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Computerised adaptive method for assessing university undergraduates' mental well-being within an African context: An open-source set-up with Concerto ☆

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ABSTRACT

This research presents the development of a computerised adaptive testing system for assessing university undergraduates' mental health in an African setting. An item pool of 375 items that reflect eight sub-constructs of mental well-being (coping with normal stress of life, realising potential, studying effectively, social interaction, school-life balance, emotional stability, healthy living, and belief system) was developed. FastTest was used to pilot-test the item using a sample of 406 undergraduate students from South Africa and Nigeria. Each candidate was given 100 items utilising the linear on-the-fly test administration. Four hundred and seven responses were received which was subjected to psychometric analysis using the Samejima's Graded IRT model to calibrate the items. One hundred and seventy-five items resulted which was used to design the mental wellbeing adaptive scale for use within the university community at no cost to the student and institution.

1. Using concerto, the detailed inflow with an html embedded function is clearly explained.
2. The scale dynamically adjusts the difficulty/relevance of questions based on respondents' previous answers, thereby enhancing precision and reducing users test burden.
3. An adaptable, scalable, and culturally appropriate non-illness method for assessing students' mental wellbeing being an improvement on the linear form is presented.

Specifications table

Subject area:	Psychology
More specific subject area:	Psychological assessment
Name of your method:	A computerised adaptive method for assessment administration using Concerto
Name and reference of original method:	Harrison, C., Loe, B. S., Lis, P., & Sidey-Gibbons, C. (2020). Maximizing the potential of patient-reported assessments by using the open-source concerto platform with computerized adaptive testing and machine learning. *Journal of Medical Internet Research, 22*(10), e20950. https://doi.org/10.2196/20950
Resource availability:	The Concerto parameter table and simulation report are available at https://osf.io/24czv/ and https://osf.io/jr8w5

☆ **Related research article:** Not Applicable

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Background

Mental wellbeing assessment is the first step in ensuring that a person's mental health. Mental well-being is a critical component of overall health, particularly for university undergraduates who are academically independent [1] and often subjected to high levels of stress and mental health challenges [2,3]. Mental health and psychosocial support are necessary for the attainment of SDG goal 3 of ensuring healthy lives and promoting well-being for all as reported by 89 % of countries [4]. Mental well-being is a critical aspect of student life, significantly impacting academic performance and overall quality of life. However, traditional assessment tools often fall short in capturing the unique socio-cultural dynamics prevalent in African university settings. As such, universities that place a high priority on mental health create an environment that fosters holistic development and student achievement.

Mental health is an essential component of overall well-being, encompassing emotional, psychological, and social aspects of an individual's life [5]. Research on student well-being at the tertiary level is still in its infancy in Africa, despite the fact that well-being research has expanded rapidly over the past 20 years. There are re-occurring incidences of university undergraduate who committed suicide due to depression from academic challenges, among many others [6–12]. These incidences show an urgent for mental health interventions that can pick red flags at the earliest stages as these individuals led normal lives like their peers until their sudden death. This need informed this study which introduces a Computerised Adaptive Testing (CAT) approach to mental well-being assessment among university undergraduates named as Computerised Adaptive Mental Well-being Scale (MWB-Scale).

Method details

The Computerised Adaptive Mental MWB-Scale development process involved four main stages: item pool creation, pilot testing, calibration and deployment as informed by simulation results. The Computerised Adaptive Mental MWB-Scale was conceptualised using the World Health Organisation's definition of mental wellbeing as informed by an extensive literature review to understand the construct of mental wellbeing within the African context based on which the items in the survey was designed and developed by a transdisciplinary team of related experts and deployed trans-disciplinarily. This informed the generation of a context-appropriate and comprehensive item pool of 375 items reflecting eight sub-constructs of mental well-being, including coping with the normal stresses of life, realise potentials, studying productively, social interaction, school-life balance, emotional stability, healthy living and belief system developed using a four-point Likert Scale. The population for this study were students in higher institutions while the target population were students who experienced the lock down necessitated by the Covid-19 Pandemic. The cluster and convenience sampling technique as employed. These sampling techniques were regarded as the most appropriate considering that the link to the survey was shared through online channels. Using the link https://app.fasttestweb.com/testing/pr/20/2?rldbqn = 1, the items were administered using the FastTest web application [13]. Using this application, each participant was allotted unique test codes to ensure single entry and individuality of response. The item pool was subjected to pilot testing with a sample of university undergraduates in Nigeria and South Africa using the linear on-the-fly test administration procedure. Using this procedure, a hundred items was administered per candidate. Statistical analysis using the Samejima's Graded IRT model (SGRM-IRT) was employed to calibrate the items.

