and K19 (DIF: −0.67; Prob: 0.0198) fell into the moderate to large DIF category (Zwick *et al.,* 1999) (Appendix F). Items K6 and K19 were found to be easier for students in the first to the fifth terms compared to those in the sixth to the twelfth terms. However, these items were not removed because they are relevant for assessing antibiotic-related knowledge, supported by the content and construct validity results. Moreover, dropping these items might lower the reliability and validity of the AKAQ (Zwick *et al.,* 1999; Gothwal *et al.,* 2009).

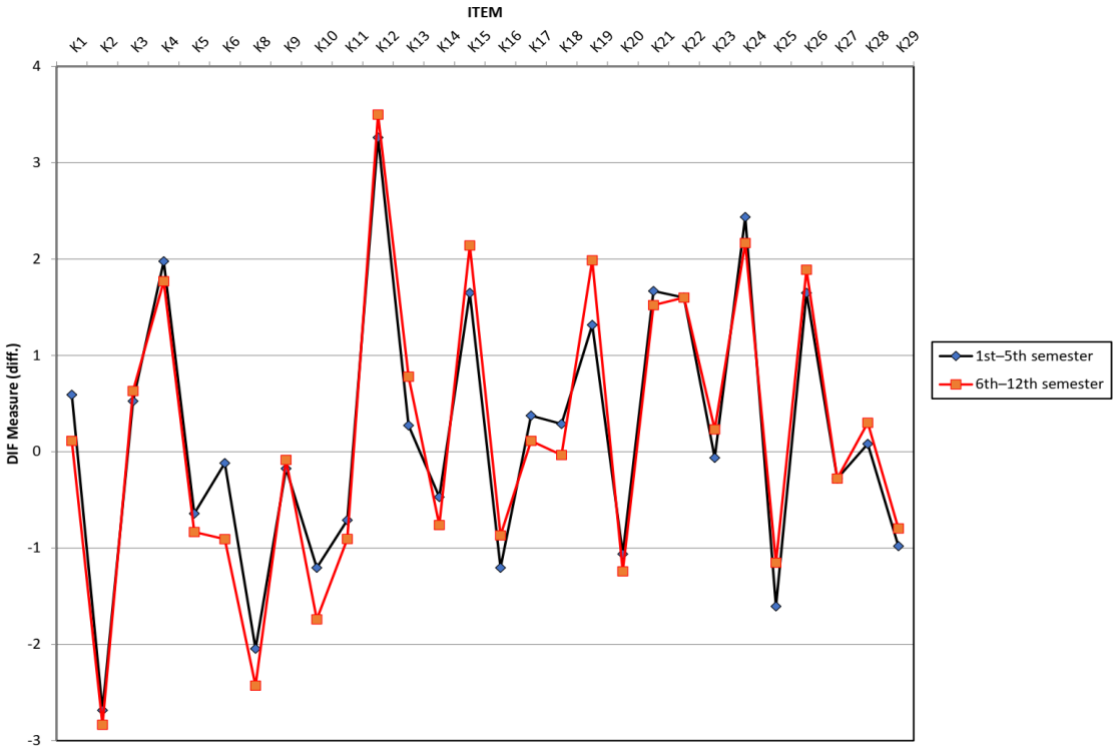


Figure 3: DIF based on the term

Discussion

This study is the first to develop AKAQ using the Rasch measurement model as a psychometric analysis. Rasch analysis is different from item response theory, which is a scale characterised by a positive correlation between the ability of respondents and the probability of respondents favouring more challenging items (Streiner & Norman, 2008). Rasch measurement can solve several problems in assessing misconceptions that cannot be resolved based on classical test theory, such as detecting the difficulty level of an item accurately and precisely, determining the misfit of items and persons, and identifying DIF items (Boone *et al.,* 2014; Adams *et al.,* 2020).

Linacre (Linacre, 1998; Linacre, 2021) established ideal ranges for infit and outfit MNSQ and ZSTD scores to minimise the inclusion of misfitting items (questions) and persons. AKAQ was analysed using Rasch analysis, and the results show that these questionnaires have a good model fit for the 28 items and 447 persons in the final tool based on MNSQ and ZSTD scores. However, this study revealed 56 persons with misfit MNSQ values (Appendix B) but positive point measure correlations (PTMEA Corr). Examination of the PTMEA Corr detects polarity items intended to examine whether or not the items in AKAQ measure the same dimension. A zero or negative value indicates a conflict with the variable or construct for the item response or respondent (Linacre, 2021). Items with positive PTMEA (+) values show that the item measuring the construct can distinguish between the ability of the respondents (Bond *et al.,* 2020). However, the persons with misfit values were excluded because those do not bring efficiency to building measurements of the questionnaire (Linacre, 1998; Wright & Stone, 1998).

Identifying and excluding misfitting items and persons in the AKAQ were crucial steps in refining the questionnaire. Linacre (Linacre, 1998; Linacre, 2021) established ideal ranges for infit and outfit MNSQ and ZSTD scores to minimise the inclusion of misfitting items (questions) and persons.

The decision to exclude specific items was based on rigorous analysis, considering both statistical indicators and practical implications. One item misfit (K7) was found based on outfit MNSQ value. K7 item (amoxicillin is an antibiotic) had the lowest difficulty level (Appendix F), yielding a 99.0% percentage of correct answers. Therefore, it was excluded due to its consistently high correct response rates, indicating a lack of variability among respondents. Retaining such items would compromise the measurement of antibiotic knowledge, as they fail to effectively differentiate between respondents with varying knowledge levels. The rationale underlying the removal

of specific items was guided by the principles of measurement efficiency and construct validity. Items with misfitting values were considered inefficient in enhancing AKAQ's accuracy. The goal was to ensure that the remaining items collectively formed a questionnaire with optimal fit validity and internal consistency, meeting psychometric standards. After exclusion, the AKAQ demonstrated improved utility, providing a more robust and efficient assessment of antibiotic knowledge. Reliability test results indicated that the questionnaire had acceptable to high internal consistency, as set by the National Quality Forum's Measure Evaluation Criteria (National Quality Forum, 2021).

The AKAQ is expected to achieve the unidimensionality criteria. The unidimensionality result confirms that all items in AKAQ measure one-dimensional antibiotic knowledge, including general knowledge of antibiotics, AMR and AMS. All unidimensionality parameters confirming the construct validity of the AKAQ achieved an acceptable threshold (Linacre, 1998; Brentani & Silvia, 2007; Linacre, 2021).

The item-person analysis indicates that all items could measure student abilities in antibiotic-related knowledge, spanning from low to high proficiency. The construction of the items, from the easiest at the bottom to the hardest at the top of the Wright map, enables a proper evaluation to capture the range of student abilities (Linacre, 1998; Linacre, 2021). The item about the ability of beta-lactamase enzyme to destroy the beta-lactam ring was the most challenging item to answer by pharmacy students, and similar findings have been reported in previous studies from the United Kingdom (Inácio *et al.,* 2017) and Pakistan (Hayat *et al.,* 2021). The question related to the mechanism of antibiotic resistance was difficult for pharmacy students to adequately answer, probably because of the inadequate education in the pharmacy curriculum, especially for students in the first part of the curriculum (first to fifth terms) than in the second part of the curriculum (sixth to twelfth terms). The least complicated item in the AKAQ (after excluding K7) was the statement about whether bacterial infections could be cured with antibiotics (K2). This finding is supported by previous studies from the United Kingdom (Inácio *et al.,* 2017) and Sri Lanka (Zawahir *et al.,* 2017), where the item related to the efficacy of antibiotics in treating bacterial infection was also correctly answered by more than 95% of the sample.

Furthermore, the DIF analysis revealed that only two of the 28 items were biased based on terms (Appendix F). DIF items were found only in K6 and K19 because these items are easier for students in the sixth to twelfth terms compared to those in the first to fifth terms. No other DIF items could explain the difference between pre-final and final-year students. The results from China (Huang *et al.,* 2013) support these findings that pre-final year students had more knowledge than students in early-year terms, likely due to their updated knowledge of pharmacology (including antibiotic courses), which they have completed in the past year. However, these items were still retained to analyse the psychometric properties of the developed test because all questionnaire items were valid and reliable.

The application of Rasch analysis in developing the AKAQ holds multifaceted significance for antibiotic knowledge assessment. Rasch analysis elevates the precision of knowledge measurement by identifying and excluding misfitting items and respondents through meticulous examination of MNSQ and ZSTD values. The fit values of MNSQ and ZSTD verify that the questionnaire achieves the validity criteria, indicating that AKAQ items measure antibiotic knowledge as a target construct appropriately based on Rasch parameters. Therefore, confirming MNSQ and ZSTD values means ensuring the effectiveness and precision of the AKAQ questionnaire.

