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ORIGINAL PAPER

Adaptation and Validation of the Mindful Student Questionnaire in Chinese

Qiu Wang[1] · Yiqi Wu[2] · Ruohan Feng[1] · Xin Hao[3] · Joshua C. Felver[4] · Ying Zhang[5] · Rachel Razza[6]

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Abstract

Objectives The current study examined the reliability and validity of the Mindful Student Questionnaire (MSQ) among a sample of Chinese vocational school students.

Method Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) models were fitted using MSQ and Student Subjective Wellbeing Questionnaire (SSWQ) data collected from 2910 adolescent students. Factor structure analysis, reliability, convergent validity, and predictive validity were examined to investigate the psychometric properties of MSQ.

Results The EFA indicated that a 3-factor solution (i.e., mindful attention, mindful acceptance, and approach and persistence) was most suitable for the MSQ in the study sample. This 3-factor CFA model indicated that inter-factor correlations were different from those originally reported by the scale developer in a US adolescent student sample. The reliability coefficients (Cronbach's alpha and composite reliability) were acceptable. Discriminative, convergent, and predictive validity were demonstrated through the MSQ's relation with the SSWQ.

Conclusions The 15-item, 3-factor MSQ demonstrates strong reliability and validity, offering a new multidimensional model of MSQ to assess mindfulness among Chinese adolescents in a school setting.

Preregistration This study is not preregistered.

Keywords Mindfulness · Psychological flexibility · Adolescent · Validation · Reliability · Vocational school

Exploring and harnessing the power of mindfulness in youth groups is a rapidly growing research trend (Dunning et al., 2019; Schutt & Felver, 2020). Additionally, the application of mindfulness has been steadily increasing in clinical and educational settings to help students from kindergarten to 12th grade (Lucas-Thompson et al., 2019). School-based Mindfulness-Based Programs (MBPs) include a wide range of activities (e.g., meditation, yoga, body scanning, and mindful eating) as well as various topical areas of focus, including mental health promotion, well-being, stress reduction, and cognitive ability (Gouda et al., 2016; Zenner et al., 2014). Developing effective curricula or treatment packages tailored to students' specific needs is critical to the success of school-based MBPs (Diamond, 2010; Renshaw, 2020). Furthermore, a rigorous multidimensional mindfulness instrument is essential for adolescents to assess their progress in various facets of MBPs (e.g., mindful attention and mindful acceptance), and would be highly useful to develop and evaluate future interventions. Although multidimensional self-report mindfulness assessment scales for adults are well-developed, there is a current lack of such assessment scales that are theoretically coherent and contextually appropriate for use with culturally diverse student populations (Goodman et al., 2017; McKeering & Hwang, 2019; Schutt & Felver, 2020).

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✉ Qiu Wang
wangqiu@syr.edu

1 School of Education, Syracuse University, 350 Huntington Hall, Syracuse, NY 13210, USA

2 The Education University of Hong Kong, Hong Kong, China

3 Department of Psychology, Syracuse University, Syracuse, NY, USA

4 Bronfenbrenner Center for Translational Research, College of Human Ecology, Cornell University, Ithaca, NY, USA

5 Department of Psychology, Clarkson University, Potsdam, NY, USA

6 Falk College of Sport & Human Dynamics, Syracuse University, Syracuse, NY, USA

Despite the fact that some multidimensional mindfulness scales have been well-developed and are helpful to advance the understanding of adults' mindfulness, there is a relative dearth of measurement validation research among diverse adolescent populations (Goodman et al., 2017; Guerra et al., 2019; Pallozzi et al., 2017). According to a systematic review of the use of mindfulness measures with adolescents, multidimensional measures such as the Kentucky Inventory of Mindfulness Skills (Baer et al., 2004) and the Five Facet Mindfulness Scale (FFMQ; Baer et al., 2006; Deng et al., 2011) appeared to be more limited in their adaptability for adolescents, underscoring calls for future research and development efforts (Pallozzi et al., 2017). Additionally, individuals' introspective self-perception may lead to biased ratings due to cultural influences (e.g., social desirability) on how individual self-report mindfulness (Brown et al., 2007; Grossman, 2015). These neglected socio-cultural influences may significantly impact the measurement validity mindfulness scale in diverse populations, and further studies are thus needed to examine whether translated mindfulness scales are appropriate for cross-cultural use among non-native English speakers (Cheung et al., 2020). Thus, there is a need to validate self-report mindfulness scales across an internationally diverse population of adolescents in order to advance the field of mindfulness research among culturally diverse adolescent populations (Bergomi et al., 2013).

