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Construction and psychometric validation in Spanish schoolchildren of a knowledge questionnaire on basic life support and Automated External Defibrillator (ConocES-BLS/AED) in Spain

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ABSTRACT

The 60 % of cardiac arrests happen in the out-of-hospital setting. In 2023, the International Liaison Committee on Resuscitation issued a statement entitled "Children save lives", recommending the teaching of basic life support to children from the age of 12. However, we have not identified validated instruments that assess the level of knowledge of schoolchildren about BLS and AED. Objective: Construction and psychometric validation of a questionnaire to assess knowledge on Basic Life Support (BLS) and Automated External Defibrillator (AED) in primary to secondary school children. Method: Cross-sectional descriptive study of validation of the questionnaire consisting of several phases: construction of the questionnaire on knowledge on BLS and AED (ConocES-BLS/AED), content validation, pilot test and psychometric validation. Results: The ConocES-SVB/AED questionnaire was constructed, content validation was carried out by 14 experts, the pilot test carried out on 105 students reported good reliability (0.84), and finally with the psychometric validation a questionnaire composed of 12 items was obtained and psychometrically validated using the Item Response Theory in a final sample of 182 participants. Adequate fit values and acceptable reliability (0.65) were obtained, demonstrating its usefulness to accurately measure the level of knowledge about SVB/AED maneuvers in schoolchildren. Conclusions: The created and validated questionnaire provides educators with a fundamental resource to identify areas of lack of knowledge, improve and design effective educational interventions for schoolchildren on SVB/AED maneuvers.

Introduction

Cardiovascular diseases are the leading cause of death in the world, causing thousands of cardiorespiratory arrests annually.[1] Globally, the annual incidence of cardiorespiratory arrest deaths is estimated at 17.9 million people.[1] In Spain, according to the Spanish Out-of-Hospital Cardiac Arrest Registry, 60,000 arrests were reported in 2022, of which 60 % occurred in an out-of-hospital setting.[2]

Sudden cardiac arrests occur daily, mostly unexpectedly, and tend to happen outside the hospital setting, in public places or homes. Those on the front lines of these emergencies are rarely health professionals.[3] To optimize the prognosis and care in cases of cardiac arrest, essential actions have been outlined that make up the so-called chain of survival and which is divided into four links: 1: Early recognition and asking for help (call 112); 2: Early CPR (Cardiopulmonary Resuscitation); 3: Early defibrillation and 4: Post-resuscitation care.[3]

The application of CPR maneuvers by witnesses of a cardiorespiratory arrest increases the chances of survival with good neurological status, since from the first 3–5 min the brain tissue suffers serious damage.[4] The European Resuscitation Council (ERC) provides specific instructions on the care of a person in CPR as well as the teaching of these manoeuvres, which advises training the entire population (including school-age children) so that they can act until the arrival of the emergency services.[5] In 2023, the International Liaison Committee on Resuscitation issued a statement titled "Kids Save Lives," recommending the teaching of basic life support to children from the age of 12. The proposal suggests a two-hour training for all students in schools around the world.[5,6]

In this sense, the American Heart Association and the European Resuscitation Council highlight that schoolchildren can learn CPR

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techniques from the age of 4 and perform effective compressions from the age of 10. This increases the number of people trained to respond to emergencies and improves survival rates.[7]

However, we have not identified validated instruments that assess the level of knowledge of schoolchildren about BLS and AED; We have only found preliminary protocols[8] or research that has used non-validated instruments.[9–11] In addition, the available studies focus on measuring the effectiveness of different training programs[12–14] for the adult population and do not use specific validated questionnaires to assess knowledge.

The availability of a validated questionnaire to assess schoolchildren's knowledge of CPR and AED techniques is necessary in the field of public health. This would facilitate accurate and rapid assessment, thus improving the chances of survival in critical situations. In addition to its direct impact on emergency response, this measure can promote an entrenched culture of safety and collaboration from the early stages of education.