The rigorous validation process, guided by Linacre's criteria, yields a questionnaire with strong fit validity and high internal consistency, meeting the Measure Evaluation Criteria of the National Quality Forum (NQF), establishing the AKAQ as a psychometrically robust tool for assessing antibiotic knowledge. Confirmation of unidimensionality criteria validates that all items measure a single dimension, i.e. antibiotic knowledge, strengthening questionnaire construct validity.

The present study demonstrates AKAQ's efficacy in measuring students' abilities across a spectrum of antibiotic-related knowledge, providing a comprehensive evaluation from fundamental concepts to more specific knowledge items. Beyond methodological contributions, the Rasch-validated AKAQ holds practical implications globally, allowing educators to customise pharmacy school curricula, ensuring the instrument is relevant and impactful in enhancing antibiotic knowledge education.

Limitations

This study has some limitations. First, pharmacy education in Indonesia is diverse, with no standardised curricula, inducing potential bias that may influence the external validity of results. Moreover, the AKAQ included items covering basic antibiotic knowledge, aligning with the intention to assess a broad spectrum of knowledge applicable to students in the first part of their curriculum. Therefore, while this study provides valuable insights into antibiotic knowledge among

Indonesian undergraduate pharmacy students, caution should be exercised when extrapolating the findings to different educational contexts. Data were self-reported by participants who were voluntarily recruited via WhatsApp, introducing the possibility of selection bias. Additionally, the dominance of students from some universities in the sample may impact the study's external validity. Social media recruitment channels such as WhatsApp might attract specific demographics, potentially influencing the level of antibiotic knowledge reported. Further studies are recommended to validate the questionnaire among global student populations and different educational levels. Additionally, the study only performed a DIF analysis to understand the difference based on terms; thus, further DIF analysis would be warranted to compare gender differences.

Conclusion

The AKAQ was successfully developed and validated to assess knowledge about antibiotics in undergraduate pharmacy students in Indonesia. The AKAQ achieved adequate fit validity and reliability criteria using the Rasch analysis, affirming its psychometric robustness. Rasch analysis provides a valuable tool for evaluating AKAQ's psychometric aspect and adds to existing methods. The instrument shows promise in facilitating targeted educational interventions and advancing antibiotic stewardship initiatives. Further research is required to determine the instrument's applicability across diverse pharmacy students worldwide and educational levels.

List of abbreviations

AKAQ: antibiotic knowledge assessment questionnaire
MNSQ: mean-square
ZSTD: z-standard
DIF: differential item functioning
AMR: antimicrobial resistance
CVI: content validity index
UA: universal agreement
AMS: antimicrobial stewardship
JMLE: joint maximum likelihood estimation
IRT: item response theory
CTT: classical test theory
PTMEA Corr: positive point measure correlations
K: knowledge item

Conflict of interest

The authors declare no conflict of interest.

Authors' Contributions

IYK, and MAB; methodology, formal analysis, software: IYK, MAB, and SS; ethics and data collection: DAN and RP, investigation: IYK, MAB, MM and RB; data curation and validation: MM and RB; writing—original draft preparation: IYK, MAB, MM and RB; writing—review and editing: MM, RB, DC; and funding acquisition: DC. All authors have read and approved the final version of the manuscript.

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Appendix A: Content Validity Index (CVI) of the 29-items draft AKAQ from 4 experts

Variable construct	Panel 1		Panel 2		Panel 3		Panel 4		Expert in agreements	I-CVI Score	S-CVI score
	n	Code	n	Code	n	Code	n	Code			
K1	4	1	4	1	4	1	4	1	4	1.00	1
K2	4	1	4	1	4	1	3	1	4	1.00	1
K3	4	1	4	1	4	1	3	1	4	1.00	1
K4	4	1	4	1	4	1	4	1	4	1.00	1
K5	4	1	3	1	4	1	4	1	4	1.00	1
K6	4	1	4	1	4	1	4	1	4	1.00	1
K7	4	1	4	1	4	1	4	1	4	1.00	1
K8	4	1	4	1	4	1	4	1	4	1.00	1
K9	3	1	4	1	4	1	3	1	4	1.00	1
K10	4	1	4	1	4	1	3	1	4	1.00	1
K11	4	1	4	1	4	1	4	1	4	1.00	1
K12	3	1	3	1	4	1	4	1	4	1.00	1
K13	4	1	4	1	4	1	3	1	4	1.00	1
K14	4	1	4	1	4	1	3	1	4	1.00	1
K15	4	1	4	1	4	1	4	1	4	1.00	1
K16	4	1	4	1	4	1	4	1	4	1.00	1
K17	4	1	4	1	4	1	3	1	4	1.00	1
K18	4	1	4	1	4	1	4	1	4	1.00	1
K19	4	1	4	1	4	1	4	1	4	1.00	1
K20	4	1	3	1	4	1	4	1	4	1.00	1
K21	4	1	4	1	4	1	4	1	4	1.00	1
K22	4	1	4	1	4	1	4	1	4	1.00	1
K23	4	1	4	1	4	1	4	1	4	1.00	1
K24	4	1	4	1	4	1	4	1	4	1.00	1
K25	4	1	4	1	4	1	4	1	4	1.00	1
K26	4	1	4	1	4	1	4	1	4	1.00	1
K27	3	1	4	1	4	1	4	1	4	1.00	1
K28	4	1	4	1	4	1	4	1	4	1.00	1
K29	4	1	4	1	4	1	4	1	4	1.00	1
Mean			1.00		1.00		1.00	1.00	Summary	30.00	30.00
Average proportion of items judged as relevance (4 experts): 1.00									Average	1.00	1.00
									Conclusion	Acceptable	Acceptable

*I-CVI, item level content validity index; S-CVI, scale level content validity index

Appendix B: All items of AKAQ and percentage of answers by category response

Item	Questions	Correct answer
GENERAL KNOWLEDGE OF ANTIBIOTICS		
K1	Antibiotics are useful for viral infections	41.2%
K2	Bacterial infections can be treated with antibiotics	95.6%
K3	Antibiotics can be used to cure colds	45.0%
K4	Pain and inflammation can be treated with antibiotics	71.8%
K5	Antibiotics can cause allergic reactions	78.8%
K6	Aspirin is an antibiotic	26.0%
K7	Amoxicillin is an antibiotics	99.0%
K8	Antibiotics must be obtained with a doctor's prescription	93.0%
K9	All antibiotics must be taken before eating	30.8%
ANTIBIOTICS RESISTANCE		
K10	Resistance occurs when bacteria lose its sensitivity to antibiotics	87.0%
K11	Bacteria can alter membrane permeability and cause resistance	79.6%
K12	Beta-lactamases are enzymes produced by bacteria that break open the beta-lactam ring	9.2%
K13	Prescribing broad-spectrum antibiotics increases antibiotics resistance	56.6%
K14	Independent use of antibiotics can increase antibiotic resistance	76.8%
K15	The use of narrow-spectrum antibiotics is more at risk of causing resistance than broad-spectrum antibiotics	71.6%
K16	Sensitivity tests and bacterial culture tests are able to minimize resistance and determine the appropriate antibiotic	83.4%
K17	Antibiotics can be used independently if you have already used the same antibiotic	38.6%
K18	Antibiotics can be used by other people with the same symptoms	36.4%
K19	Bacteria that are resistant to antibiotics can be passed from one person to another	33.2%
ANTIBIOTIC STEWARDSHIP		
K20	Antibiotic stewardships an effort to optimize the use of antibiotics in patients	84.2%
K21	Antibiotics are overused Nationally and Internationally in healthcare	33.4%
K22	The sale of narrow-spectrum antibiotics without a prescription is a form of antibiotic stewardship	66.6%
K23	Rapid diagnostic tests enable more accurate diagnosis, specific antibiotic treatment and decrease antibiotic resistance	65.4%
K24	The use of combinations of antibiotics with the same spectrum reduces resistance	78.8%
K25	The study of the consumption of antibiotics and the manufacture of formularies is a preventive measure against the occurrence of antibiotic resistance	87.2%
K26	Stopping the use of antibiotics for livestock does not prevent antibiotic resistance	69.6%
K27	Antibiotic stewardship will reduce antibiotic resistance	71.8%
K28	Antibiotic stewardship improve cost-effectiveness in the health care sector	63.2%
K29	Antibiotic stewardship improve collaboration between health care providers	81.4%