Mindfulness is currently attracting much scholarly attention and a variety of advanced studies in China have been developed among school population. We summarized the results from articles with adolescents in China published in the past 5 years (2018–2023; see Table S1 in the Supplementary Information) and found a lack of studies on the development and validation of mindfulness scales with youth in China during this time. Although the Child and Adolescent Mindfulness Measure (CAMM; Greco et al., 2011) and Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003) were the most frequent scales in studies among Chinese students and contribute to the broad understanding of adolescent mindfulness in China, there are notable limitations. Mindfulness is typically considered a multi-faceted construct that includes measurement of various specific subordinate components (e.g., FFMQ; Baer et al., 2006); however, the MAAS and CAMM are only measured with a unidimensional (i.e., 1-factor) latent structure (Ma & Fang, 2019; Wang et al., 2021; Yang et al., 2019). Furthermore, given that heterogeneity of mindfulness practices (Felver et al., 2023) may correspondingly result in various effects to different components of mindfulness (Roeser et al., 2023), unidimensional measurements of mindfulness may be inadequate to capture the consequences and inner mechanisms of mindfulness practices (Goodman et al., 2017; Hölzel et al., 2011). Also, these scales present challenges for researchers to assess subordinate facets of mindfulness among adolescents in non-Western cultural contexts and to explore the multi-faceted mindfulness structure than multidimensional scales (Ma & Fang, 2019; Wang & Kong, 2020). To advance the study of mindfulness in culturally diverse adolescent populations, the current research aimed to translate and validate a multidimensional adolescent self-report mindfulness questionnaire.

The scale selected for translation and adaptation, the Mindful Student Questionnaire (MSQ; Renshaw, 2017), is a 15-item mindfulness scale designed for adolescents that consists of three dimensions: *mindful attention scale* (MATS; the ability to regulate an individual's attention to focus on the present moment), *mindful acceptance scale* (MACS; the behavior of awareness and adaptability of the present moment), and *approach and persistence scale* (APS; the ability to persist in the long-term goal while accepting difficult life situations). Approach and persistence are aspects of psychological flexibility (Hayes et al., 2006), which refers to students' abilities to regulate and persist with behaviors for potentially valuable outcomes. The development and validation of the MSQ in the USA identified a 3-factor construct that addressed an unmet need to measure the students' mindfulness using a more comprehensive multidimensional scale structure, which in turn affords the opportunity to explore inter-factor relationships among these aspects of mindfulness (Renshaw, 2017). Renshaw (2017) asserted that the MSQ's tripartite structure of mindfulness encapsulated an interconnected and synergistic system, thereby offering a more comprehensive representation of the underlying mechanisms inherent in mindfulness-based practices. This three-dimensional model, thus, responds to the scholarly demand for a nuanced measurement and understanding of the intricate interrelationships among mindfulness subcomponents, thereby elucidating the complexity of the mindfulness process (Christopher et al., 2009; Grossman, 2015; Renshaw, 2017). Additionally, the MSQ was designed for the adolescent population by including school-specific items (e.g., "When I am feeling bad at school, I still…") to help interpret mindfulness within the school context.

Renshaw (2017) preliminarily validated the MSQ with a middle school sample in the USA and recommended a larger and more diverse youth sample for further validation. The present study was intended to examine whether the translated version of the MSQ demonstrates acceptable reliability and validity among adolescent school students in China. The aim of the current study was to assess the psychometric properties of the translated MSQ. First, the factor structure of the translated MSQ was explored and validated. Second, the scale reliability and internal consistency were examined (Cronbach's alpha and McDonald's omega; McDonald, 1999). Third, the convergent validity and discriminant validity of MSQ were calculated with criterion indicators of the Student Subjective Well-being Scale (SSWQ; Renshaw et al., 2015). Last, hierarchical regression was employed to evaluate the