Developing a knowledge test that includes both content validity and statistical validity is essential for ensuring the accuracy and reliability of the instruments. While content validity, which assesses how well the instrument reflects the knowledge being measured, is considered sufficient by many researchers, statistical validity provides an additional level of rigor that ensures the results are consistent and generalizable.[15] Similarly, knowledge tests play a key role in distinguishing between students who have achieved the objectives of the instrument and those who have not, which is essential for a comprehensive learning process.[16]

For all these reasons, the general objective of this research was the construction and validation of a questionnaire to assess the knowledge of BLS and AED of primary and secondary school students (6 to 16 years old).

Methods

Study design

Descriptive cross-sectional study of questionnaire validation consisting of the following phases: construction of the knowledge questionnaire on BLS and AED (ConocES-BLS/AED), content validation, pilot test and psychometric validation.

Questionnaire construction

The initial bank of items from the first version of the questionnaire was taken as ERC in its "Kids Save Lives" campaign[6] and a previous scale, validated at a Spanish university, for training schoolchildren on BLS.[8] The items with four answer options of the reference scales were transformed into dichotomous items, with three answer options (true/false/I don't know).This decision was made since items with four response options can be confusing for the target population, in addition to not offering an unknown answer, basing the probability of getting it right on chance. To guarantee the quality of the questions, the existing recommendations in the literature were followed both for the creation of knowledge[14,17] and specific questionnaires for the healthcare field,[18,19] the items were written using simple and clear language, without ambiguities or confusing terms so that it was easily understandable by the target population to which it was addressed, schoolchildren between 6 and 16 years old. Therefore, a first version of the scale was generated, consisting of 21 items.

Content validation

A content validation of the first version of the ConocES-BLS/AED questionnaire was carried out using the Delphi Method through consultation with a panel of 15 experts in questionnaire creation, health professionals in the clinical field of emergencies with more than ten years of experience and university professors specializing in emergencies with teaching experience, was contacted by The response rate was 93 % (n = 14), only one expert did not participate in the content validation.[20] They were invited to participate through a questionnaire located on the SurveyMonkey® platform where they had to assess the relevance and clarity of the items on a Likert scale with values from 1 (Not relevant/clear) to 4 (Highly relevant/clear).[21] They were offered the opportunity to propose an alternative wording for each item. Initially, the possibility of holding two rounds of consultation was raised, but it was not necessary since there were no strong discrepancies between the judges.

To analyze the degree of agreement among the experts, V of Aiken was used, establishing 0.90 as a critical value both in relevance and in clarity of wording of the items.[18] As a result, a total of 5 items that did not exceed the critical value (Supplementary Material 1) were eliminated and 9 items were modified in their wording as they were not considered clear, following the recommendations provided by the group of experts. After this phase, the second version of the questionnaire was obtained, consisting of 16 items.

Pilot test

The pilot sample consisted of 105 high school students in february 2024. The difficulty Index (dI), Discrimination Index (DI), corrected item-total correlation (I-T) and reliability (Cronbach's alpha and McDonald's ω) were evaluated.[22] Items with very low or very high difficulty (dI $>$ 0.8 or $<$0.2), poor or no discriminative capacity (DI = 80–0.19 or $<$0, respectively) and/or low ($<$0.30) or very low ($<$0.20) corrected item-total correlation were candidates for elimination[22] (Supplementary Material II). The clarity of the wording of the items was evaluated by means of a question with two answer options (yes/no), which the participants had to answer in each of the items, asking the reason why they did not consider an item clear.

As a result, the questionnaire showed good reliability, 0.84 (95 % CI 0.78–0.88) in the two statistics used and all items showed acceptable values of difficulty, discriminative ability and correlation. No items that were difficult to comprehend were detected, according to the comments of the test participants. After this analysis, the third version of the questionnaire was obtained, with 16 items.

All analyses were performed with Microsoft Excel and JASP® version 0.17.2.1.

