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Rasch Analysis of the General Life Skills Scale for Dating Violence Prevention in Indonesian Adolescents

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ABSTRACT

Introduction: Early life skills education has the potential to be an effective intervention in preventing adolescent dating violence (ADV). However, measurement tools for life skills in general in the context of ADV prevention are still limited.
Objective: This study aims to evaluate the psychometric properties of the General Life Skills Scale (GLSS) using the Rasch model.
Methods: This study is classified as research and development. A total of 366 junior high school students (111 students from private schools and 255 students from public schools) in Indonesia participated in the empirical validation of the General Life Skills Scale (GLSS). The GLSS consists of 48 items spread across the constructs of personal skills (22 items) and social skills (26 items). GLSS used a four-point Likert scale, from 1 (strongly disagree) to 4 (strongly agree). The psychometric properties of the GLSS were evaluated using Rasch modeling. The psychometric properties were reviewed based on reliability, item fit, unidimensionality, and item distribution at each level of difficulty.
Results: The results of the analysis showed that the GLSS had excellent reliability (α = 0.96; person reliability = 0.93; item reliability = 0.95). The separation index showed the scale's ability to distinguish respondents in five ability strata and items in six difficulty levels. Of the 48 items, 26 items met the Rasch model fit criteria, and unidimensionality analysis confirmed that the scale measured one main construct. However, the Wright map showed logit gaps between items, especially at the very easy difficulty level.
Conclusion: The GLSS is considered valid and reliable for measuring adolescents' life skills in the context of preventing dating violence; however, improvements in item distribution are recommended to enhance measurement accuracy.
Theoretically, this study contributes to the development of a general life skills scale in adolescent development theory. Practically, this study provides a validated scale for educators to design life skills curricula and can be integrated into school-based ADV prevention programs.

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INTRODUCTION

Adolescent Dating Violence (ADV) is a significant global public health issue (1), with prevalence varying between countries and types of violence. In the United States, approximately 10% of Asian-American adolescents report having experienced physical or sexual violence in a dating relationship in the past 12 months (2). U.S. national data also shows a prevalence of physical violence among adolescent girls of approximately 10% and sexual violence of 13% (3). One in three adolescents in Canada who have been in a dating relationship have experienced or perpetrated dating violence in the past 12 months. The prevalence of physical violence is 11.8%, psychological violence is 27.8%, and cyber violence is 17.5% (4). Studies in several European countries also report the prevalence of dating violence victims between 26.7% (males) and 34.1% (females) (5). In Germany, 56.1% of adolescents reported being victims of dating violence in the past 12 months, with emotional violence being the most commonly reported (6). In the Indonesian context, the National Commission on Violence Against Women reported 422 out of 2,098 cases of gender-based dating violence in the private sphere, and service agencies reported 3,528 cases out of a total of 8,172 cases (7). Psychological and sexual violence had a prevalence of 39.6% and 28.8%, respectively (7,8).

Dating violence (DV) has a negative impact on adolescents as victims. DV affects mental health, such as an increased risk of depression, anxiety, traumatic stress, suicidal ideation, self-harm, and post-traumatic stress disorder (PTSD) (9–13). Adolescents who are victims of physical or sexual violence in dating relationships are at risk of physical injury, chronic health problems, eating disorders, and reproductive health problems (14–16). Socially, adolescents who are victims of violence may experience social isolation, withdrawal from their peer group, and a decline in social support (9,14).

Intervention and education from school age are very important to prevent dating violence. Previous studies have reported that school-based interventions can significantly reduce dating violence rates, increase knowledge, and promote positive attitudes toward healthy relationships (17–19). Effective programs will work when they involve teacher training, special curricula, student campaigns, and the involvement of parents and the community (19,20). Interventions starting at school age are important because during this period, adolescents are forming relationship patterns and social values. Early education will help students build communication skills, conflict resolution, and awareness of the signs of unhealthy relationships (17,18,21). Interventions involving multiple levels (school, family, and community) are considered more effective than single interventions (19,21). In this context, schools and life skills education programs play an important role in building resilience and healthy decision-making skills in adolescents, thereby supporting the creation of healthy and adaptive relationships in adolescence and adulthood.