*K, knowledge item

Appendix C: Person fit measurement

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
1	29	12	1,1624	0,8712	2,7278	2,8027	0,3753	0,445
2	29	17	1,4523	1,9415	1,8227	1,4418	0,2737	0,4946
3	29	18	1,0393	0,251	1,8149	1,3418	0,4547	0,4128
4	29	24	1,1135	0,4511	1,8034	1,0518	0,3282	0,3481
5	29	16	1,2479	1,2012	1,7456	1,4217	0,3689	0,4629
6	29	14	1,543	2,4915	1,7004	1,4517	0,2481	0,5182
7	29	12	1,2671	1,3513	1,692	1,4317	0,3584	0,4646
8	29	25	1,1418	0,5011	1,6544	0,8917	0,2757	0,3268
9	29	17	1,4722	2,0115	1,6504	1,2117	0,2835	0,498
10	29	22	1,6393	2,1016	1,65	0,9717	0,1708	0,4673
11	29	13	1,3457	1,7013	1,6398	1,3616	0,3281	0,4824
12	29	22	1,5429	1,8315	1,6281	0,9516	0,1995	0,4533
13	29	22	1,5538	1,8616	1,626	0,9516	0,2023	0,455
14	29	15	1,0358	0,251	1,6103	1,2716	0,4762	0,424
15	29	16	1,1341	0,7011	1,6077	1,2216	0,4265	0,4412
16	29	14	1,5252	2,4215	1,6063	1,3016	0,2709	0,5152
17	29	14	1,4106	1,9614	1,5843	1,2616	0,3108	0,4954
18	29	13	1,4157	2,0014	1,5837	1,2716	0,3153	0,4948
19	29	16	1,1914	0,9512	1,5827	1,1816	0,4116	0,4523
20	29	19	1,2266	0,9912	1,5798	0,9916	0,3578	0,4404
21	29	20	1,0424	0,251	1,5744	0,9316	0,452	0,397
22	29	11	1,4055	1,8914	1,5722	1,1916	0,3123	0,4831
23	29	15	1,2182	1,1012	1,5689	1,2116	0,395	0,4598
24	29	16	1,1371	0,7111	1,563	1,1516	0,4321	0,4418
25	29	24	1,5351	1,5715	1,5527	0,8416	0,1725	0,4087
26	29	19	1,4203	1,6814	1,5526	0,9616	0,297	0,474
27	29	20	1,2624	1,0813	1,5449	0,9015	0,341	0,4368
28	29	17	0,969	-0,079	1,542	1,0615	0,5029	0,404
29	29	20	1,6898	2,4417	1,5395	0,8915	0,1915	0,5054
30	29	24	1,1369	0,5211	1,5253	0,8215	0,3235	0,3517
31	29	20	0,9288	-0,2191	1,5247	0,8815	0,4948	0,3747
32	29	20	1,3748	1,4714	1,5121	0,8615	0,3066	0,4559
33	29	15	1,5221	2,3615	1,5058	1,1115	0,2764	0,514
34	29	20	1,3813	1,4914	1,4905	0,8415	0,3095	0,4569
35	29	15	1,1392	0,7411	1,4839	1,0715	0,4332	0,4447
36	29	18	1,3968	1,6714	1,4797	0,9215	0,3146	0,4785
37	29	18	1,1566	0,7512	1,4763	0,9215	0,417	0,4354
38	29	19	1,4258	1,7014	1,4664	0,8615	0,3025	0,4749
39	29	15	1,1638	0,8612	1,4663	1,0415	0,4279	0,4494
40	29	17	0,8645	-0,5991	1,4597	0,9415	0,5498	0,3816
41	29	24	1,3884	1,2014	1,4453	0,7414	0,2398	0,3887
42	29	17	1,4689	2,0015	1,4428	0,9214	0,2999	0,4974
43	29	17	1,0952	0,5111	1,4334	0,9014	0,4422	0,4295
44	29	18	1,2514	1,1213	1,4311	0,8614	0,3803	0,4529
45	29	4	1,359	0,9114	1,4256	0,7114	0,2872	0,3405
46	29	22	1,1725	0,7012	1,4188	0,7414	0,3596	0,3952
47	29	9	1,3643	1,5414	1,4164	0,8514	0,3405	0,4557
48	29	19	1,2876	1,2113	1,4141	0,7914	0,3551	0,4513
49	29	12	1,2021	1,0512	1,4123	0,9614	0,4053	0,4525
50	29	18	1,1987	0,9212	1,4098	0,8314	0,4014	0,4433
51	29	15	1,5007	2,2715	1,4085	0,9414	0,2986	0,5103
52	29	17	1,3907	1,7114	1,3994	0,8514	0,3325	0,484
53	29	22	1,377	1,3514	1,3988	0,7214	0,2831	0,4283
54	29	19	0,9688	-0,059	1,3929	0,7614	0,4954	0,3914
55	29	22	1,1292	0,5511	1,3863	0,7114	0,3886	0,3878
56	29	19	1,4001	1,6114	1,3857	0,7514	0,3182	0,4706
57	29	13	1,2687	1,3713	1,3797	0,9214	0,3901	0,4684
58	29	17	1,072	0,4011	1,3796	0,8214	0,4643	0,4249
59	29	13	1,2692	1,3713	1,371	0,9014	0,3864	0,4685
60	29	22	1,2977	1,1113	1,3697	0,6914	0,3162	0,4158
61	29	17	1,4635	1,9815	1,3684	0,8014	0,3107	0,4965

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
62	29	8	0,91	-0,2991	1,3679	0,7414	0,515	0,3602
63	29	17	1,4694	2,0015	1,3664	0,8014	0,3094	0,4975
64	29	21	1,2612	1,0413	1,3636	0,6814	0,3566	0,4245
65	29	15	1,2605	1,2913	1,3631	0,8614	0,3918	0,4677
66	29	18	1,3788	1,6014	1,3555	0,7514	0,335	0,4754
67	29	20	1,2476	1,0312	1,3533	0,6914	0,365	0,4343
68	29	19	1,2335	1,0112	1,351	0,7114	0,3831	0,4417
69	29	18	1,3851	1,6214	1,3494	0,7413	0,335	0,4765
70	29	16	1,4068	1,8414	1,3464	0,8013	0,3364	0,4914
71	29	18	1,438	1,8114	1,3239	0,7013	0,32	0,4855
72	29	18	1,438	1,8114	1,3239	0,7013	0,32	0,4855
73	29	17	1,076	0,4211	1,3207	0,7313	0,4647	0,4257
74	29	24	1,1517	0,5612	1,3144	0,6213	0,3308	0,354
75	29	11	1,1285	0,6911	1,313	0,7613	0,4422	0,4329
76	29	19	1,1367	0,6411	1,3126	0,6613	0,4192	0,424
77	29	15	1,0503	0,3211	1,3121	0,7713	0,4886	0,4269
78	29	19	1,0877	0,4411	1,3061	0,6513	0,4428	0,4148
79	29	19	1,3417	1,4113	1,3057	0,6513	0,3533	0,4607
80	29	19	1,3197	1,3313	1,2997	0,6413	0,3561	0,4569
81	29	11	1,1611	0,8412	1,2932	0,7313	0,4316	0,4391
82	29	21	1,3533	1,3414	1,2915	0,6013	0,3231	0,4397
83	29	18	1,3328	1,4313	1,2883	0,6513	0,3631	0,4674
84	29	21	1,3412	1,3013	1,2878	0,6013	0,3271	0,4378
85	29	19	1,1957	0,8712	1,284	0,6213	0,4061	0,4349
86	29	23	0,8479	-0,4592	1,2821	0,5913	0,487	0,3216
87	29	24	1,0884	0,3811	1,2812	0,5913	0,3548	0,3442
88	29	24	1,2333	0,7912	1,279	0,5813	0,31	0,3663
89	29	19	1,2366	1,0312	1,2676	0,6013	0,392	0,4422
90	29	21	1,1357	0,6011	1,2675	0,5813	0,4097	0,4028
91	29	19	1,2998	1,2613	1,2617	0,5913	0,3685	0,4534
92	29	11	1,3178	1,5313	1,2601	0,6713	0,3788	0,4678
93	29	21	1,2091	0,8612	1,2591	0,5713	0,3766	0,4156
94	29	15	0,9601	-0,139	1,2585	0,6713	0,5266	0,4082
95	29	15	1,1858	0,9612	1,2578	0,6713	0,4318	0,4537
96	29	20	1,1304	0,6011	1,2574	0,5713	0,4222	0,4134
97	29	16	1,3395	1,5713	1,2565	0,6513	0,372	0,4795
98	29	20	1,0895	0,4411	1,2542	0,5713	0,4307	0,4058
99	29	11	1,1715	0,8912	1,2528	0,6513	0,4304	0,4411
100	29	14	1,3018	1,5013	1,2516	0,6713	0,3897	0,476
101	29	18	0,9673	-0,079	1,2514	0,6013	0,5132	0,3982
102	29	22	0,98	0,011	1,242	0,5512	0,4564	0,3613
103	29	21	1,3462	1,3213	1,2413	0,5512	0,3285	0,4386
104	29	20	1,201	0,8612	1,2407	0,5512	0,3951	0,4261
105	29	9	1,1374	0,6711	1,2396	0,5912	0,44	0,4161
106	29	19	1,22	0,9612	1,2367	0,5612	0,3992	0,4393
107	29	18	1,1066	0,5411	1,2303	0,5712	0,4582	0,4259
108	29	16	1,329	1,5313	1,2257	0,5912	0,3805	0,4777
109	29	12	1,0633	0,3911	1,225	0,6212	0,4891	0,4256
110	29	23	1,2299	0,8412	1,2216	0,5312	0,336	0,3873
111	29	16	1,3179	1,4913	1,2143	0,5712	0,3853	0,4757
112	29	20	0,9983	0,071	1,2121	0,5212	0,4738	0,3885
113	29	19	1,0835	0,4311	1,2111	0,5212	0,4521	0,414
114	29	16	1,0983	0,5411	1,2025	0,5512	0,4716	0,4342
115	29	19	1,2424	1,0512	1,2019	0,5112	0,3966	0,4433
116	29	17	1,0198	0,161	1,1955	0,5312	0,5014	0,4145
117	29	10	1,3517	1,6014	1,1933	0,5312	0,3667	0,4651
118	29	7	1,0607	0,3111	1,1878	0,4912	0,4566	0,3729
119	29	17	1,1952	0,9412	1,1878	0,5112	0,4282	0,4487
120	29	17	1,1952	0,9412	1,1878	0,5112	0,4282	0,4487
121	29	17	1,1952	0,9412	1,1878	0,5112	0,4282	0,4487
122	29	13	1,1819	0,9712	1,1835	0,5412	0,4405	0,4521
123	29	16	1,2614	1,2513	1,1804	0,5112	0,4097	0,4654
124	29	13	1,274	1,3913	1,1797	0,5312	0,4108	0,4694