Psychometric validation

The psychometric analysis of the questionnaire was performed using Item Response Theory (IRT) using the Rasch model, due to the advantage of being able to measure the level of knowledge through items distributed in a continuum of difficulty levels (from the simplest to the most complex), categorizing the participants in a more complete way. It is established that the probability of success of one of the items is directly related to the skill present in the participants, which is an invariable element, so that two people with the same skill level will be categorized at the same skill point. Rasch's model is capable of measuring the parameters of people and items, independently, establishing that the differences are due to the level of mastery of the participants and the items with which the ability is measured are not related.[23]

The model presents two basic assumptions: construct one-dimensionality and local item independence.[23] The unidimensionality of the construct was verified through exploratory factor analysis and comparison of the eigenvalues obtained with those offered through parallel simulation performed with the free Monte Carlo PCA software®. Previously, the possibility of factorization was corroborated with a value of the Kaiser–Meyer–Olkin test (KMO) $>$ 0.6 and Bartlett's statistical significance ($p < 0.05$).[24] The local independence of the items was evaluated by analysis of the correlation matrix and the Q3 Yen statistic, for which the value of ±0.30 should not be exceeded.[25]

The fit values of the items to the Rasch model were established in an optimal range between 0.8–1.2 for the infit and outfit values and as acceptable values between 0.5–1.5, not exceeding the critical value of 0.2–2 points.[26] The value of infit allows us to evaluate the behavior of the items on the participants and the value of the outfit, determine the atypical or unusual cases.[27] The difficulty of the scale was calculated using the Rasch model, establishing the average level as the score of 0.

As a measure of the quality of the questionnaire, the separation index (preferably above 2) and reliability (with a value sought above 0.70) were measured for both items and people.[28] The items were also represented through the characteristic curves (ICC) of each of them to show the relationship between the level of aptitude and the probability of correct response to the item. Finally, final version reliability of ConocES-BLS/AED was measured with the Cronbach's alpha and McDonald's ω reliability statistics, whose value is usually set from 0.70, although values above 0.65 may be acceptable.[28,29] Although traditionally the Cronbach alpha value has been reported to demonstrate reliability or internal consistency, it is increasingly common to complement this information with the McDonalds omega statistic, since it is considered a very robust reliability index not influenced by the number of items and it was already anticipated that the number of items would be detrimental in the previous phases of content validation and pilot testing.[30] To this end, jMetrik® and JASP® 0.17.2.1 were used.

The final sample consisted of at least 10 participants for each item of analysis, following the recommendations of Muñiz et al.[31] from three schools in the province of Jaen in May 2024.

Participants were selected using a convenience sampling procedure. We contacted several educational centers in the province of Jaén. The inclusion criteria for participation in the study were: 1) being a student at the educational centers and being between 6 and 16 years of age, 2) presenting the informed consent accepted and signed by the parents or legal guardians, 3) knowing how to read and write. Students who did not complete the questionnaire correctly were excluded, obtaining a response rate of 96 %. The questionnaire was administered in paper format to the students before and after an educational intervention of BLS carried out by the researchers themselves who went to the educational centers.

The data used for the validation analysis were deposited in the repository of the University of Jaen, (RUJA), accessible through Handle: https://hdl.handle.net/10953/ 3087.

Ethical considerations

This research has the approval of the Ethics Committee of the University of Jaen (20240111/ENE. PRY1).

A week before the visit to the school, an information sheet was sent to the parents or legal guardians of the minors on the purposes and purpose of the research, as well as the implications for the participant. They were also provided with informed consent so that they could sign it in case they approved their son's or daughter's participation in the study.

Results

The initial sample consisted of 189 elementary and high school students, of which 7 were eliminated for not completing the questionnaire completely, obtaining the final sample of 182 participants, of which 54.95 % were female with an average age of 11.11 years. Table 1 shows the sociodemographic characteristics of the sample.

Rasch model

The KMO test had a value of 0.68 and Bartlett was significant ($p < 0.001$), so it was possible to factorize the data to demonstrate whether the construct measured in the questionnaire was one-dimensional. The AFE revealed that, initially, the questionnaire was composed of two dimensions. It was found that by eliminating item 13 (*The correct rhythm of chest compressions in an adult is 100 to 120 compressions per minute*), one-dimensionality was achieved, as reflected in the scree plot (Fig. 1). Before being eliminated, it was subject to debate by the research group, which also took into account the comments of experts during validation. It was considered to be too technical an item for the age of the target population, since it is sometimes difficult for them to memories or count up to that number, especially at younger ages.