Table 1 Socio-demographic and family characteristics of participants ($n = 2910$)

	Frequency	%
Gender		
Male	1891	64.98%
Female	1019	35.02%
Residence		
Rural	2659	91.37%
Township	153	5.26%
City	98	3.37%
Grade		
Grade 10	1520	52.23%
Grade 11	349	11.99%
Grade 12	1041	35.77%
Parental educational level		
Father		
Junior high school and below	2410	82.82%
Senior high school	460	15.81%
College/university	40	1.37%
Mother		
Junior high school and below	2518	86.53%
Senior high school	354	12.16%
College/university	38	1.31%

predictive validity and incremental validity with subscale scores of the SSWQ.

Method

Participants

Under the rule of thumb defined by Comrey and Lee (1992), a sample size of 1000 + is an optimal condition to run factor analysis models. A minimum sample size ($n = 1125$) was determined by the power analysis (MacCallum et al., 1996; Preacher & Coffman, 2006) with the following parameter settings: type I error (alpha) of 0.05, a preferred power value of 0.80, the RMSEA (root mean square error of approximation) value of 0.05, and degrees of freedom ($df = 63$) of the proposed model. A total of 2910 adolescents aged 15–18 years ($M = 17.53$, $SD = 0.95$) participated in this study. Participants included 1891 males (64.98%) and 1019 females (35.02%). Participant demographics are shown in Table 1. All participants were native Mandarin Chinese speakers and were enrolled in a vocational school at the time of the study.

Procedure

Students and their guardians were informed at the beginning of the voluntary nature of participation and the data anonymity. Before collecting the data, the potential participants and their guardians were asked to sign the student assent and parental informed consent form, respectively. Then, school administrative staff were invited to distribute the questionnaire link to online WeChat group via the widely used survey platform *Tencent Questionnaire* (Tencent, 2022 https://wj.qq.com/mine.html), and students finished the questionnaires under the guidance of their guardians at home.

Among 2910 participants, we randomly selected 50% of males ($n = 1891$) and females ($n = 1019$) using the SPSS random selection algorithm, respectively, which resulted in two equal-sized samples for the exploratory factor analysis (EFA; $n = 1455$) and the confirmatory factor analysis (CFA; $n = 1455$). Either EFA or CFA sample size was greater than the required minimum sample size ($n = 1125$) determined by the power analysis (MacCallum et al., 1996; Preacher & Coffman, 2006).

Measures

Measures are composed of demographic questions and two questionnaires. The demographic questionnaire contained survey items regarding the participants' age, grade, gender, birthplace, parents' education level, understanding of mindfulness, and previous mindfulness practice experience.

Translation and Cross-cultural Adaptation

The translation process was composed of four steps (see Supplementary Figure S1) based on Valmi's model (Sousa & Rojjanasrirat, 2011; Zmnako & Chalabi, 2019). First, two independent translators who were native Chinese speakers and graduate students in psychology translated the original MSQ from the source language (English) into the target language (Chinese, see Table S6 in the Supplementary Information). The 1st, 2nd, 3rd, and 4th authors discussed and compared the two forward-translated versions, and they resolved the ambiguities and discrepancies. For example, researchers discussed and decided on the final version of "when my thoughts come and go" when two translated versions of this item appeared to be different. The revised simplified Chinese version was ready for the blind back-translation process. Two bilingual translators who were native English speakers back translated the revised Chinese version into English, and they were completely blind to the original version of the MSQ. Finally,

the 1st, 2nd, 3rd, and 4th authors joined in resolving the inconsistencies between the two back-translated versions and the original scale. Any ambiguities regarding cultural background in words or sentences between the two blind back-translations and the original English version of the MSQ (Renshaw, 2017) were discussed to reach a full consensus and complete agreement.

Mindful Student Questionnaire

The three-dimensional questionnaire (Renshaw, 2017) measures students' mindful attention (MATS), mindful acceptance (MACS), and approach and persistence (APS) using 15 items, five items that tap each dimension. All MSQ items are positively phrased, and example items include "When I am at school, I notice when my feelings change from good to bad" (MATS), "When I am feeling bad at school, I still have a good attitude" (MACS), and "When I am doing something hard at school, I try to work and work to get it right" (APS). Students responded to each item on a 5-point Likert scale. Neither the whole-scale Cronbach's alpha- nor McDonald's omega-values were available. The three subscale Cronbach's alpha coefficients with the US middle school adolescents ranged from 0.77 to 0.90 (Renshaw, 2017).