Method validation

Computerised Adaptive MWB-Scale was designed and published on Concerto which is an open-source platform created with the goal of providing a safe, adaptable, and user-friendly platform for developing assessments. By taking advantage of running on the Concerto an open-source platform [14], the Computerised Adaptive MWB-Scale has a user interface which communicates with back-end functionality, such as scoring, CAT, and/or machine learning algorithms, via R programming language functionalities. This is an advantage that Concerto brings as R programming has gained popularity among psychometricians due to its versatility and accessibility [15,16]. There are already over 15,000 free R packages available for statistical computing tasks such as psychometric analysis, adaptive testing, and machine learning [17]. The Computerised Adaptive MWB-Scale used both pre-written and developed R code on Concerto to administer computerised adaptive tests, with a user-uploaded item parameter table [18]. The Computerised Adaptive MWB-Scale on the Concerto platform was installed on Amazon cloud-based servers that comply with rigorous security demands. This installation was informed by the up to date installation guidance at the Concerto GitHub webpage [19].

Computerised adaptive MWB-Scale test flow

The Computerised Adaptive MWB-Scale was configured using the Computer Adaptive Test option. With this option, the next item algorithm will be used to determine next item. Leveraging on the free to use point-and-click interface based on which the test was designed with minimal prior programming skills. As such, Computerised Adaptive MWB-Scale was designed using generic templates on the Concerto platform which did not require building codes. The Computerised Adaptive MWB-Scale test flow is shown in Fig. 1.

The first stage of the Computerised Adaptive MWB-Scale is the showPage, which provides a detailed information on the development process, the population it suits and context of use. The page was setup using the launch starter dialog box using the direct input and editable HTML option as shown in Fig. 1a.

The second stage of the Computerised Adaptive MWB-Scale is the assessment node where the CAT algorithm is specified in terms of the item specification, stopping rule (based on minimum and maximum accuracy), CAT options (IRT Model, item selection criteria,

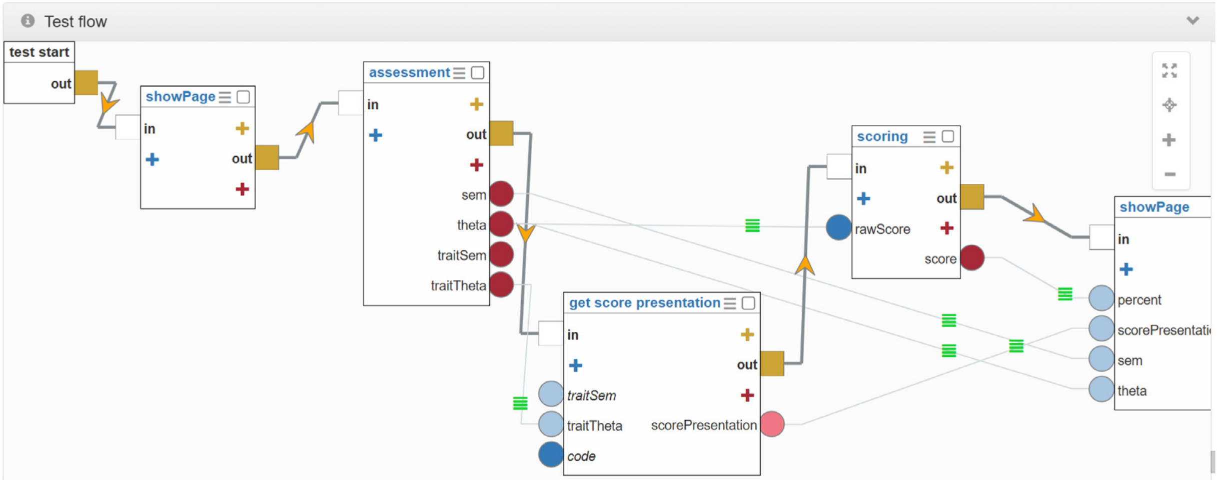
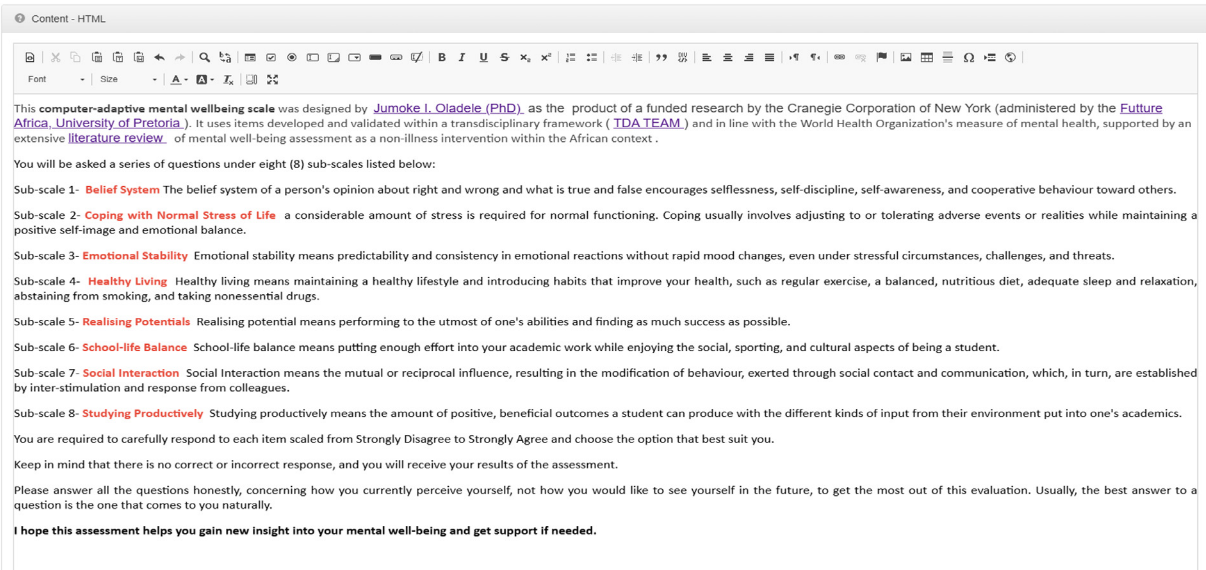