Table 1
Sociodemographic characteristics of the sample of schoolchildren (N=182).

Characteristics	Value
Mean age (years)	11.11 (*SD=1.61*)
Genus, n (%)	
Male	79 (43,1)
Female	100 (54,95)
No response	3 (1,65)
Previous training in BLS, n (%)	
No	104 (57,14)
Yes	75 (41,21)
No response	3 (1,65)
Has a family member explained first aid to you?, n (%)	
No	136 (74,73)
Yes	40 (21,98)
No response	6 (3,3)
Cardiorespiratory arrest witnessed, n (%)	
No	143 (78,57)
Yes	36 (19,78)
No response	3 (1,65)

SD: Standard deviation.
CPR: Cardiopulmonary Resuscitation.
PCR: Cardiorespiratory arrest.

Table 2 shows the values of the Rasch model for each item. Two outfit values are above the recommended value of 1.5, although only one of them exceeds the critical value 2, so this item was discarded.

Using the item map, it was verified that the same item with an outfit value greater than 2 outside was at the upper limit of the participants' skill level (Fig. 2), which confirmed the need to be discarded.

In addition, the verification of the local independence of the items by means of Q3 of Yen, showed that item 2 (*When we find a person lying on the ground, it is essential to ensure the safety of the environment and check that there is no danger*) and 9 (*When faced with an unconscious person who is not breathing, we call the emergency services and begin chest compressions*) compromised this assumption (Supplementary Material III), so they were also eliminated.

After eliminating the problematic items, the final version of the questionnaire consisting of 12 items (Supplementary Material IV) showed infit and outfit values within the recommended range (from 0.82 to 1.25 and 0.66 to 1.37, respectively), with a mean value of 1 for both adjustment parameters. The difficulty values were found to be between −2.10 for the easiest item (*You must wait for the arrival of the health personnel to initiate the first actions of the chain of survival*) and 1.29 in the case of the most difficult (*The correct sequence for cardiopulmonary resuscitation in an adult is 25 chest compressions and 2 breaths*). The separation index for items was 4.77 and 0.94 for people. The reliability of the items was 0.96 and for people, 0.47. This means that the items have a good ability to order the participants appropriately, according to the latent trait, although with certain restrictions for the sample of schoolchildren selected.

The items characteristic curves (ICC) show how they represent ascending functions, representing different degrees of difficulty depending on the degree of ability (theta) of the participants and the

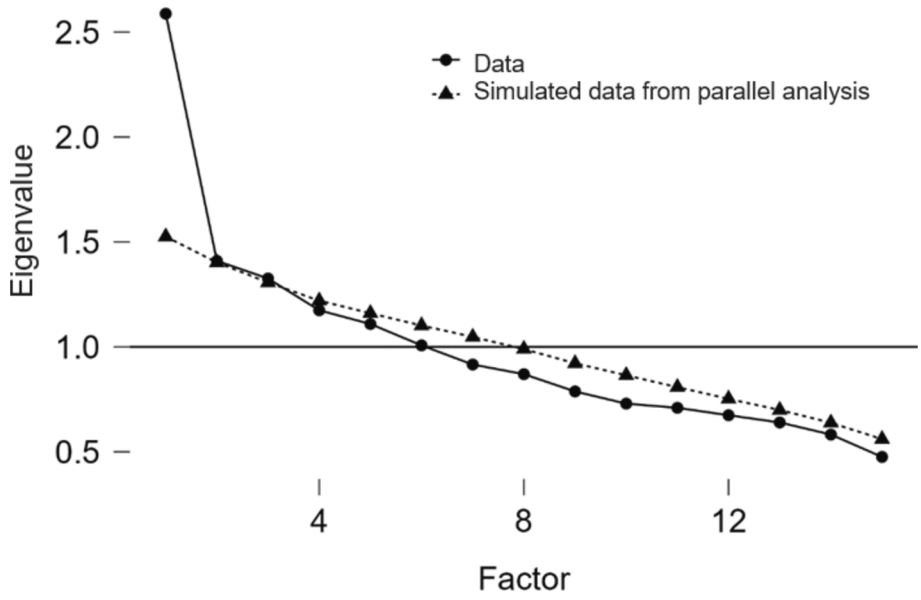

Fig. 1. Scree plot.

probability of success (Fig. 3).