Student Subjective Wellbeing Questionnaire (SSWQ)

The SSWQ is a self-report measure rated on a 4-point Likert scale and is commonly used in assessing adolescents' positive psychological functioning at school (Renshaw et al., 2015). The SSWQ consists of 16 items comprising four subscales: Joy of Learning (e.g., "I get excited about learning new things in class"), School Connectedness (e.g., "I feel like I belong at my school"), Educational Purpose (e.g., "I feel like the things I do at school are important"), and Academic Efficacy (e.g., "I am a successful student"). Cronbach's alpha coefficients ranged between 0.76 and 0.86 in the original SSWQ (Renshaw, 2017; Renshaw et al., 2015). The Chinese version of SSWQ had satisfying composite reliability measures (McDonald's omega; McDonald, 1999): 0.82 for Joy of Learning, 0.82 for School Connectedness, 0.82 for Educational Purpose, 0.80 for Academic Efficacy, and 0.94 for the total (Zhang et al., 2018). The Chinese version of SSWQ evidenced adequate reliability in our study sample; Cronbach's alphas were as follows: 0.84 for Joy of Learning, 0.83 for School Connectedness, 0.85 for Educational Purpose, 0.85 for Academic Efficacy, and 0.95 for the whole scale.

Data Analyses

EFA was used to determine the factor structure of the MSQ. In EFA, we used the first split-half sample ($n = 1455$) and examined 3-factor structure solutions: 1-factor, 2-factor, and 3-factor models (Preacher et al., 2013). Besides the goodness of model fit indices, three rules of thumb were used to determine the number of factors: the Kaiser–Meyer–Olkin measure of sampling adequacy (KMO > 0.80) with Bartlett's sphericity test, the item communalities (between 0.25 and 0.40 acceptable, closer to one the better) (Beavers et al., 2013), and the factor loadings (> 0.32; Kahn, 2006). When the sample size is larger than 200, Tabachnick and Fidell (2013) argued that multivariate factor analysis is robust using data with acceptable values of skewness and kurtosis. For example, kurtosis between − 2 and + 2 is considered acceptable. Hair et al. (2018) and Byrne (2016) suggested an acceptable skewness range from − 2 to + 2, along with a more liberal kurtosis range from − 7 to + 7.

Following EFA, we further ran the CFA to examine the 3-factor model's goodness of fit using the second split-half sample ($n = 1455$). The analysis was conducted using Mplus Version 8.8 (Muthén & Muthén, 1998–2017), and the maximum likelihood extraction method (ML) was employed. The factor structure of EFA was obtained through the oblique rotation (e.g., Geomin) to allow correlated factors. We used multiple indices to evaluate both EFA and CFA models' goodness of fit (Hu & Bentler, 1999). In addition to chi-square (χ^2), degree of freedom (*df*), Akaike's Information Criteria (AIC), and Bayesian Information Criteria (BIC), other model fit indexes (West, et al., 2012), e.g., χ^2/df ratio (< 5), Comparative Fit Index (CFI > 0.95), Tucker Lewis index (TLI > 0.95), Root Mean Square Error of Approximation (RMSEA < 0.06), and Standardized Root Mean Square Residual (SRMR < 0.08).

Three types of reliability measures, Cronbach's alpha, rho_a, and rho_c, were calculated to evaluate the subscale internal consistency. Cronbach's alpha is the conservative lower bound of the true internal consistency reliability (Trizano-Hermosilla & Alvarado, 2016). The composite reliability rho_c (Jöreskog, 1971) and the reliability coefficient rho_a (Dijkstra & Henseler, 2015) are generally greater than Cronbach's alpha. Five thousand bias-corrected and accelerated (BCa) bootstrap samples generated the 95% bias-corrected confidence interval (CI) for each reliability coefficient's significance testing (Hair et al., 2022). The bias-corrected and accelerated (BCa) bootstrap was developed by Efron (1987) and derived estimates of standard errors and confidence intervals for complex estimators including correlation coefficients. BCa was the most recommended method due to its power in adjusting for both bias and skewness in the bootstrap distribution (Hair et al., 2022). If the value of 0 is not in the 95% BCa confidence interval, it indicates that the correlation coefficient is statistically insignificant from 0. The reliability and internal consistency of the MSQ were assessed by reporting its Cronbach's alpha (> 0.70) and the McDonald's composite reliability (MCR, > 0.60; McDonald, 1999). Based on the item loading results, AVE (average variance extracted, > 0.50) was analyzed in reporting the discriminant