Life skills are abilities that can be learned and developed throughout life; they are not innate traits or personality traits (22,23). In general, life skills encompass a set of skills that help individuals build healthy relationships, manage emotions, make appropriate decisions, and solve problems in everyday life (24). In this context, general life skills refer to basic skills consisting of two main domains: personal skills and social skills. Personal skills relate to the ability to recognize, manage, and direct one's own behavior and emotions. Meanwhile, social skills include the ability to establish positive interactions, build healthy social networks, and work with others. To support the development of these abilities, life skills education was developed as a structured educational approach aimed at equipping students with the personal, social, and emotional skills needed to face life's challenges adaptively and effectively (25–27). Personal skills will help adolescents recognize risky situations, control impulses, and make healthy decisions. Meanwhile, social skills will strengthen adolescents' ability to resist peer pressure, resolve conflicts without violence, and build healthy relationships (22,28).

Research on the development of life skills instruments has been reported previously, such as Bussu and Mangiarulo using shared musical experiences to evaluate adolescents' perceptions of life skills development. This study focused on communication, cooperation, and emotional management in adolescents (29). Boon (30) used a qualitative approach to identify autonomy, communication, and self-regulation as dimensions of life skills relevant to college students. The instrument was validated through reliability testing and factor analysis (classical testing). In the field of sports, Cronin and Allen (31) developed the Life Skills Scale for Sport, which was validated using confirmatory factor analysis in classical testing in the context of athletes. Although there have been previous studies, there is limited information on the development of a general life skills scale in the context of adolescents as a preventive measure against dating violence. Therefore, this study aims to evaluate the psychometric properties of the general life skills scale using Rasch modeling in the context of preventing dating violence among adolescents. Rasch modeling was chosen because it provides an objective evaluation (32,33). Rasch modeling does not depend on specific samples or items. Meanwhile, classical tests are highly dependent on the samples and items used, so that reliability and validity results can change if the samples or items change (32,34).

METHOD

Research Type and Sample

This study is a development study to produce a quality General Life Skill scale. This study involved 366 junior high school students from private schools (111 students) and public schools (255 students) in Indonesia. Respondents were collected using convenience sampling (35). Before analysis, the data was treated and cleaned based on extreme values and Pt. Mea. Corr. Respondents with high and low extreme logit values and those with Pt. Mea. Corr. ≤ 0.00 were excluded from the analysis. The data cleaning process excluded 96 respondents (8 with extreme values and 88 with Pt. Mea. Corr. ≤ 0.00), leaving 270 respondents (141 males and 129 females) as the final sample. Extreme values in Rasch modeling can reduce data quality, interfere with parameter estimation, and compromise the validity of score interpretation (36,37). Meanwhile, a Pt. Mea. Corr. value ≤ 0.00 indicates that the person is inconsistent or not in line with the construct (38–40). This can lead to biased estimates of ability and reduced measurement validity (38,40,41). A sample size of 250 can be used to obtain stability, high precision, and a measurement confidence level of up to 99% (42,43). Therefore, the number of respondents involved in this study has exceeded the expected measurement confidence level.

Instrumentation and Data Collection Procedures

The data collection process was carried out by distributing paper and pencil questionnaires. Data collection was carried out after coordinating with the school and guidance counselors as field supervisors. Data collection was voluntary, and students filled out informed consent forms. Students were informed that the data provided would be kept confidential and would not be directly linked to their final school grades. They could withdraw their responses if they felt uncomfortable with the information provided. The data collection process lasted for about 1 month. This study has received ethical clearance from Diponegoro University with the number 185/EA/KEPK-FKM/2025.