Finally, the questionnaire obtained a Cronbach's alpha reliability value of 0.65 (95 % CI 0.57–0.72) and 0.66 in the case of McDonald's ω (95 % CI 0.58–0.73).

The final ConocES-BLS/AED questionnaire is composed of 12 items (Fig. 3). Each correct answer obtains 1 point, with a maximum score of 12. The option "don't know/no answer" was scored with 0 points, as was the incorrect answer. In order to improve the interpretation of the final scores of the questionnaire, three levels were suggested, depending on the score obtained: Insufficient knowledge is considered if 0 to 5 points are obtained, good knowledge between 6 and 10 points, and excellent knowledge between 11 and 12 points.

Discussion

In our study we have constructed and validated the ConocES-BLS/AED knowledge questionnaire in a final sample of 182 participants. The structure of our questionnaire allows us to categorize the knowledge of the students as insufficient, good or excellent. Psychometric validation was performed using IRT, applying the Rasch model. It was confirmed that the final version of the questionnaire presented adequate fit values and acceptable reliability, demonstrating its usefulness to accurately measure the level of knowledge in BLS/AED in schoolchildren.

Given the importance of training school-age children in BLS to improve survival rates after SCA in the community,[6] it is important to have a tool that allows you to evaluate your knowledge both before and after training. However, no validated instrument has been found to measure knowledge in schoolchildren. ConocES-SVB/DEA is the first questionnaire validated through TRI with the ability to possibly measure schoolchildren's knowledge about BLS and the use of the AED.

In the available literature, there are instruments, mostly for the health population, such as the Cardiff test[32] and the Raval Sud Test[33] which consist of assessing practical competence in BLS and AED skills. These instruments are geared towards training and assessment of advanced competencies required in professional environments, where accuracy and effectiveness in emergency response are critical. However, for school-age students, the educational approach must be adapted to their level of cognitive and physical development in an accessible and age-appropriate way.[6]

Previous studies have evaluated various types of training activities aimed at schoolchildren on CPR and AED at various educational levels.[9–11] The quizzes and tests used to measure knowledge were created *ad hoc* not validated[10,12] or using other validation methods.[11] Taken together, this research highlights the need for future research to use specific instruments to assess knowledge among schoolchildren.

The lack of validated instruments to measure knowledge makes it difficult to compare psychometrics with previous studies in the same population, which could be explained by the fact that it is a relatively new topic. Still, when comparing our data using an instrument designed for the healthcare population, our findings turn out to be similar.[34]

The main finding of our study was the creation of a questionnaire to assess the knowledge of BLS and AED schoolchildren. This questionnaire supports key findings from the Kids Save Lives study,[6] which emphasizes the importance of BLS training for schoolchildren as an effective means of improving community preparedness for out-of-hospital cardiac arrests.

In the process of validating measurement instruments, reliability is an essential aspect to ensure the consistency and accuracy of the results obtained. In the case of health-related instruments, such as in our research, a Cronbach's alpha coefficient of 0.65 may be considered adequate in specific contexts, especially in exploratory studies or in the initial phases of instrument development.[35] As Taber[36] notes in a methodological review on reliability in science education research, an alpha greater than 0.60 can be considered acceptable under certain circumstances, especially when the constructs being measured are complex or when the main focus is on content validity.[36] Similarly, widely used health instruments, such as the General Health Questionnaire, have reported Cronbach's alphas close to 0.65, which supports the idea that the interpretation of reliability should be adjusted according to the study's purpose and the nature of the instrument used.[37] Therefore, this reliability threshold may be appropriate when content validity or the instrument's ability to capture complex constructs like knowledge is prioritized.[38]

Our instrument is useful for assessing the efficacy of educational interventions in school-aged children on BLS in future research, assessing not only acquired knowledge but also practical skills and confidence to act in a real emergency.