Table 2 The 15-item MSQ's unrotated factor matrix of 3-factor EFA with eigenvalues and goodness-of-fit indices ($n = 1455$)

Item statement	Eigenvalues		
	F_1 (MATS)	F_2 (MACS)	F_3 (APS)
When I am at school, I notice *when my feelings change from good to bad*	**0.65***	−0.04	0.03
... *how other people feel and act*	**0.70***	0.18	−0.02
... *the many things that happen around me*	**0.60***	0.15	−0.00
... *when my thoughts come and go*	**0.68***	−0.02	0.06
... *how other people react to what I do*	**0.65***	0.01	0.00
6. When I am feeling bad at school, I still *have a good attitude*	0.03	**0.71***	0.01
... *am kind to myself*	−0.02	**0.79***	−0.08*
... *think nice thoughts*	0.00	**0.77***	0.02
... *stay calm*	−0.02	**0.61***	0.14*
... am friendly to others	0.09*	**0.54***	0.24*
11. When I am doing something hard at school, I try to *work and work to get it right*	0.03	0.01	**0.80***
... do the best I can	0.04	0.02	**0.83***
... *focus on doing a good job*	−0.02	0.01	**0.86***
... *keep going until I finish*	−0.02	0.05	**0.79***
... *do everything I can to do well*	−0.02	0.02	**0.79***
F_1	1.00		
F_2	[a]0.05	1.00	
F_3	[a]0.09	[a]0.68*	1.00
$\chi^2_{63} = 1181.35$	RMSEA = 0.04	CFI = 0.99	SRMR = 0.01
$\chi^2/df = 2.88$	90% C.I. = [0.03, 0.04]	TLI = 0.98	AIC = 53,706.06

MATS, mindful attention scale; *MACS*, mindful acceptance scale; *APS*, approach and persistence scale. [a]Inter-factor correlations of the EFA model
*$p < 0.05$

validity of the MSQ. Convergent validity was estimated by testing the correlation between the MSQ and the SSWQ. The subscale internal consistency reliability, convergent validity, and discriminant validity were systematically evaluated with 5000 bootstrap samples using SmartPLS Version 4 (Ringle et al., 2014). Finally, we examined the predictive validity through hierarchical regression, in which MSQ scores were used to predict scores of SSWQ with ΔR^2 (change in coefficient of determination) as the predictive criterion measure. The analysis was performed in IBM SPSS Statistics (Version 27).

Results

Item-wise descriptive statistics are displayed in Supplementary Table S2, along with communalities that were derived using the maximum likelihood method. The first five items (Item 1 to Item 5) had means from 3.10 to 3.44, the second five (Item 6 to Item 10) from 4.03 to 4.35, and the third five (Item 11 to Item 15) from 3.75 to 4.19. The 15 communality values were from 0.38 to 0.73, which surpassed the common minimum value of 0.30, indicating an acceptable percentage of variance explained by the factor model (Beavers et al., 2013). The skewness and kurtosis values were in the acceptable range from −2 to 2, which supported the use of maximum likelihood estimation to retrieve factors in EFA.