The General Life Skill Scale consists of 48 items spread across two main constructs, namely personal skills (22 items) and social skills (26 items). Personal skills consist of two sub-constructs, namely: self-awareness skills (12 items) and rational thinking skills (10 items). The assessment scale used is a four-point Likert scale, ranging from a score of 1 (strongly disagree) to a score of 4 (strongly agree).

Data Analysis

The psychometric properties of the General Life Skills Scale (GLSS) were analyzed using the Rating Scale Model in Rasch analysis, as all items used the same 4-point Likert scale structure. Rasch analysis allows for the objective measurement of latent constructs, converting ordinal scores into intervals, and ensuring the validity and reliability of the instrument (44–46). Data analysis using the Joint Maximum Likelihood Estimation (JMLE) algorithm implemented in Winsteps 4.6.1 software (47). Item fit is evaluated using outfit mean square (MNSQ) statistics with a threshold of 0.5-1.5 for productive measurements, and z-standard values (ZSTD) with a threshold of -2.0 to +2.0, as well as Pt. Mea. Corr. values with a threshold of 0.40 to 0.85. These parameters are used to maintain measurement precision. Items that fall outside the item fit threshold will be excluded from the scale being evaluated (48).

RESULTS

Statistical Summary

A summary of the psychometric properties of the General Life Skills Scale is presented in Table 1.

Table 1. Summary statistic of the General Life Skill Scale

Index	Person	Item
Mean	1.88	0.00
Standard Deviation	1.38	0.54
Separation	3.77	4.36
Strata	5.36	6.15
Reliability	0.93	0.95
Cronbach Alpha	0.96	

Source: Primary Data

Based on Table 1, the mean person value of 1.88 logit is higher than the mean item, indicating that the respondents' General Life Skill abilities are above the average level of item difficulty. The standard deviations for person and item are 1.38 and 0.54, respectively. Cronbach's Alpha index shows a value of 0.96. In addition, the reliability of the person is 0.93, and the reliability of the item is 0.95. The separation index values are 3.77 (person) and 4.36 (item), respectively, and the strata index is 5.36 (person) and 6.15 (item).

Item Fit

The fit of the 48 items on the GLSS to Rasch modeling is summarized in Table 2.