Fig. 1. Computerised Adaptive MWB-Scale Test Flow.


Content - HTML

Font Size

This **computer-adaptive mental wellbeing scale** was designed by Jumoke I. Oladele (PhD) as the product of a funded research by the Cranegie Corporation of New York (administered by the Futture Africa, University of Pretoria). It uses items developed and validated within a transdisciplinary framework (TDA TEAM) and in line with the World Health Organization's measure of mental health, supported by an extensive literature review of mental well-being assessment as a non-illness intervention within the African context .

You will be asked a series of questions under eight (8) sub-scales listed below:

Sub-scale 1- **Belief System** The belief system of a person's opinion about right and wrong and what is true and false encourages selflessness, self-discipline, self-awareness, and cooperative behaviour toward others.

Sub-scale 2- **Coping with Normal Stress of Life** a considerable amount of stress is required for normal functioning. Coping usually involves adjusting to or tolerating adverse events or realities while maintaining a positive self-image and emotional balance.

Sub-scale 3- **Emotional Stability** Emotional stability means predictability and consistency in emotional reactions without rapid mood changes, even under stressful circumstances, challenges, and threats.

Sub-scale 4- **Healthy Living** Healthy living means maintaining a healthy lifestyle and introducing habits that improve your health, such as regular exercise, a balanced, nutritious diet, adequate sleep and relaxation, abstaining from smoking, and taking nonessential drugs.

Sub-scale 5- **Realising Potentials** Realising potential means performing to the utmost of one's abilities and finding as much success as possible.

Sub-scale 6- **School-life Balance** School-life balance means putting enough effort into your academic work while enjoying the social, sporting, and cultural aspects of being a student.

Sub-scale 7- **Social Interaction** Social Interaction means the mutual or reciprocal influence, resulting in the modification of behaviour, exerted through social contact and communication, which, in turn, are established by inter-stimulation and response from colleagues.

Sub-scale 8- **Studying Productively** Studying productively means the amount of positive, beneficial outcomes a student can produce with the different kinds of input from their environment put into one's academics.

You are required to carefully respond to each item scaled from Strongly Disagree to Strongly Agree and choose the option that best suit you.

Keep in mind that there is no correct or incorrect response, and you will receive your results of the assessment.

Please answer all the questions honestly, concerning how you currently perceive yourself, not how you would like to see yourself in the future, to get the most out of this evaluation. Usually, the best answer to a question is the one that comes to you naturally.

I hope this assessment helps you gain new insight into your mental well-being and get support if needed.

Fig. 1a. Computerised Adaptive MWB-Scale Show Page HTML Function.

scoring method, the metric constant and content balancing), and Responses (requirements, bank and Theta/SEM options) as shown in Fig. 1bi to biv.

As shown in Fig. 1bi, the flat table item type was specified with the item bank embedded in a data table; and the response options column split into multiple columns. The test was ordered as CAT with the next item algorithm used to determine the next item. Also, customisable options for Item per page, item exposure and skipping items was specified.

As shown in Fig. 1bii, the stopping rules were specified to show unlimited items with the minimum accuracy of 0.5 and maximum accuracy of 3 as informed by a post-hoc simulation run. These figures were chosen in line with best practices when developing computerised adaptive tests [20,21].

As shown in Fig. 1biii, in the CAT option window, the polytomous Graded Response IRT Model was specified using the Maximum Fisher Information (MFI) item selection criteria which indicates the number of items to be chosen from the next item selection rule, among those the next item to be administered will be randomly picked up using the default value of 1. This value is the usual selection of the optimal item for the specified MFI criterion. Furthermore, the ability estimator of the Expected a posteriori (EAP) method and a $D = 1.7$ which yields approximately the normal metrix. These options were also informed by a simulation study which is in line with best practices when developing computerised adaptive tests [20,21]. The choice for EAP ability estimation method is further strengthened by studies which shows that the method has an unusually good properties for computerized adaptive testing being based on numerical evaluation of the mean and variance of the posterior distribution [22,23].