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
125	29	15	1,1525	0,8012	1,1791	0,5212	0,4526	0,4473
126	29	11	1,0123	0,131	1,1774	0,5112	0,4977	0,41
127	29	9	1,0604	0,3411	1,1733	0,4812	0,4748	0,4018
128	29	17	1,2328	1,0912	1,173	0,4912	0,4165	0,4557
129	29	13	0,9992	0,061	1,1609	0,4912	0,5124	0,4157
130	29	13	1,149	0,8111	1,1581	0,4912	0,4547	0,4458
131	29	16	1,2723	1,3013	1,1565	0,4712	0,4092	0,4674
132	29	14	1,0915	0,5311	1,1553	0,4812	0,4761	0,4358
133	29	11	1,091	0,5111	1,1535	0,4712	0,4765	0,4256
134	29	23	1,0127	0,141	1,1514	0,4512	0,4295	0,3514
135	29	22	0,9946	0,071	1,1507	0,4412	0,4517	0,364
136	29	11	1,1629	0,8512	1,1505	0,4612	0,4458	0,4394
137	29	20	0,8512	-0,5691	1,1443	0,4311	0,5332	0,3587
138	29	22	1,255	0,9713	1,1432	0,4311	0,3519	0,4089
139	29	22	1,255	0,9713	1,1432	0,4311	0,3519	0,4089
140	29	16	1,2217	1,0812	1,1396	0,4411	0,4284	0,458
141	29	16	1,2268	1,1112	1,1393	0,4411	0,4278	0,4589
142	29	11	1,1466	0,7811	1,1388	0,4411	0,4529	0,4363
143	29	20	1,0816	0,4111	1,1343	0,4211	0,456	0,4044
144	29	20	1,2798	1,1413	1,1318	0,4111	0,3812	0,4398
145	29	19	1,1373	0,6411	1,1276	0,4011	0,4461	0,4241
146	29	12	1,0608	0,3711	1,1237	0,4111	0,4883	0,4251
147	29	22	1,101	0,4511	1,1217	0,4111	0,4131	0,383
148	29	19	1,2384	1,0312	1,1176	0,3911	0,4104	0,4426
149	29	13	1,134	0,7411	1,1104	0,3911	0,4656	0,4429
150	29	14	1,2101	1,0912	1,1086	0,3811	0,4417	0,4589
151	29	21	1,1472	0,6411	1,1033	0,3911	0,4128	0,4049
152	29	19	1,1715	0,7812	1,1027	0,3711	0,4333	0,4304
153	29	18	1,2451	1,1012	1,1008	0,3611	0,4161	0,4518
154	29	20	1,2438	1,0112	1,096	0,3711	0,3998	0,4336
155	29	16	1,1403	0,7311	1,0927	0,3511	0,4631	0,4425
156	29	18	1,1204	0,6011	1,0917	0,3511	0,4593	0,4286
157	29	13	1,2136	1,1212	1,0892	0,3411	0,4409	0,4582
158	29	15	1,18	0,9312	1,0874	0,3411	0,4529	0,4526
159	29	20	1,1284	0,5911	1,076	0,3411	0,4423	0,413
160	29	13	1,1441	0,7911	1,0757	0,3111	0,4694	0,4448
161	29	19	1,0179	0,151	1,0734	0,3211	0,4923	0,4012
162	29	18	1,035	0,231	1,0733	0,3211	0,4937	0,4119
163	29	22	1,3596	1,3014	1,0722	0,3511	0,3292	0,4256
164	29	20	0,9934	0,051	1,0688	0,3311	0,4876	0,3875
165	29	20	1,2746	1,1213	1,0682	0,3311	0,3927	0,439
166	29	16	1,2089	1,0312	1,0624	0,2911	0,4442	0,4556
167	29	23	1,1815	0,6912	1,061	0,3411	0,3704	0,3796
168	29	22	1,2411	0,9312	1,0561	0,3311	0,3722	0,4066
169	29	16	1,0727	0,4211	1,0553	0,2711	0,4927	0,4291
170	29	14	1,0934	0,5411	1,0498	0,261	0,4898	0,4362
171	29	18	1,0445	0,271	1,0461	0,271	0,4935	0,4138
172	29	24	1,0906	0,3811	1,0403	0,331	0,374	0,3445
173	29	15	0,9863	0,001	1,0379	0,231	0,5309	0,4137
174	29	18	1,1639	0,7812	1,0316	0,251	0,4545	0,4368
175	29	21	1,0784	0,3911	1,0309	0,291	0,4472	0,3925
176	29	16	1,1678	0,8512	1,0291	0,221	0,4629	0,4478
177	29	21	1,1094	0,5011	1,0289	0,291	0,4369	0,3981
178	29	14	1,0775	0,4611	1,0239	0,201	0,5003	0,433
179	29	16	1,1453	0,7511	1,022	0,211	0,4715	0,4434
180	29	21	1,0469	0,271	1,0201	0,281	0,4604	0,3868
181	29	15	1,1155	0,6311	1,0199	0,201	0,4839	0,44
182	29	21	1,1235	0,5511	1,0191	0,281	0,4338	0,4007
183	29	20	1,0495	0,281	1,0167	0,261	0,4765	0,3983
184	29	14	1,1516	0,8212	1,0149	0,181	0,4734	0,4477
185	29	16	1,076	0,4311	1,0146	0,191	0,4952	0,4298
186	29	25	1,2328	0,7212	1,0143	0,341	0,3071	0,3396
187	29	18	0,8765	-0,5091	1,0136	0,211	0,5662	0,379