Table 2. Item fits in the GLSS to the Rasch modeling

Item	Measure	Model S.E	Outfit		Pt. Mea. Corr.	Item Status
			MnSq	ZStd		
PSSA_EU1	-1.70	0.14	1.12	0.68	0.43	Fit
PSSA_EU2	-0.46	0.12	1.19	1.50	0.51	Fit
PSSA_EU3	-0.27	0.12	0.76	-2.25	0.64	Misfit
PSSA_EU4	-0.40	0.12	1.26	2.09	0.51	Misfit
PSSA_EU5	1.79	0.09	2.32	9.90	0.29	Misfit
PSSA_SR1	-0.12	0.12	1.31	2.52	0.51	Misfit
PSSA_SR2	1.36	0.10	2.29	9.55	0.35	Misfit
PSSA_SR3	0.20	0.11	1.05	0.52	0.51	Fit
PSSA_SA1	0.04	0.12	1.21	1.79	0.50	Fit
PSSA_SA2	0.24	0.11	1.24	2.01	0.48	Misfit
PSSA_SA3	-0.02	0.12	1.47	3.65	0.49	Misfit
PSSA_SA4	0.57	0.11	1.58	4.59	0.49	Misfit
PSTS_CriT1	0.01	0.12	0.80	-1.84	0.61	Fit
PSTS_CriT2	-0.03	0.12	0.77	-2.15	0.62	Misfit
PSTS_CriT3	-0.31	0.12	0.88	-1.02	0.62	Fit
PSTS_CriT4	-0.36	0.12	0.94	-0.47	0.57	Fit
PSTS_PS1	0.05	0.12	0.90	-0.88	0.60	Fit
PSTS_PS2	0.09	0.12	0.84	-1.49	0.59	Fit
PSTS_PS3	-0.20	0.12	0.66	-3.27	0.65	Misfit
PSTS_CreT1	0.35	0.11	0.99	-0.02	0.54	Fit
PSTS_CreT2	-0.31	0.12	0.62	-3.72	0.68	Misfit
PSTS_CreT3	0.30	0.11	0.80	-1.89	0.61	Fit
SCSC_CS1	-0.66	0.12	0.93	-0.53	0.60	Fit
SCSC_CS2	-0.31	0.12	0.89	-0.96	0.62	Fit
SCSC_CS3	-0.96	0.13	0.74	-2.02	0.62	Misfit
SCSC_CS4	0.09	0.12	1.16	1.42	0.56	Fit
SCSC_CS5	0.18	0.11	1.14	1.27	0.51	Fit
SCSC_CS6	0.64	0.11	1.13	1.19	0.50	Fit
SCSC_CS7	0.66	0.11	1.24	2.08	0.48	Misfit
SCSC_CS8	-0.29	0.12	0.71	-2.71	0.66	Misfit
SCSC_CS9	0.19	0.11	0.79	-1.95	0.64	Fit
SCSC_CS10	0.20	0.11	1.15	1.32	0.59	Fit
SCSC_CS11	1.15	0.10	1.79	6.28	0.40	Misfit
SCSC_CS12	-0.36	0.12	0.81	-1.72	0.59	Fit
SCSC_CS13	-0.58	0.12	0.71	-2.55	0.64	Misfit
SCSC_TS1	0.01	0.12	0.91	-0.80	0.61	Fit
SCSC_TS2	-0.10	0.12	0.82	-1.67	0.61	Fit
SCSC_TS3	0.03	0.12	1.22	1.86	0.50	Fit
SCSC_TS4	0.02	0.12	0.73	-2.64	0.65	Misfit
SCSC_TS5	0.31	0.11	0.84	-1.46	0.60	Fit
SCSC_TS6	0.13	0.12	1.02	0.23	0.61	Fit

Item	Measure	Model S.E	Outfit		Pt. Mea. Corr.	Item Status
			MnSq	ZStd		
SCSC_TS7	-0.24	0.12	0.71	-2.76	0.67	Misfit
SCSC_TS8	-0.29	0.12	0.83	-1.53	0.63	Fit
SCSC_TS9	0.06	0.12	0.90	-0.92	0.64	Fit
SCSC_TS10	-0.06	0.12	0.73	-2.56	0.63	Misfit
SCSC_TS11	-0.23	0.12	0.72	-2.70	0.63	Misfit
SCSC_TS12	0.01	0.12	0.77	-2.22	0.60	Misfit
SCSC_TS13	-0.42	0.12	0.66	-3.27	0.65	Misfit

Source: Primary Data

The evaluation of item fit in the GLSS was conducted based on three main indices, namely: Outfit Mean Square (Outfit MnSq), Outfit Z-Standardized (ZStd), and Point Measure Correlation (Pt. Mea. Corr.). Based on Table 2, 26 of the 48 items (54.2%) showed good fit to the model because they met all three criteria simultaneously. Three items (PSSA_EU5, PSSA_SR2, and PSSA_SA4) (6.25%) had Outfit MnSq values outside the acceptable range of 0.5 to 1.5. Meanwhile, 22 items (45.8%) showed Outfit ZStd values outside the acceptance limits, i.e., outside the range of -2 to 2. Based on Pt. Mea. Corr., 4.2% (PSSA_EU5 and PSSA_SR2) showed values outside the recommended limits.

Unidimensionality

The unidimensionality of the GLSS was analyzed using the Principal Component Analysis of Residuals (PCAR) method. The PCAR method was used to detect additional dimensions beyond the main dimensions (49,50). The analysis results showed that the raw variance explained by measures was 36.6%, while the unexplained variance in the first contrast was 8.9%.

Item map

The mapping of item difficulty levels on the GLSS is visualized in Figure 1 using the Wright Map.