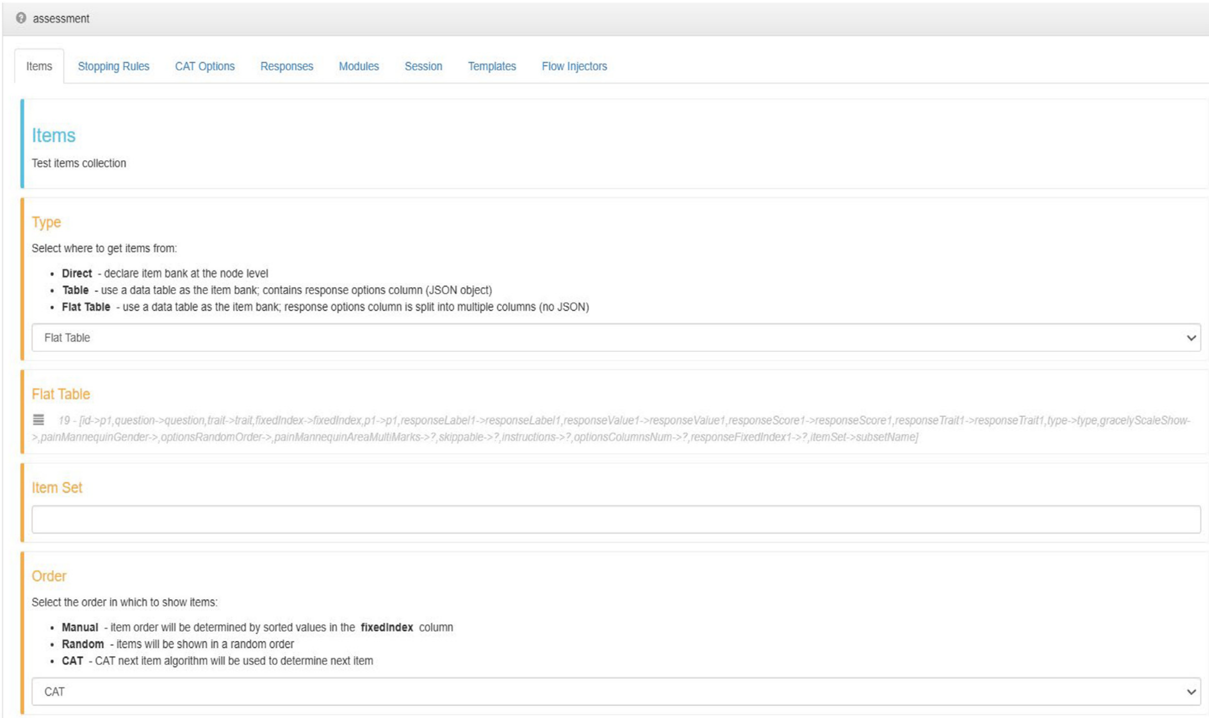


Fig. 1bi. Computerised Adaptive MWB-Scale Item Option.