As we have mentioned, this questionnaire can be used in training workshops within schools and will allow students to acquire new social skills, thus increasing their safety in the event of cardiorespiratory arrest, which can occur at any time and in any place, where medical assistance may be delayed and they may be the only ones able to act at that moment.

Table 2
ConocES-BLS/AED Rasch model parameters.

Item	Difficulty (SE)	Infit	Outfit
It is necessary to wait for the arrival of health personnel to initiate the first actions in the chain of survival.	−2,15(0,19)	0,93	0,94
When we find a person lying on the ground, it is essential to guarantee the safety of the environment and check that there is no danger.	−0,84 (0,17)	0,71	0,63
When a person is unconscious and not breathing, I must place them in a lateral safety position.	1,67 (0,27)	1,26	2,68
In an emergency situation, the number we should call is 112.	−1,01 (0,17)	0,74	0,78
When I find a person lying on the ground and after asking for help, I must check if they respond to both verbal stimuli (yelling) and painful stimuli (shaking them).	−0,57 (0,17)	1,34	1,49
To open the airway, the forehead-chin maneuver is performed.	1,22 (0,24)	1,00	0,95
To check that a person is breathing correctly, visualizing the elevation of the chest would be enough.	−0,75 (0,17)	1,19	1,24
Basic Life Support (BLS) is the set of maneuvers that is performed when a person is in Cardio-Respiratory Arrest (CPA), to maintain circulation until the patient receives complete health care.	0,87 (0,21)	0,85	0,71
In the face of an unconscious person who is not breathing, we call the emergency services and begin chest compressions.	−0,54 (0,17)	0,77	0,67
Whenever possible, we should change the rescuer (person who performs compressions) every two minutes, to maintain quality compressions.	−0,21 (0,18)	1,20	1,17
The correct sequence for CPR in an adult is 25 chest compressions and 2 breaths.	1,28 (0.24)	1,04	1,61
To perform quality compressions in an adult, the heel of both hands with the fingers interlaced should be placed in the center of the chest.	−0,30 (0,18)	0,84	0,75
I can do resuscitation maneuvers by skipping ventilations and applying chest compressions continuously at a rate of 100 per minute.	0,53 (0,20)	1,21	1,45
When I have the Automated External Defibrillator (AED), I should turn it on as soon as possible and follow the instructions.	0,33 (0,19)	0,82	0,77
The Automated External Defibrillator (AED) can only be used by healthcare professionals.	0,49 (0,20)	1,02	1,47

SE: standard error; Infit: Weighted mean square fit; Outfit: unweighted mean square fit.
In bold, outfit value above 2.

Likewise, it would be relevant to carry out comparative studies to determine the best evaluation strategy in different educational and cultural contexts. In addition, our questionnaire provides school education professionals with a tool to identify groups that could benefit most from priority educational interventions.

Our study has as its main limitation having been carried out exclusively in a population of a single province. Although it is possible that sociodemographic characteristics are comparable in other regions, the generalizability of our findings to different school populations or educational contexts cannot be assured. It is suggested to carry out additional validations in various populations of schoolchildren and with a larger sample size to guarantee the applicability and external validity of our instrument, especially at the cultural level. Another possible limitation of our research is the use of a reliability coefficient that, while acceptable in exploratory or initial development contexts, may restrict precision in the assessment of more complex constructs. Nonetheless, this level of reliability remains valid for interpreting preliminary results and guiding future improvements to the instrument, providing a solid foundation for reviewing and optimizing its internal consistency in subsequent research.

In the future, it would be necessary to design future effective educational interventions in BLS and DEA for schoolchildren, such as workshops for all students in the same educational center, as well as carrying out said interventions in other educational centers in the province.