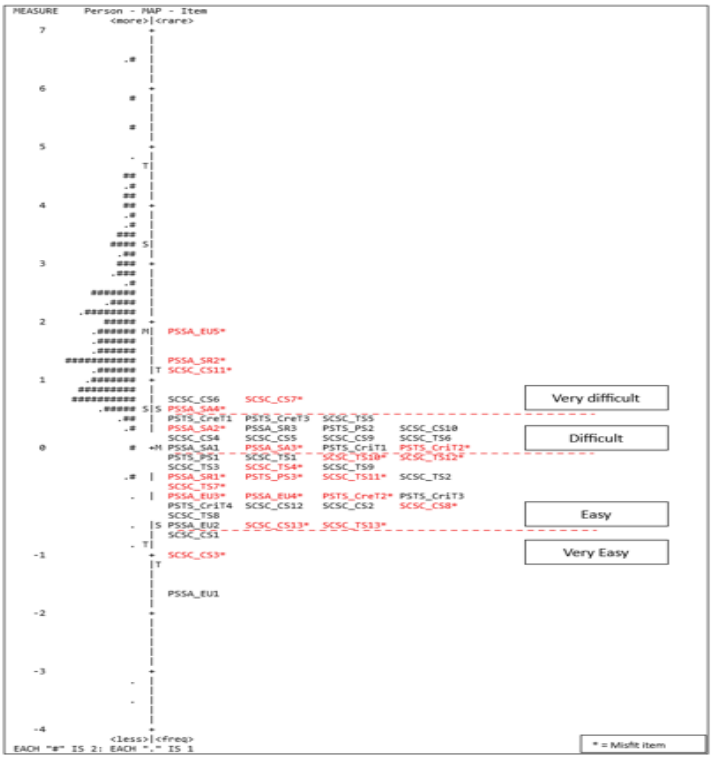

Figure 1. Item difficulty level map in GLSS

Figure 1 shows the distribution of students' General Life Skills (person) on the left and the distribution of item difficulty levels on the right on the same logit scale. The distribution of student abilities ranges from the lowest level (bottom) to the highest (top), as do the items, which are mapped from the easiest (bottom) to the most difficult (top). In general, all items are spread across four levels of difficulty. Most items are in the difficult category (12 out of 26 items) and easy category (11 out of 26 items). Meanwhile, there is only 1 item at the very difficult level and 2 items at the very easy level. Additionally, there is a logit gap of 1.04 between the SCSC_CS1 item (-0.66 logit) and the PSSA_EU1 item (-1.70 logit), which are located in the very easy item category.

DISCUSSION

Statistical Summary

The significant difference between the mean person and mean item (1.88 logit) in Table 1 shows that, in general, students' General Life Skills abilities are relatively higher than the average difficulty of items on the GLSS. This may indicate that the GLSS is quite easy for the population of respondents tested. From another perspective, this shows that the population already has a high level of General Life Skills. The standard deviation of the items is smaller than the standard deviation of the persons, indicating that the variation in item difficulty is narrower than the variation in student ability. The mean and standard deviation of the items are also used as limits in grouping the difficulty levels of the items (51,52).

A Cronbach's Alpha value of 0.96 is in the very good category, which means that the internal consistency between items on this scale is very high (34,53). However, because alpha is unable to precisely measure the differentiation of individual abilities or the specific level of difficulty of items, our analysis is supported by the person and item reliability indices from the Rasch model. The person reliability index is determined based on the actual error estimate from the Rasch model (54,55). A person's reliability index of 0.93 indicates that the GLSS is consistently able to distinguish respondents based on their ability level. Meanwhile, an item reliability index of 0.95 indicates the consistency of the GLSS in ranking items from the easiest to the most difficult. This value is closely correlated with the item separation index, which describes how well the GLSS distinguishes the gradation of item difficulty (56,57).