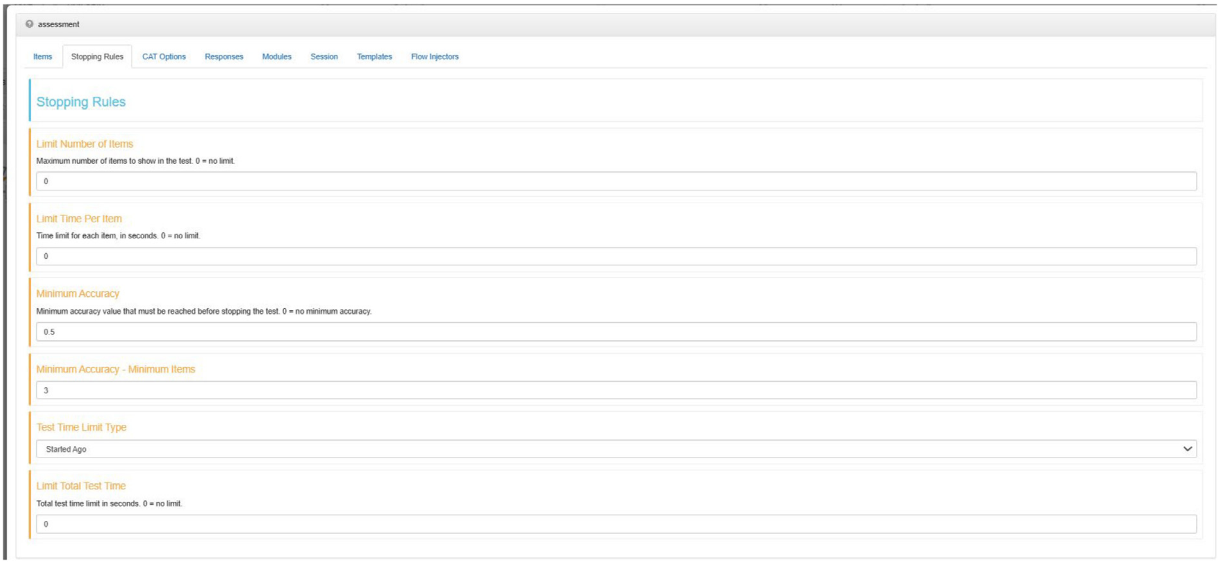


Fig. 1bii. Computerised Adaptive MWB-Scale Stopping Rule.

Fig. 1biv shows the response options requiring user to answer all items before proceeding to next page while calculating the theta and SEM values with the option for specifying the location to save item responses. Worthy of note is the embedded get score presentation option which was deployed using the R code function in Concerto. Through this, the researcher designed a tailor-fit response saving template. This is to aid data analysis for continued research on the designed Computerised Adaptive MWB-Scale.

As shown in Fig. 1c, the percentile scoring type was used which hinged on the normal distribution with a mean of 0 and standard deviation of 1. The choice of the Percentile ranks is appropriate as percentiles are routinely used for determining an individual's

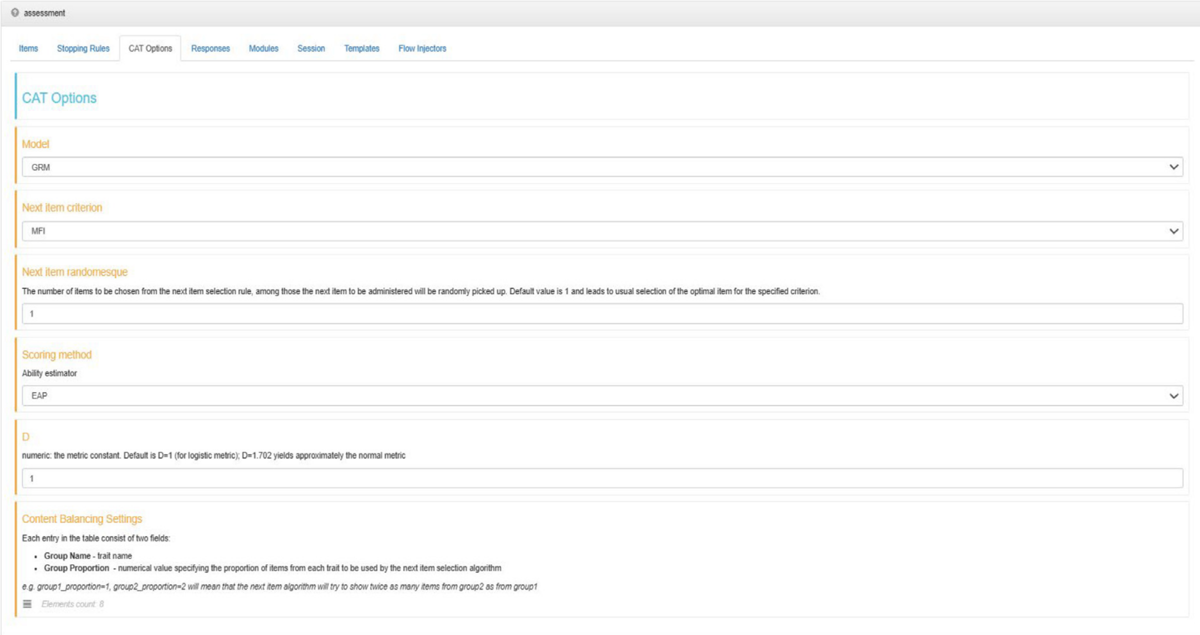


Fig. 1biii. Computerised Adaptive MWB-Scale CAT Options.