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
188	29	15	1,0674	0,4011	1,0089	0,171	0,5019	0,4304
189	29	19	0,8836	-0,4491	1,0084	0,221	0,5469	0,3738
190	29	16	1,1024	0,5511	1,0046	0,171	0,4893	0,435
191	29	8	1,3483	1,3713	1,0032	0,211	0,384	0,4385
192	29	24	0,8646	-0,3491	1,0015	0,291	0,466	0,3067
193	29	17	1,0745	0,4111	1,0013	0,181	0,4939	0,4254
194	29	17	1,0828	0,4511	1,0011	0,181	0,4929	0,4271
195	29	16	1,0912	0,5011	1,0008	0,161	0,4933	0,4328
196	29	19	1,1555	0,7212	0,9957	0,201	0,4526	0,4275
197	29	18	1,1157	0,5811	0,9957	0,181	0,4743	0,4277
198	29	19	1,0531	0,3011	0,9956	0,201	0,4876	0,4081
199	29	23	1,0157	0,151	0,9929	0,251	0,4397	0,3519
200	29	9	0,8609	-0,5791	0,9901	0,171	0,5679	0,362
201	29	17	1,0778	0,4311	0,9899	0,161	0,4963	0,4261
202	29	17	1,0597	0,3511	0,986	0,151	0,5024	0,4225
203	29	17	1,1155	0,5911	0,9856	0,151	0,4821	0,4335
204	29	21	1,151	0,6512	0,9844	0,231	0,4284	0,4055
205	29	14	1,0643	0,3911	0,984	0,111	0,5074	0,4304
206	29	19	1,2222	0,9712	0,9786	0,181	0,4341	0,4397
207	29	16	1,0284	0,211	0,9717	0,101	0,52	0,4202
208	29	21	0,8948	-0,3491	0,97	0,211	0,522	0,3576
209	29	17	1,0534	0,3211	0,9677	0,111	0,5075	0,4212
210	29	21	1,0754	0,3711	0,9674	0,211	0,4554	0,392
211	29	14	1,0895	0,5211	0,9632	0,061	0,5018	0,4354
212	29	20	1,0303	0,201	0,9626	0,181	0,4904	0,3946
213	29	15	0,8633	-0,6591	0,9575	0,061	0,5838	0,3871
214	29	18	1,0693	0,3811	0,9527	0,111	0,4958	0,4187
215	29	19	1,1079	0,5311	0,9509	0,131	0,4749	0,4186
216	29	20	1,1564	0,6912	0,9509	0,171	0,4494	0,4181
217	29	16	1,0919	0,5111	0,9503	0,061	0,5001	0,433
218	29	23	0,9458	-0,0991	0,9463	0,1909	0,4596	0,3396
219	29	19	1,0156	0,141	0,9452	0,1209	0,5064	0,4008
220	29	17	0,9622	-0,109	0,9443	0,0709	0,541	0,4026
221	29	16	1,0109	0,121	0,9384	0,0309	0,5291	0,4166
222	29	18	1,0919	0,4811	0,9333	0,0709	0,4912	0,4231
223	29	22	1,1486	0,6211	0,9309	0,1609	0,4173	0,3912
224	29	25	1,1033	0,4011	0,9292	0,2509	0,3411	0,3212
225	29	19	1,1104	0,5411	0,9263	0,0909	0,4782	0,4191
226	29	18	1,0612	0,3411	0,9255	0,0609	0,5025	0,4171
227	29	18	0,9623	-0,099	0,9243	0,0609	0,5351	0,3972
228	29	24	1,1141	0,4511	0,9232	0,1909	0,3788	0,3482
229	29	17	1,0822	0,4511	0,9225	0,0209	0,5025	0,427
230	29	15	1,0216	0,171	0,9218	-0,0191	0,5298	0,4211
231	29	23	0,9426	-0,1091	0,9209	0,1609	0,4701	0,339
232	29	21	1,1059	0,4911	0,9193	0,1509	0,4536	0,3975
233	29	15	1,0275	0,201	0,9189	-0,0291	0,5292	0,4223
234	29	18	1,0619	0,3511	0,9187	0,0509	0,503	0,4172
235	29	24	1,2493	0,8412	0,9173	0,1809	0,3356	0,3687
236	29	21	1,0099	0,121	0,9075	0,1309	0,4874	0,3799
237	29	13	1,0012	0,071	0,9059	-0,0691	0,5391	0,4161
238	29	17	1,0356	0,241	0,9036	-0,0191	0,5216	0,4177
239	29	14	0,9941	0,031	0,9014	-0,0791	0,5437	0,4159
240	29	22	1,1531	0,6312	0,9007	0,1209	0,4207	0,3919
241	29	14	1,0484	0,311	0,8992	-0,0891	0,5254	0,4271
242	29	11	0,915	-0,3791	0,8985	-0,0691	0,5663	0,3898
243	29	15	1,0751	0,4411	0,8958	-0,0791	0,5167	0,432
244	29	13	0,9673	-0,109	0,8921	-0,1091	0,5542	0,409
245	29	22	1,0084	0,121	0,8894	0,1009	0,474	0,3665
246	29	18	0,993	0,041	0,8892	-0,0091	0,5318	0,4035
247	29	16	0,956	-0,149	0,8876	-0,0791	0,5546	0,4051
248	29	20	1,0852	0,4211	0,8863	0,0709	0,4792	0,405
249	29	17	1,0282	0,201	0,8834	-0,0591	0,5262	0,4162
250	29	20	0,9744	-0,029	0,883	0,0609	0,5159	0,3838

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
251	29	22	0,885	-0,3591	0,8827	0,0909	0,5181	0,3434
252	29	19	1,0185	0,161	0,8798	0,0109	0,5138	0,4013
253	29	21	1,0713	0,3611	0,8794	0,0909	0,4705	0,3912
254	29	17	0,9811	-0,019	0,8696	-0,0891	0,5444	0,4065
255	29	16	0,9688	-0,089	0,8656	-0,1291	0,553	0,4078
256	29	23	0,9287	-0,1591	0,8651	0,0809	0,4854	0,3365
257	29	15	0,9411	-0,2391	0,8615	-0,1591	0,5652	0,4042
258	29	16	0,9417	-0,2191	0,8591	-0,1391	0,5638	0,4021
259	29	11	1,1298	0,7011	0,8585	-0,1591	0,4964	0,4331
260	29	19	0,9756	-0,029	0,8539	-0,0291	0,5329	0,3928
261	29	16	0,9076	-0,3991	0,8536	-0,1491	0,5777	0,3947
262	29	15	0,8963	-0,4791	0,8497	-0,1892	0,5832	0,3944
263	29	16	0,9781	-0,039	0,8496	-0,1592	0,5527	0,4098
264	29	18	1,0304	0,211	0,8494	-0,0892	0,5242	0,411
265	29	16	0,9698	-0,079	0,849	-0,1592	0,5555	0,408
266	29	21	0,8422	-0,5692	0,8418	0,0308	0,557	0,3469
267	29	20	1,1169	0,5511	0,8402	0,0008	0,4771	0,4109
268	29	18	0,9788	-0,019	0,8399	-0,0992	0,5423	0,4006
269	29	16	0,9641	-0,109	0,8397	-0,1892	0,5587	0,4068
270	29	13	1,0557	0,3511	0,8394	-0,2392	0,5302	0,4273
271	29	21	0,9711	-0,029	0,8348	0,0208	0,5108	0,3725
272	29	21	0,9862	0,031	0,8343	0,0208	0,5029	0,3754
273	29	24	1,0635	0,3011	0,8323	0,0808	0,4053	0,3402
274	29	20	0,9351	-0,1891	0,832	-0,0192	0,5366	0,376
275	29	17	0,9137	-0,3491	0,8298	-0,1692	0,5721	0,3923
276	29	24	1,0021	0,111	0,8289	0,0708	0,4242	0,3302
277	29	2	1,4408	0,8214	0,8263	0,3408	0,2899	0,2599
278	29	19	1,1006	0,5011	0,8232	-0,0892	0,4978	0,4172
279	29	15	0,908	-0,4191	0,823	-0,2592	0,5827	0,397
280	29	22	1,0212	0,171	0,8224	0,0008	0,4736	0,3688
281	29	17	0,9598	-0,119	0,8213	-0,1892	0,5582	0,4021
282	29	26	0,9529	0,031	0,817	0,2208	0,361	0,2686
283	29	14	0,9535	-0,179	0,8164	-0,2892	0,5694	0,4073
284	29	21	0,9397	-0,1591	0,8152	0,0008	0,5236	0,3664
285	29	14	0,933	-0,2891	0,811	-0,3092	0,5766	0,4029
286	29	13	0,915	-0,3991	0,8102	-0,3092	0,5826	0,3978
287	29	17	0,9218	-0,3091	0,8094	-0,2092	0,573	0,394
288	29	13	0,9941	0,031	0,8079	-0,3192	0,5549	0,4147
289	29	22	0,9698	-0,029	0,8056	-0,0192	0,4938	0,3594
290	29	15	0,9052	-0,4291	0,8039	-0,2992	0,5859	0,3964
291	29	17	0,8586	-0,6291	0,8034	-0,2292	0,5959	0,3803
292	29	19	0,9248	-0,2591	0,8031	-0,1192	0,5572	0,3825
293	29	22	1,0505	0,2711	0,8001	-0,0292	0,4681	0,3741
294	29	21	0,8507	-0,5391	0,7991	-0,0292	0,557	0,3486
295	29	16	0,9527	-0,169	0,7968	-0,2892	0,569	0,4044
296	29	21	0,9046	-0,2991	0,7954	-0,0292	0,5374	0,3595
297	29	15	0,9201	-0,3491	0,7949	-0,3292	0,5824	0,3996
298	29	12	1,0078	0,101	0,7937	-0,3392	0,5498	0,4143
299	29	6	0,9348	-0,1091	0,7933	-0,0092	0,5212	0,3317
300	29	13	0,8774	-0,6091	0,7927	-0,3592	0,5977	0,3896
301	29	22	1,0328	0,211	0,7898	-0,0392	0,4767	0,3709
302	29	14	0,8569	-0,7191	0,7895	-0,3592	0,607	0,3861
303	29	18	0,9871	0,021	0,7892	-0,2092	0,5482	0,4023
304	29	14	0,8816	-0,5791	0,7889	-0,3592	0,5978	0,3917
305	29	16	0,9079	-0,3991	0,7827	-0,3192	0,5859	0,3948
306	29	16	0,8291	-0,8192	0,7823	-0,3192	0,6144	0,3773
307	29	19	1,0122	0,131	0,7812	-0,1592	0,5319	0,4001
308	29	19	0,9195	-0,2791	0,7769	-0,1692	0,5623	0,3813
309	29	13	0,863	-0,6891	0,7752	-0,4092	0,6049	0,3864
310	29	17	0,9076	-0,3791	0,7733	-0,2892	0,5831	0,391
311	29	19	1,0082	0,111	0,7707	-0,1792	0,5348	0,3993
312	29	18	0,9331	-0,2291	0,7669	-0,2492	0,5684	0,3911
313	29	22	1,0463	0,261	0,7631	-0,0892	0,4752	0,3733