The separation index is often reported together with reliability, where a good separation value is usually followed by high reliability (58,59). The Person Separation index shows the ability of the instrument to distinguish respondents into different ability strata (57,60). Meanwhile, the Item Separation index shows how well the instrument distinguishes the level of item difficulty evenly from easy to difficult (57,59). A person separation index of 3.77 and an item separation index of 4.36 indicate that the GLSS is capable of distinguishing at least four levels of person ability and more than four levels of item difficulty. In other words, based on the stratum indices (5.36 for person and 6.15 for item), student ability can be classified into five strata and items into six strata of difficulty. This shows that the GLSS has a fairly broad coverage and can be used to differentiate respondents more accurately.

Overall, the information from the reliability and separation indices supports that the developed GLSS has good measurement quality and is suitable for use as a measuring tool in the context of preventing dating violence among Indonesian adolescents.

Item Fit

The results of the item fit analysis in Table 2 indicate that more than half of the items in the GLSS (54.2%) meet the Rasch model, as they fulfill all three criteria simultaneously. This is a good initial indication that most items in the GLSS work according to the Rasch model. Three items (PSSA_EU5, PSSA_SR2, and PSSA_SA4) with Outfit MnSq values outside the 0.5–1.5 range need to be evaluated further. Outfit MnSq values that are too low (below 0.5) indicate that the responses are too consistent or predictable (overfit), and values above 1.5 indicate noise or responses that do not fit the pattern, known as misfit (61,62). Items with misfit need to be revised or reevaluated in terms of wording and contextual relevance. Outfit ZStd is a standard transformation of Outfit MnSq to a z-score scale. The Outfit ZStd value is used to see whether the deviation of responses to items is statistically significant. Table 2 shows that 45.8% of items have ZStd values outside the range of -2 to 2. This indicates that quite a few items in the GLSS have responses that deviate from the model predictions. Although ZStd can be sensitive to sample size, this remains an important note to follow up on, especially if extreme ZStd values appear consistently on certain items (40).

Pt. Mea. Corr. is a measure used to assess item polarity, whether the item moves in the same direction as the construct or not. Positive and high values, between 0.40 and 0.85, indicate that the item moves in the same direction as the

construct, meaning that respondents with high abilities tend to answer the item correctly or choose the higher category (38,48). Based on the Pt. Mea. Corr. values, only 4.2% (PSSA_EU5 and PSSA_SR2) were outside the ideal range of 0.40 to 0.85. This indicates that the PSSA_EU5 and PSSA_SR2 items did not move in the same direction as the construct measured in the GLSS. Overall, although there are still some items that show misfit or deviant response patterns, the majority of items (26 out of 48 items) have shown performance consistent with the Rasch model. Improvements to misfit items are needed to make the GLSS stronger in measuring constructs consistently and validly.

Unidimensionality

Unidimensionality is an important aspect of construct validity, as it ensures that all items in an instrument measure one main construct. If this is not fulfilled, the results of item and person parameter estimates in the Rasch model may be biased and do not reflect actual ability (63,64). In this study, PCAR analysis was used to evaluate whether there were other hidden dimensions in the residuals, apart from the main dimension being measured. Based on commonly used thresholds, the GLSS is considered unidimensional if the raw variance explained by measures exceeds 30% and the unexplained variance in the first contrast is less than 15% (65). A value of 36.6% for raw variance explained indicates that most of the data variance is indeed explained by the main dimension. Meanwhile, the unexplained variance value of 8.9% in the first contrast indicates that there are no additional dimensions strong enough to be considered as other constructs.

Thus, these results support that the items in the GLSS consistently measure one dimension, namely General Life Skills, which is relevant to the purpose of this scale in the context of preventing dating violence among Indonesian adolescents.