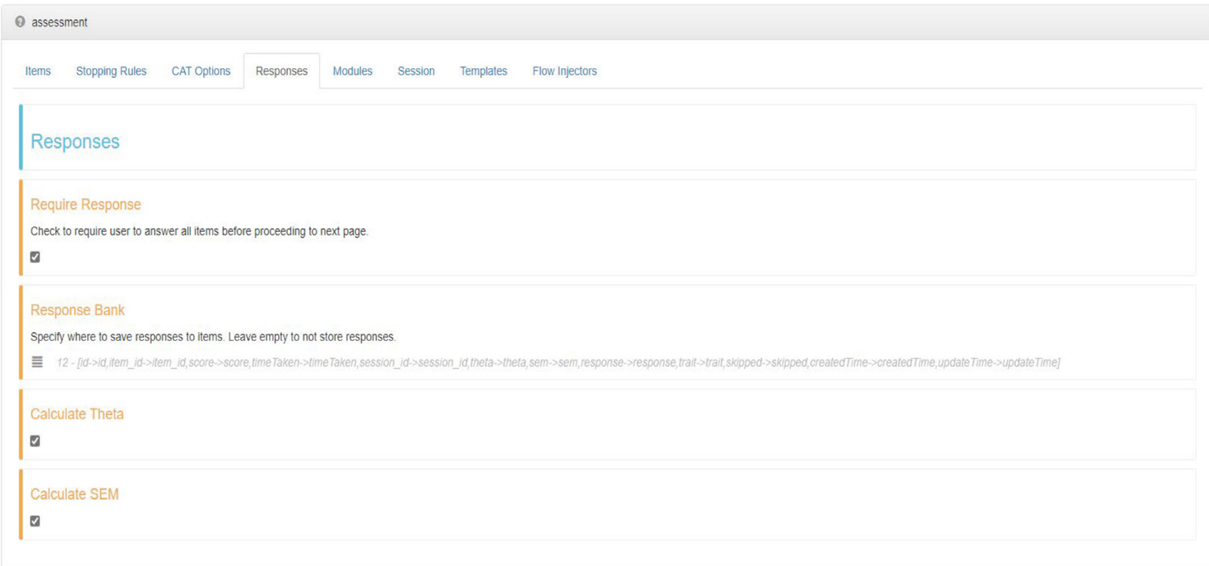


Fig. 1biv. Computerised Adaptive MWB-Scale Response Options.

position in a group and relevant for interpreting standardised test scores as applied to identifying individuals with need for mental health attention using the MWB-Scale [24]. The choice of scoring is important as this scale is available for public use as institutional dedicated links with a looped support systems accessible by specific populations [25,26].

Fig. 1d shows the result display page where respondents to the scale items are given instant feedback being a major advantage with computerised adaptive tests [27]. The *showPage* was customised using the illustration given by [15]. The frontend display for is shown in Fig. 1e.

Worthy of note on the showPage is a link provided to an immediately accessible online support system which is displayed alongside the assessment results (feedback) as shown in Fig. 1eii.

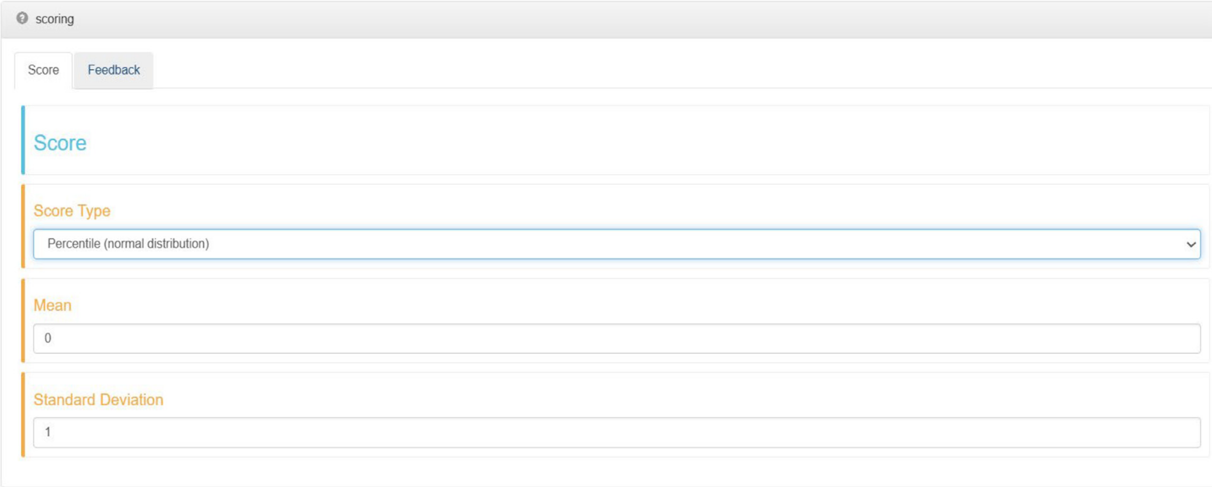


Fig. 1c. Computerised Adaptive MWB-Scale Scoring Options.