The Kaiser–Meyer–Olkin measure was 0.913, with a statistically significant Bartlett's sphericity test ($\chi^2 = 10042.72$, $df = 105$, $p < 0.001$), which indicated the sampling adequacy to conduct EFA. Three EFA models (e.g., 1-factor, 2-factor, and 3-factor models) were conducted to examine the factor structure of MSQ. The 3-factor model achieved the best goodness-of-fit results: $\chi^2 = 181.35$, $df = 63$ ($p < 0.001$); $\chi^2/df = 2.88$, RMSEA = 0.04, with a 90% CI [0.03, 0.04]; CFI = 0.99, TLI = 0.98, SRMR = 0.01, AIC = 52693.01, and BIC = 53073.37, compared to the 1-factor solution ($\chi^2 = 3071.21$, $df = 90$; $\chi^2/df = 34.13$, RMSEA = 0.15, with a 90% CI [0.15, 0.16]; CFI = 0.70, TLI = 0.65, SRMR = 0.13, AIC = 55528.87, BIC = 55766.59) and 2-factor solution ($\chi^2 = 1220.40$, $df = 76$; $\chi^2/df = 16.06$, RMSEA = 0.10, with a 90% CI [0.10, 0.11]; CFI = 0.89, TLI = 0.84, SRMR = 0.05, AIC = 53706.06, BIC = 54017.74). The 3-factor model, supported by the scree plot with the parallel analysis (Horn, 1965; see Supplementary Figure S2), was converged and consistent with the original structure in Renshaw (2017). The 15 items as designed in Renshaw (2017) were significantly

Table 3 The 15-item MSQ's 3-factor CFA results ($n = 1455$)

Items		Standardized loading (*SE*)	*M* (*SD*)
MATS ($\alpha = 0.78$; rho_c = 0.83; rho_a = 0.87; AVE = 0.51)[a]			3.27 (0.80)
mats1		0.61 (0.02)***	3.44 (1.05)
mats2		0.68 (0.01)***	3.41 (1.11)
mats3		0.68 (0.02)***	3.41 (1.08)
mats4		0.66 (0.02)***	3.17 (1.09)
mats5		0.67 (0.02)***	3.10 (1.12)
MACS ($\alpha = 0.86$; rho_c = 0.90; rho_a = 0.87; AVE = 0.65)[b]			4.18 (0.79)
macs1		0.71 (0.02)***	4.03 (1.06)
macs2		0.73 (0.01)***	4.29 (1.02)
macs3		0.80 (0.01)***	4.14 (1.02)
macs4		0.75 (0.01)***	4.09 (0.99)
macs5		0.76 (0.01)***	4.35 (0.91)
APS ($\alpha = 0.92$; rho_c = 0.94; rho_a = 0.92; AVE = 0.75)[c]			4.04 (0.81)
aps1		0.82 (0.01)***	4.03 (0.95)
aps2		0.84 (0.01)***	4.19 (0.91)
aps3		0.88 (0.01)***	4.13 (0.94)
aps4		0.78 (0.01)***	3.75 (1.03)
aps5		0.82 (0.01)***	4.11 (0.96)
$\chi^2_{86} = 372.91$	RMSEA = 0.05	CFI = 0.97	SRMR = 0.04
$\chi^2/df = 4.34$	90% C.I. = [0.04, 0.05]	TLI = 0.97	AIC = 51,957.17

[a]MATS' 95% CIs: Cronbach's alpha [0.76, 0.80]; rho_c [0.79, 0.86]; rho_a [0.86, 0.97]; AVE [0.45, 0.54]. [b]MACS' 95% CIs: Cronbach's alpha [0.85, 0.88]; rho_c [0.89, 0.91]; rho_a [0.85, 0.88]; AVE [0.62, 0.68]. [c]APS' 95% CIs: Cronbach's alpha [0.91, 0.92]; rho_c [0.93, 0.94]; rho_a [0.91, 0.93]; AVE [0.73, 0.77]

***$p < 0.001$

loaded with strong loadings (> 0.50) on MATS, MACS, and APS, respectively (Table 2). The largest cross-loading of Item 10 on APS (0.24) was significant ($p < 0.05$), but smaller than the minimum cutoff value of 0.32. It further indicated that Item 10 ("When I am feeling bad at school, I still I am friendly to others") should be loaded as it was originally designed on factor MACS.