Item map

The Wright Map provides a very useful visual representation for assessing the balance between the ability level of respondents and the difficulty level of items. Items are grouped based on the Logit Value of Item (LVI) (66). In Rasch modeling, LVI is the main parameter that indicates the difficulty level of items and allows for linear comparison with the ability of respondents (52,67). Looking at the distribution in Figure 1, it can be seen that although the range of item difficulty levels is fairly even, the items are dominated by two levels: difficult and easy. This means that most items measure respondents with medium to high and medium to low abilities, but only a few specifically target groups with very low or very high abilities. This distribution is not entirely ideal, especially when the measurement objective is to reach all ability groups with the same precision. This imbalance becomes more apparent with a logit gap of 1.04 between two items that should fill the “very easy” area. This gap indicates that no item can fill the ability range between these two points. As a result, respondents with abilities in the empty logit range may not be accurately measured because there are no items that truly represent their ability level (52,68).

This imbalance can lead to a loss of information and a decrease in measurement accuracy, especially for respondent groups that happen to be in areas not covered by the items. Therefore, one suggested solution is to add items with an appropriate level of difficulty to fill the logit gap. This would make the measurement tool more comprehensive and enable it to measure the entire spectrum of respondents' abilities more validly and reliably (52,69).

CONCLUSION

This study successfully tested the psychometric properties of the General Life Skill Scale (GLSS) as it relates to sexual violence education readiness among dating adolescents. Based on the results of analysis using Rasch modeling, the GLSS has acceptable psychometric characteristics. This is supported by excellent internal reliability, person reliability, and item reliability values. The GLSS can differentiate respondents into five ability strata and items into six levels of difficulty. A total of 26 out of 48 items met the standards for good fit to the Rasch model, and 26 items were spread across two developed constructs, namely 11 items representing the personal skill construct and 15 items representing the social skill construct. The unidimensionality analysis results support that the GLSS measures the main construct consistently and that 26 items are spread across four levels of difficulty. However, the results of item mapping on the Wright Map showed logit gaps between items that could affect measurement accuracy in certain respondent groups. Therefore, the addition of items with appropriate difficulty levels is needed to improve the coverage of the ability range and measurement precision. Overall, the GLSS is suitable for use as a valid and reliable instrument for

measuring adolescents' life skills in the context of sexual violence prevention education. Therefore, GLSS not only serves as an evaluative tool for dating violence prevention programs but also has significant diagnostic utility.

This study makes a significant contribution by developing and reporting the psychometric properties of the General Life Skills Scale (GLSS) as an important skill for preventing dating violence. However, several limitations should be noted. First, the use of convenience sampling may limit the generalization of findings to a broader adolescent population. Second, this study did not perform Differential Item Functioning (DIF) analysis to test measurement invariance across demographic variables such as gender, school type, and socioeconomic background. Local dependency between items was also not examined, which could potentially affect Rasch parameter estimates. In addition, cross-validation with an independent sample and testing for cross-cultural invariance in the diverse Indonesian context have not been conducted. Therefore, further research may consider multi-group Rasch analysis to assess measurement invariance across genders, regions, and school types; conduct DIF examinations to identify item function differences in population subgroups; evaluate local dependence using Q3 statistics; and perform cross-validation with samples from various regions. In addition, further development of the scale through the addition or revision of items in the very easy difficulty range can help fill logit gaps, improve item distribution, and increase measurement accuracy across the entire range of respondent abilities.

AUTHOR'S CONTRIBUTION STATEMENT

Suci Musvita Ayu contributed to designing the research, collecting data, performing Rasch analysis, interpreting the results, and drafting the manuscript. Zahroh Shaluhiyah, Bagoes Widjanarko, and Ani Purwanti contributed by providing overall supervision of the research process, assisting in concept formulation, validating the methodology, reviewing and revising the manuscript, and providing guidance during the publication process.

CONFLICTS OF INTEREST

Both authors declare that they have no competing interests.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the drafting process, we used generative artificial intelligence (AI) tools or AI-supported technology. ChatGPT was used to improve quality and ensure sentence consistency, maintain coherence between sentences within paragraphs, evaluate the clarity and direction of the narrative flow in the manuscript, and improve academic language standards. DeepL and Grammarly were used to support text translation and improve grammatical clarity in the manuscript.

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