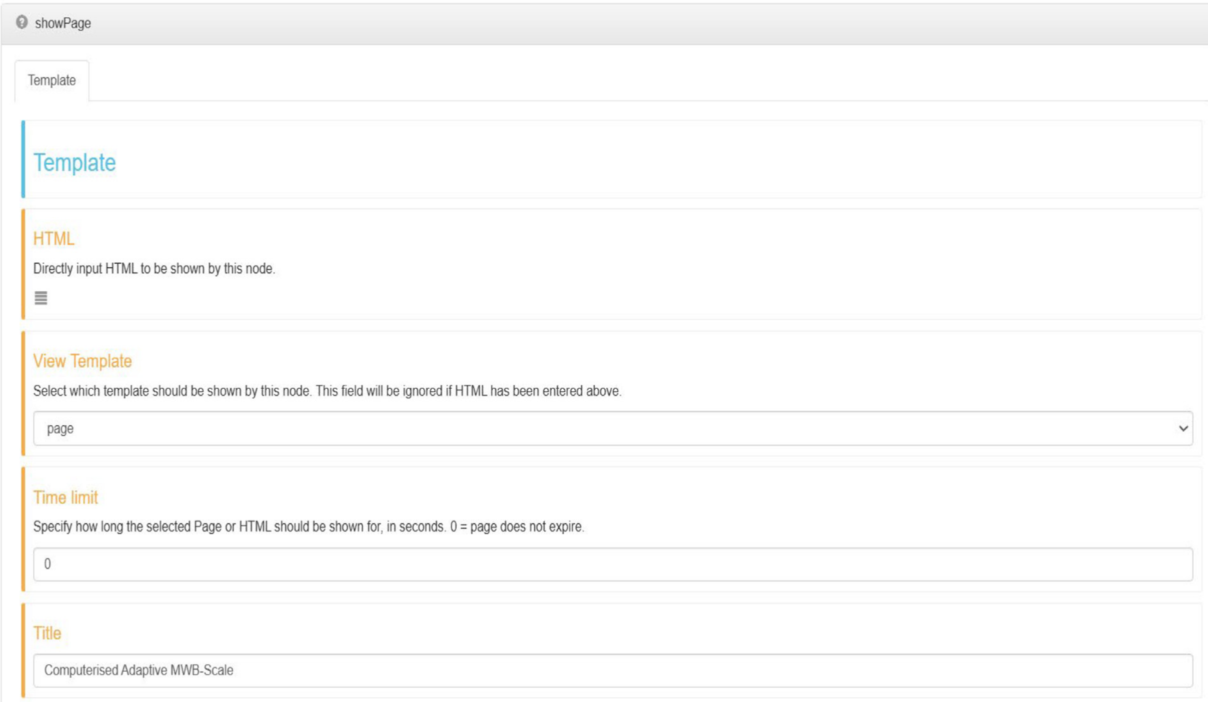


Fig. 1d. Computerised Adaptive MWB-Scale Show Page Options.

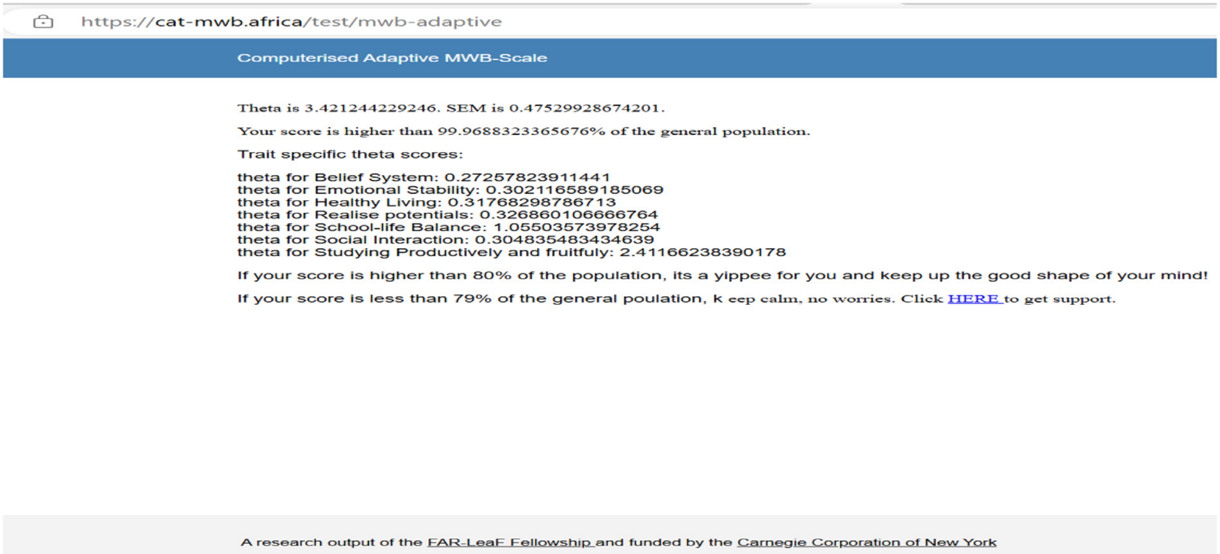


Fig. 1ei. Computerised Adaptive MWB-Scale Front-end Display.