The inter-item correlations of 15 items ranged from − 0.00 to 0.74 (see Supplementary Table S3), further indicating satisfactory convergent and discriminant validity. The range of within-factor item correlations was from 0.37 to 0.48 in factor MATS, from 0.48 to 0.58 in MACS, and from 0.62 to 0.72 in APS. The range of between-factor item correlations was from − 0.00 to 0.19 for MATS, from − 0.00 to 0.52 for MACS, and from − 0.01 to 0.52 for APS. The cross-factor inter-item correlation between Item 10 and Item 12 was 0.52, which is smaller than the lowest correlation coefficient in the inter-item correlation in factor APS. This also suggested that Item 10 should be loaded on factor MACS rather than on APS. In order to account for this inter-item correlation, we used "a correlated uniqueness approach" (Brown, 2015, p. 40) by allowing Item 10's residual to be correlated with Item 12's in the CFA (see Figure S3).

Following EFA, we fit the 3-factor CFA model using the second sample ($n = 1455$). The 3-factor CFA model achieved the goodness-of-fit results: $\chi^2 = 372.91$, $df = 86$ ($p < 0.001$); $\chi^2/df = 4.34$, RMSEA = 0.05, with a 90% CI [0.04, 0.05]; CFI = 0.97, TLI = 0.97, SRMR = 0.04, AIC = 5195.17, BIC = 52216.02). Table 3 summarizes item-wise descriptive statistics and factor loading values on each dimension of MSQ. The range of items loading from 0.61 to 0.68 in factor MATS, from 0.71 to 0.80 in MACS, and from 0.78 to 0.88 in APS. All these items fit well in each dimension, and all 15 factor loadings were statistically significant ($p < 0.001$; Table 3). Item 10's residual was statically correlated with Item 12's ($r = 0.14$, $p = 0.031$) in the CFA (Figure S3). Cronbach's alpha and MCR of the whole scale were 0.85 and 0.92, respectively. The subscale internal consistency reliability, convergent, and discriminant validity were systematically evaluated with 5000 bootstrap samples using SmartPLS Version 4 (Ringle et al., 2014). The predictive/incremental validity was later examined using hierarchical regression in SPSS.

Three types of reliability measures, Cronbach's alpha, rho_a, and rho_c, were calculated to evaluate the subscale internal consistency. Table 3 summarizes the reliability

Table 4 The MSQ's subscale correlations and HTMT indices for validity analysis

Subscale	Inter-factor correlation (HTMT index)[c]			Sqrt. (AVE)[b]
	MATS [95% CI]	MACS [95% CI]	APS [95% CI]	
MATS	—	(0.20)[c]	(0.18)[c]	0.71 (0.50)
MACS	0.10**	—	(0.78)[c]	0.81 (0.65)
APS	0.09**	0.72***	—	0.86 (0.75)
Joy of learning[a]	−0.03 [−0.09, 0.03]	0.32** [0.26, 0.38]	0.38** [0.32, 0.43]	-
School connectedness[a]	−0.06* [−0.13, −0.00]	0.32** [0.26, 0.38]	0.33** [0.28, 0.39]	-
Educational purpose[a]	0.003 [−0.06, 0.06]	0.34** [0.28, 0.39]	0.36** [0.31, 0.42]	-
Academic efficacy[a]	−0.07** [−0.14, −0.01]	0.29*** [0.23, 0.35]	0.36** [0.30, 0.41]	-
SSWQ	−0.04 [−0.11, 0.02]	0.34** [0.28, 0.40]	0.39** [0.33, 0.44]	-

MSQ, mindful student questionnaire. [a]The four subscales of *SSWQ* (student subjective wellness questionnaire) were also used for predictive and incremental validity analysis (Renshaw, 2017). The correlation effect size cutoffs (Cohen, 1988) are as follows: > 0.10 (small), > 0.30 (medium), and > 0.50 (large). [b]The minimum AVE values of 0.5 indicated convergent validity. The square root of AVE should be larger than the inter-factor correlation to demonstrate discriminant validity. [c]The heterotrait-monotrait (HTMT) values should be lower than 0.85 to indicate discriminant validity, and/or the 95% CI should not contain 0.85