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
314	29	17	0,7922	-0,9792	0,7593	-0,3292	0,6244	0,3653
315	29	13	0,8387	-0,8392	0,7578	-0,4492	0,6154	0,3809
316	29	17	0,8785	-0,5291	0,7569	-0,3292	0,5948	0,3847
317	29	17	0,9148	-0,3391	0,7552	-0,3392	0,5835	0,3925
318	29	11	0,9732	-0,069	0,7551	-0,4092	0,5628	0,402
319	29	23	0,8252	-0,5492	0,7548	-0,0792	0,5295	0,3172
320	29	18	0,9491	-0,1591	0,7537	-0,2792	0,5657	0,3944
321	29	25	1,1194	0,4411	0,7532	0,0408	0,3684	0,3236
322	29	16	0,8093	-0,9292	0,7516	-0,3992	0,6235	0,3727
323	29	19	0,9155	-0,2991	0,7508	-0,2192	0,567	0,3805
324	29	18	0,8898	-0,4391	0,749	-0,2893	0,5856	0,3819
325	29	18	0,8306	-0,7392	0,7477	-0,2893	0,6053	0,369
326	29	21	0,9615	-0,069	0,7468	-0,1093	0,5247	0,3707
327	29	20	0,8738	-0,4591	0,7465	-0,1593	0,5694	0,3634
328	29	16	0,8971	-0,4591	0,7462	-0,4093	0,5952	0,3924
329	29	23	1,0096	0,131	0,7451	-0,0893	0,467	0,3509
330	29	22	0,9692	-0,029	0,741	-0,1193	0,5022	0,3593
331	29	18	0,9325	-0,2391	0,7393	-0,3093	0,5733	0,391
332	29	11	0,7869	-1,0992	0,7378	-0,4593	0,6291	0,3615
333	29	17	0,8852	-0,4891	0,736	-0,3793	0,5959	0,3861
334	29	17	0,9063	-0,3791	0,7336	-0,3893	0,5895	0,3907
335	29	17	0,9063	-0,3791	0,7336	-0,3893	0,5895	0,3907
336	29	14	0,7334	-1,4693	0,7322	-0,5193	0,6577	0,3572
337	29	15	0,8995	-0,4591	0,7318	-0,4893	0,599	0,3951
338	29	13	0,9164	-0,3891	0,7272	-0,5393	0,5932	0,3981
339	29	18	0,9138	-0,3291	0,7265	-0,3393	0,5812	0,387
340	29	20	0,9667	-0,059	0,7243	-0,1993	0,5425	0,3823
341	29	24	1,0503	0,2611	0,722	-0,0793	0,4286	0,3381
342	29	16	0,848	-0,7192	0,7206	-0,4693	0,615	0,3815
343	29	21	1,0366	0,231	0,7204	-0,1493	0,506	0,3849
344	29	21	0,9396	-0,1591	0,72	-0,1493	0,5358	0,3664
345	29	12	0,8433	-0,7992	0,7199	-0,5393	0,6157	0,379
346	29	17	0,8529	-0,6591	0,7177	-0,4193	0,6092	0,379
347	29	21	0,9641	-0,059	0,7165	-0,1593	0,5284	0,3712
348	29	20	0,9531	-0,119	0,7143	-0,2093	0,5485	0,3796
349	29	4	0,9915	0,121	0,7139	0,0607	0,4812	0,2909
350	29	18	0,9068	-0,3591	0,7136	-0,3693	0,5857	0,3855
351	29	22	1,0533	0,2811	0,7136	-0,1693	0,4818	0,3746
352	29	18	0,8226	-0,7792	0,7135	-0,3693	0,6127	0,3672
353	29	18	0,8226	-0,7792	0,7135	-0,3693	0,6127	0,3672
354	29	15	0,8474	-0,7492	0,7118	-0,5393	0,6193	0,3835
355	29	22	0,7594	-0,8892	0,7076	-0,1793	0,5803	0,3181
356	29	21	0,9604	-0,069	0,7074	-0,1693	0,5312	0,3704
357	29	17	0,8572	-0,6391	0,7069	-0,4493	0,6094	0,38
358	29	23	0,9178	-0,1991	0,7066	-0,1493	0,5001	0,3345
359	29	18	0,7037	-1,4193	0,7058	-0,3793	0,6561	0,3396
360	29	21	0,8969	-0,3391	0,7051	-0,1793	0,5521	0,358
361	29	20	0,8568	-0,5391	0,7051	-0,2293	0,5806	0,3599
362	29	25	0,9126	-0,1291	0,7024	-0,0193	0,4372	0,2922
363	29	18	0,7815	-0,9892	0,702	-0,3893	0,6284	0,3579
364	29	19	0,894	-0,3991	0,701	-0,3193	0,5816	0,376
365	29	18	0,8724	-0,5291	0,6958	-0,3993	0,5993	0,3782
366	29	19	0,8805	-0,4591	0,6953	-0,3293	0,587	0,3732
367	29	17	0,8422	-0,7092	0,6881	-0,4893	0,6174	0,3766
368	29	21	0,9532	-0,099	0,6876	-0,2093	0,5363	0,3691
369	29	16	0,8255	-0,8392	0,6863	-0,5593	0,6275	0,3765
370	29	18	0,8198	-0,7892	0,6862	-0,4293	0,6174	0,3666
371	29	19	0,8844	-0,4391	0,6854	-0,3493	0,5872	0,374
372	29	19	0,8723	-0,4991	0,6853	-0,3493	0,5913	0,3714
373	29	18	0,8635	-0,5691	0,6828	-0,4293	0,6043	0,3762
374	29	18	0,8635	-0,5691	0,6828	-0,4293	0,6043	0,3762
375	29	24	0,8643	-0,3491	0,6788	-0,1393	0,4932	0,3067
376	29	15	0,8327	-0,8392	0,6774	-0,6393	0,6292	0,3802