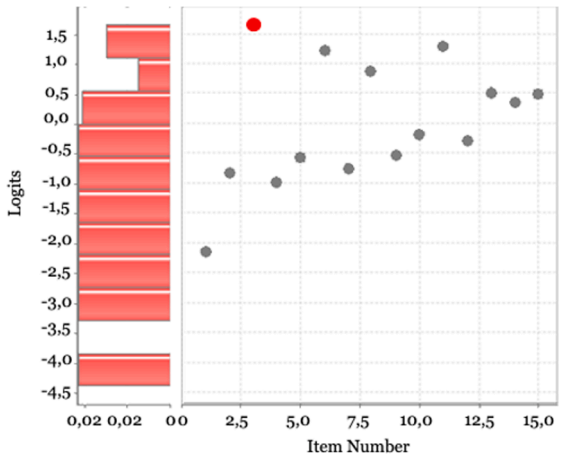

Fig. 2. Item Map: This graph relates the level of ability or latent trait (θ) of the sample, located on the ordinate axis (left), with the difficulty of the items (β), located on the abscissa axis (right). The red dot corresponds to the item that is located slightly above the participants' skill level. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Conclusions

In conclusion, our study has created and validated the ConocES-BLS/AED questionnaire to assess knowledge about BLS and AED in schoolchildren. The use of appropriate psychometric techniques has made it possible to optimize the structure of the questionnaire, ensuring its reliability and validity. This questionnaire not only contributes to the existing literature by offering a specific tool in Spanish to measure this knowledge, but also provides educators with a resource to identify areas for improvement and design effective educational interventions in BLS and AED for schoolchildren.

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CRediT authorship contribution statement

Belén Gutiérrez-Sánchez: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Investigation, Conceptualization. **Eva M.ª Montoro-Ramírez:** Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Sebastián Sanz-Martos:** Writing – review & editing, Visualization, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Francisco Segura-Galán:** Writing – review & editing, Validation, Supervision, Resources. **Henrique Da Silva Domingues:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Investigation, Conceptualization.

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.

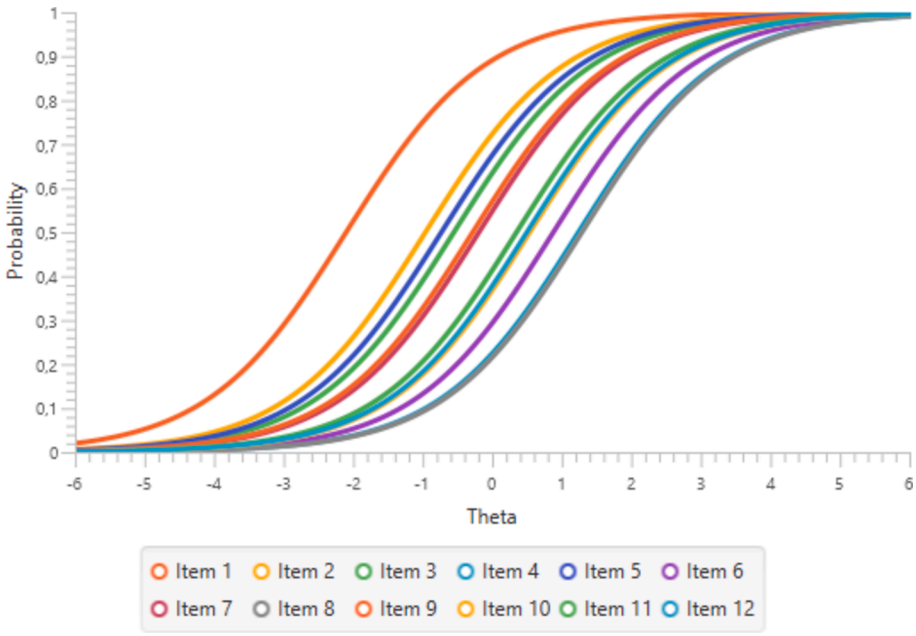

Fig. 3. Items characteristic curves of ConocES-BLS/AED final version: The graph shows the relationship between the participant's skill level (θ) (abscissa axis, on the right) and the probability of correctly answering the item (ordinate axis, on the left).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2024.100792.

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