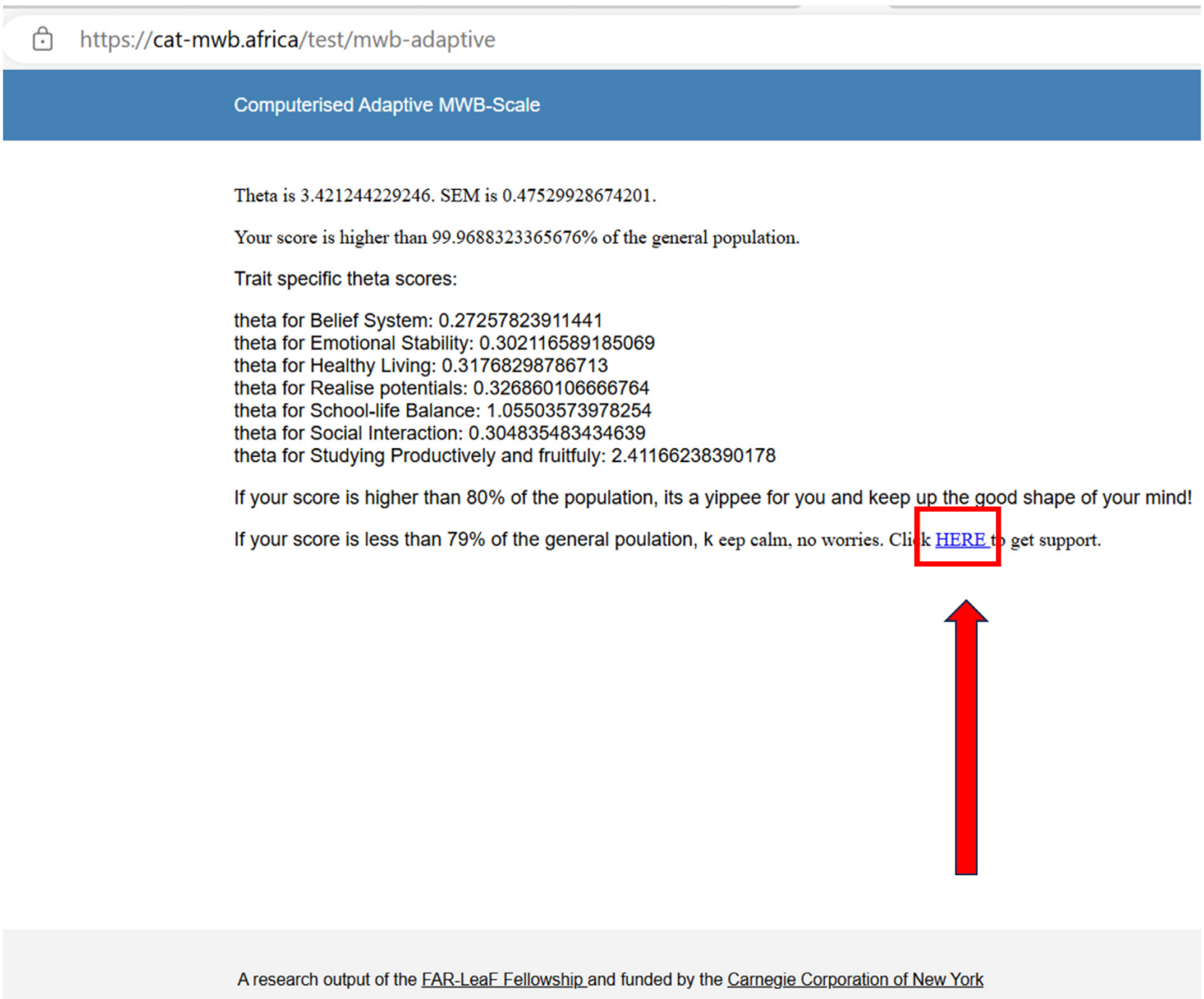


Fig. 1eii. Assessment results display page.

Adding an immediately accessible support system to the scale is important as it helps to connect the Computerised Adaptive MWB-Scale users with professionals who will provide correct diagnosis and the most relevant treatment pathways to improve their chances of long-term recovery where necessary [28].

Limitations

None.

Ethics statements

A dual-site ethical approval was obtained for the study. The obtained ethical certificates are available on request. In line with the ethical requirement with human participants, the author ensured that participants understood the goal of the study and its action-oriented methodology. Additionally, the study participants received a thorough explanation of the data gathering procedure. Before beginning the research endeavour, the researchers secured the informed consent of all participants, and they made sure that everyone who participated in the questionnaires did so voluntarily. The results of this study guarantee institutional non-disclosure and are not identify specific.

CRediT author statement

Jumoke I. Oladele: Conceptualization, Methodology, Test validation, Data curation, Original and final draft preparation. Reviewing and editing the manuscript as well as the concerto set-up were outsourced to english and technical experts respectively.

Data availability

The data on the Concerto parameter table and simulation report are available at: https://osf.io/24czv/ and https://osf.io/jr8w5 respectively.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary material and/or additional information [OPTIONAL]

The online application can be downloaded at no charge at the following website: https://cat-mwb.africa/test/mwb-adaptive

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