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
377	29	19	0,7829	-0,9392	0,6763	-0,3693	0,6208	0,3519
378	29	21	0,8193	-0,6792	0,6754	-0,2293	0,5804	0,3422
379	29	16	0,8072	-0,9492	0,6726	-0,5993	0,636	0,3722
380	29	24	1,1274	0,4911	0,6659	-0,1593	0,4137	0,3503
381	29	20	0,8373	-0,6292	0,6649	-0,2993	0,5926	0,3558
382	29	15	0,8097	-0,9692	0,6648	-0,6693	0,6386	0,3749
383	29	23	0,9885	0,061	0,6641	-0,2193	0,4846	0,3472
384	29	18	0,7894	-0,9492	0,6631	-0,4793	0,6308	0,3597
385	29	18	0,7894	-0,9492	0,6631	-0,4793	0,6308	0,3597
386	29	14	0,7537	-1,3392	0,6616	-0,7193	0,6586	0,3622
387	29	24	0,8228	-0,4892	0,6572	-0,1793	0,5089	0,2992
388	29	21	0,8913	-0,3591	0,6545	-0,2593	0,5608	0,3569
389	29	18	0,7926	-0,9292	0,6534	-0,4993	0,6313	0,3605
390	29	14	0,7395	-1,4293	0,6531	-0,7393	0,6644	0,3587
391	29	19	0,8513	-0,5991	0,6505	-0,4193	0,6035	0,3669
392	29	23	0,9053	-0,2491	0,6486	-0,2494	0,5116	0,3322
393	29	16	0,8072	-0,9492	0,6423	-0,6794	0,6408	0,3723
394	29	19	0,7422	-1,1493	0,6396	-0,4394	0,6403	0,3426
395	29	20	0,8508	-0,5691	0,6394	-0,3494	0,5921	0,3586
396	29	16	0,7945	-1,0192	0,6363	-0,6994	0,6457	0,3693
397	29	20	0,8277	-0,6692	0,6349	-0,3594	0,6001	0,3537
398	29	16	0,7749	-1,1292	0,6337	-0,7094	0,6524	0,3647
399	29	16	0,7742	-1,1392	0,6323	-0,7094	0,6529	0,3646
400	29	12	0,8151	-0,9692	0,6316	-0,7994	0,6381	0,3726
401	29	18	0,7081	-1,3893	0,6307	-0,5494	0,6621	0,3407
402	29	15	0,7441	-1,3593	0,6298	-0,7794	0,6656	0,3594
403	29	20	0,8117	-0,7492	0,6294	-0,3694	0,6062	0,3503
404	29	20	0,8117	-0,7492	0,6294	-0,3694	0,6062	0,3503
405	29	16	0,7564	-1,2392	0,6291	-0,7194	0,6593	0,3604
406	29	15	0,733	-1,4293	0,6253	-0,7894	0,67	0,3567
407	29	15	0,7289	-1,4593	0,6248	-0,7894	0,6714	0,3557
408	29	20	0,8672	-0,4891	0,6241	-0,3794	0,5904	0,3621
409	29	17	0,7561	-1,1892	0,6231	-0,6594	0,6553	0,3569
410	29	16	0,7618	-1,2092	0,6216	-0,7394	0,6586	0,3616
411	29	19	0,8132	-0,7792	0,6215	-0,4794	0,6202	0,3586
412	29	21	0,8329	-0,6092	0,6213	-0,3194	0,5844	0,345
413	29	14	0,7522	-1,3492	0,6205	-0,8394	0,6646	0,3618
414	29	17	0,7884	-1,0092	0,6204	-0,6694	0,6457	0,3644
415	29	21	0,8684	-0,4591	0,6202	-0,3294	0,5739	0,3522
416	29	20	0,6852	-1,3793	0,6176	-0,3894	0,6497	0,3218
417	29	18	0,7427	-1,1993	0,6169	-0,5894	0,6529	0,3489
418	29	15	0,7783	-1,1592	0,6136	-0,8194	0,6571	0,3675
419	29	19	0,8071	-0,8092	0,6114	-0,4994	0,6239	0,3573
420	29	23	0,9247	-0,1691	0,6038	-0,3294	0,5134	0,3358
421	29	21	0,823	-0,6592	0,6004	-0,3594	0,5906	0,3429
422	29	18	0,6546	-1,7093	0,5979	-0,6294	0,6854	0,3276
423	29	16	0,7406	-1,3293	0,5973	-0,8094	0,6691	0,3566
424	29	22	0,8244	-0,6092	0,5965	-0,3694	0,57	0,3314
425	29	19	0,6072	-1,8994	0,5962	-0,5394	0,6917	0,3099
426	29	19	0,6072	-1,8994	0,5962	-0,5394	0,6917	0,3099
427	29	18	0,7392	-1,2193	0,5945	-0,6394	0,6577	0,3481
428	29	25	0,9519	-0,009	0,5944	-0,1694	0,4375	0,2984
429	29	20	0,7828	-0,8892	0,5928	-0,4394	0,6211	0,344
430	29	21	0,7873	-0,8192	0,5845	-0,3894	0,6047	0,3354
431	29	21	0,7821	-0,8492	0,5836	-0,3894	0,6064	0,3343
432	29	23	0,8528	-0,4491	0,5812	-0,3694	0,5405	0,3225
433	29	22	0,8096	-0,6692	0,5805	-0,3994	0,5775	0,3284
434	29	19	0,7334	-1,1893	0,5732	-0,5894	0,6527	0,3406
435	29	19	0,7006	-1,3693	0,5642	-0,6094	0,6645	0,3329
436	29	25	0,8878	-0,1991	0,5547	-0,2294	0,4631	0,2882
437	29	12	0,7087	-1,6293	0,5519	-1,0494	0,685	0,3474
438	29	21	0,7682	-0,9092	0,5487	-0,4595	0,6162	0,3313
439	29	20	0,7466	-1,0693	0,5455	-0,5395	0,6404	0,3359

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
440	29	23	0,7746	-0,7592	0,5421	-0,4395	0,5699	0,3073
441	29	23	0,7746	-0,7592	0,5421	-0,4395	0,5699	0,3073
442	29	18	0,6976	-1,4493	0,539	-0,7795	0,6802	0,3382
443	29	20	0,6832	-1,3893	0,539	-0,5495	0,6607	0,3214
444	29	13	0,6857	-1,7993	0,5354	-1,1295	0,6984	0,3444
445	29	19	0,6895	-1,4293	0,535	-0,6795	0,6728	0,3302
446	29	21	0,7313	-1,0893	0,5346	-0,4895	0,6296	0,3233
447	29	21	0,7596	-0,9492	0,5316	-0,4895	0,6218	0,3294
448	29	19	0,6949	-1,3993	0,5295	-0,6895	0,6722	0,3315
449	29	17	0,6453	-1,8494	0,5291	-0,9195	0,7056	0,3297
450	29	23	0,7684	-0,7892	0,5222	-0,4795	0,5747	0,3061
451	29	21	0,7283	-1,0993	0,5208	-0,5095	0,6331	0,3226
452	29	21	0,7198	-1,1393	0,5203	-0,5195	0,6356	0,3207
453	29	17	0,645	-1,8494	0,5185	-0,9495	0,7074	0,3296
454	29	21	0,7317	-1,0793	0,5156	-0,5295	0,633	0,3233
455	29	26	1,1577	0,4912	0,5149	-0,1295	0,3478	0,2961
456	29	21	0,7254	-1,1193	0,509	-0,5395	0,6361	0,3219
457	29	22	0,741	-0,9793	0,5074	-0,5395	0,6108	0,3142
458	29	22	0,7174	-1,0893	0,5045	-0,5495	0,6186	0,3091
459	29	24	0,822	-0,4992	0,5043	-0,4295	0,5294	0,2991
460	29	19	0,6591	-1,5993	0,5013	-0,7595	0,688	0,3229
461	29	21	0,7004	-1,2393	0,4996	-0,5595	0,6451	0,3164
462	29	18	0,6041	-2,0194	0,4989	-0,8895	0,7159	0,3147
463	29	22	0,7474	-0,9493	0,4985	-0,5595	0,61	0,3155
464	29	20	0,6445	-1,5994	0,4964	-0,6495	0,6796	0,3121
465	29	19	0,6499	-1,6494	0,4917	-0,7895	0,6926	0,3206
466	29	17	0,6189	-2,0194	0,4903	-1,0295	0,7203	0,3229
467	29	22	0,7076	-1,1293	0,4851	-0,5895	0,6247	0,307
468	29	21	0,7025	-1,2293	0,4832	-0,5895	0,6476	0,3168
469	29	14	0,6137	-2,2794	0,4813	-1,3095	0,7317	0,3268
470	29	24	0,7605	-0,7192	0,4718	-0,4995	0,5528	0,2877
471	29	19	0,5905	-1,9994	0,4706	-0,8395	0,714	0,3056
472	29	20	0,6294	-1,6894	0,4671	-0,7095	0,6893	0,3085
473	29	16	0,5906	-2,2994	0,4633	-1,2295	0,7389	0,3184
474	29	22	0,7135	-1,0993	0,4631	-0,6395	0,6267	0,3083
475	29	4	0,6808	-0,7193	0,463	-0,2695	0,6014	0,241
476	29	22	0,6814	-1,2593	0,4614	-0,6395	0,6364	0,3013
477	29	23	0,7145	-1,0093	0,4603	-0,6095	0,6005	0,2952
478	29	15	0,5817	-2,4494	0,4597	-1,3295	0,7449	0,3177
479	29	19	0,6093	-1,8894	0,4588	-0,8695	0,7107	0,3104
480	29	22	0,6659	-1,3293	0,4529	-0,6595	0,6424	0,2978
481	29	23	0,7363	-0,9193	0,4513	-0,6195	0,5959	0,2996
482	29	20	0,6026	-1,8394	0,4435	-0,7696	0,7015	0,3018
483	29	19	0,5485	-2,2695	0,4337	-0,9396	0,7333	0,2945
484	29	22	0,6537	-1,3893	0,4217	-0,7296	0,6517	0,2951
485	29	21	0,5826	-1,8594	0,4044	-0,7696	0,6972	0,2885
486	29	4	0,6544	-0,7993	0,3838	-0,3996	0,6204	0,2363
487	29	26	0,8213	-0,2892	0,3806	-0,3296	0,4606	0,2494
488	29	25	0,7652	-0,5892	0,3622	-0,5696	0,532	0,2675
489	29	24	0,6733	-1,0693	0,3495	-0,7597	0,6006	0,2707
490	29	25	0,7137	-0,7593	0,3437	-0,6097	0,5493	0,2584
491	29	2	1,237	0,5612	0,3374	-0,1697	0,4125	0,2408
492	29	24	0,6332	-1,2394	0,3288	-0,8097	0,6157	0,2625
493	29	27	0,7656	-0,2692	0,3272	-0,2297	0,4181	0,2051
494	29	26	0,7543	-0,4692	0,3248	-0,4197	0,4904	0,239
495	29	23	0,5557	-1,7694	0,3193	-0,9397	0,6724	0,2603
496	29	23	0,5543	-1,7694	0,3186	-0,9397	0,673	0,26
497	29	24	0,5934	-1,4094	0,308	-0,8597	0,6308	0,2541
498	29	25	0,6478	-0,9994	0,303	-0,6997	0,5756	0,2461
499	29	21	0,4251	-2,8496	0,2996	-1,0497	0,7626	0,2465
500	29	2	0,5021	-0,7595	0,1378	-0,5499	0,6014	0,1534

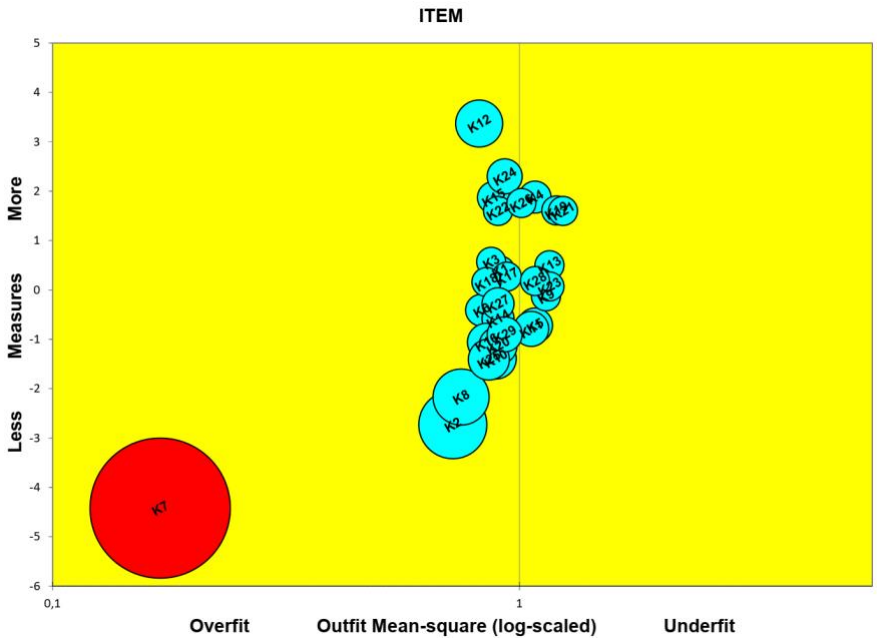
*MNSQ, mean-square; ZSTD, z-standard; PTMA, point measure correlation; RMSR, root-mean-square residual

Appendix D: Item fit measurement

ITEM	COUNT	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
K21	500	1,1638	3,8012	1,2445	2,8512	0,1619	0,4755
K19	500	1,1503	3,4912	1,1986	2,3312	0,1793	0,4721
K13	500	1,1529	4,4612	1,1593	2,8112	0,2149	0,4937
K23	500	1,1144	2,7411	1,1563	2,3812	0,2447	0,4664
K9	500	1,1034	2,2011	1,1448	1,9911	0,2528	0,4508
K28	500	1,0647	1,6811	1,0803	1,3311	0,3005	0,4619
K5	500	1,0362	0,561	1,0801	0,8111	0,3048	0,3881
K4	500	1,032	0,671	1,076	0,8111	0,282	0,4291
K11	500	1,0053	0,101	1,0617	0,6111	0,3313	0,3756
K26	500	1,0279	0,631	1,0112	0,161	0,3027	0,4369
K17	500	0,9612	-1,069	0,9373	-1,0891	0,4067	0,443
K24	500	0,9661	-0,519	0,9312	-0,5591	0,3308	0,3801
K29	500	0,9705	-0,379	0,9309	-0,5891	0,3763	0,3579
K1	500	0,9129	-2,6191	0,9087	-1,6791	0,4523	0,4363
K20	500	0,9644	-0,399	0,9042	-0,7291	0,3718	0,3348
K22	500	0,9299	-1,7391	0,9023	-1,2291	0,4082	0,4251
K27	500	0,946	-1,0791	0,8994	-1,3291	0,4189	0,4072
K14	500	0,9682	-0,509	0,8963	-1,1291	0,3947	0,3871
K10	500	0,9618	-0,359	0,8945	-0,6891	0,3655	0,3086
K15	500	0,9242	-1,5991	0,8848	-1,2291	0,4009	0,4068
K3	500	0,9201	-2,5491	0,8682	-2,5491	0,4538	0,4427
K25	500	0,9401	-0,5791	0,8596	-0,9291	0,3877	0,3031
K16	500	0,9432	-0,6791	0,8541	-1,2091	0,4043	0,3377
K18	500	0,8986	-2,7191	0,8531	-2,5391	0,4718	0,4234
K6	500	0,8963	-1,9591	0,8284	-2,1792	0,4665	0,3867
K12	500	1,0108	0,131	0,8185	-0,9492	0,2358	0,2812
K8	500	1,0622	0,4611	0,7538	-1,0992	0,3019	0,2464
K2	500	1,1571	0,8312	0,7245	-0,8993	0,2272	0,2072
K7	500	0,8134	-0,3392	0,1682	-2,1798	0,3391	0,0866

*K, knowledge item; MNSQ, mean-square; ZSTD, z-standard; PTMA, point measure correlation; RMSR, root-mean-square residual

Appendix E: Item Fit Order for all items in AKAQ with 29 items (including item K7)



Appendix F: Differential Item Functioning (DIF) by term

Name	DIF CONTRAST	JOIN S.E.	Mantel-Haenszel		Size	Active slices	Item number	DIF classification
			Chi-squ	Prob.	CUMLOR			
K1	.48	.20	35.676	.0589	.41	17	1	
K2	.15	.49	.0381	.8453	.25	17	2	
K3	-.11	.20	12.489	.2638	-.26	17	3	
K4	.21	.21	13.190	.2508	.26	17	4	
K5	.19	.24	15.371	.2150	.35	17	5	
K6	.79	.24	80.784	.0045	.75	17	6	moderate to large
K8	.38	.41	.5901	.4424	.46	17	8	
K9	-.09	.21	.1518	.6969	.10	17	9	
K10	.54	.31	17.219	.1894	.45	17	10	
K11	.20	.25	.6843	.4081	.24	17	11	
K12	-.24	.32	.8380	.3600	-.35	17	12	
K13	-.51	.20	23.627	.1243	-.32	17	13	
K14	.29	.24	12.883	.2564	.31	17	14	
K15	-.49	.21	71.371	.0076	-.67	17	15	
K16	-.34	.26	29.951	.0835	-.53	17	16	
K17	.26	.20	12.682	.2601	.26	17	17	
K18	.32	.21	.8260	.3634	.22	17	18	
K19	-.67	.21	54.267	.0198	-.50	17	19	moderate to large
K20	.18	.27	.1096	.7407	.14	17	20	
K21	.15	.20	.9444	.3312	.22	17	21	
K22	.00	.20	.0772	.7812	-.08	17	22	
K23	-.29	.20	.7477	.3872	-.20	17	23	
K24	.27	.23	10.753	.2997	.28	17	24	
K25	-.45	.29	30.927	.0786	-.61	17	25	
K26	-.24	.21	.9016	.3424	-.22	17	26	
K27	.00	.22	.1131	.7366	-.10	17	27	
K28	-.22	.20	.3108	.5772	-.13	17	28	
K29	-.18	.25	.5311	.4661	-.22	17	29	

*K, knowledge item; DIF, differential item functioning; DIF S.E., standard error of the differential item functioning; Chi-squ, chi-square; Prob., probability; CUMLOR, cumulative log-odds ratio in logits;