*$p < 0.05$; **$p < 0.01$; ***$p < 0.00$

coefficients and the 95% CIs of Cronbach's alpha, rho_a, and rho_c. The three subscale Cronbach's alpha coefficients were 0.783 with a 95% CI [0.76, 0.80] in MATS, 0.86 with a 95% CI [0.85, 0.88] in MACS, and 0.92 with a 95% CI [0.91, 0.92] in APS. All coefficients and their 95% CIs surpassed the cutoff 0.70, indicating significantly satisfactory reliabilities at 0.05 level. In addition, we computed the McDonald's composite reliability (MCR; McDonald, 1999) of each dimension: 0.79 in MATS, 0.86 in MACS, and 0.91 in APS. All three MCR values were larger than the cutoff 0.60 indicating a desirable level of composite reliability (McDonald, 1999). All three rho_c coefficients and their 95% CIs surpassed the cutoff 0.70 to display significantly satisfactory subscale reliabilities: rho_c = 0.83 with a 95% CI [0.79, 0.86] in MATS; rho_c = 0.90 with a 95% CI [0.89, 0.91] in MACS; and rho_c = 0.94 with a 95% CI [0.93, 0.94] in APS. Similarly, the three subscales had significantly acceptable rho_a coefficients and their 95% CIs did not contain the cutoff value of 0.70. MATS' reliability rho_a was 0.87 with the 95% CI [0.86, 0.97]. The reliability rho_a was 0.87 with the 95% CI [0.85, 0.88] in subscale MACS. The subscale APS'rho_a was 0.92 with the 95% CI [0.91, 0.93].

The average variance extracted (AVE) was the metric used for evaluating a subscale's convergent validity. The minimum acceptable AVE is 0.50, indicating the factor (e.g., MATS) should explain at least 50% of the variance in the five MATS items (Hair et al., 2022). As reported in Table 4, the AVE values were larger than or equal to the cutoff (0.50), indicating the convergent validity in the subscale MATS (AVE = 0.50, 95% CI = [0.45, 0.54]), in MACS (AVE = 0.65, 95% CI = [0.62, 0.68]), and in APS (AVE = 0.75, 95% CI = [0.73, 0.77]). Convergent validity requires that the square root of a factor's AVE must be greater than the inter-factor correlation (Fornell & Larcker, 1981). The last column of Table 4 lists the square root of each factor's AVE. The inter-factor correlations were 0.10 (between MATS and MACS), and 0.09 (MATS with APS), respectively, both of which were smaller than 0.71, the square root of MATS' AVE. The inter-factor correlation between MACS and APS was as large as 0.72 (> 0.50; Cohen, 1988), but it was less than either the square root of MACS's or APS's AVE. Thus, this analyses of AVE indicates satisfactory convergent validity in the 3 subscales.

The HTMT (heterotrait-monotrait) should be less than 1, with the value < 0.85 as a favorable index of discriminant validity (Henseler et al., 2015). The HTMT between MACS and APS was 0.78, with the 95% CI = [0.74, 0.82] without containing 0.85, which indicated a significantly favorable discriminant validity at 0.05 level. Similarly, discriminant validity was established between MATS and APS (HTMT = 0.18, 95% CI = [0.11, 0.25]) and between MATS and MACS (HTMT = 0.20, 95% CI = [0.14, 0.26]).

To establish predictive and incremental validity, the 4 subscales of SSWQ were correlated with and regressed on the 3 subscales of MSQ using SPSS. SSWQ's 4 subscales were Joy of learning (abbreviated as Joy), School connectedness (abbreviated as Con), Educational purpose (abbreviated as Pur), and Academic efficacy (abbreviated

to AE). Table 4 presents the inter-subscale correlation matrix of 3 factors of MSQ (MATS, MACS, and APS) and four factors of SSWQ (Joy, Con, Pur, and AE). Both MACS and APS had significant medium correlations with well-being factors in the range from 0.29 to 0.38. Further, we noticed that vocational school students' APS had relatively stronger correlations with well-being subscales than MATS and MACS. MATS had statistically significant but "trivial" (< 0.10; Cohen, 1988) negative correlations with students' school connectedness and academic self-efficacy. As shown in Table S4, when we established the MSQ's predictive and incremental validity on Joy and Pur, the irrelevant factor MATS was excluded from the analysis to avoid a poor-model-fit problem of *zero* or *negative adjusted* R^2 (e.g., Karch, 2020). MSQ's MACS and APS together significantly explained 17% (eta-square = 0.17, $p < 0.001$) of the total variation of the subscale Joy, and 17% of the subscale Pur (eta-square = 0.17, $p < 0.001$). The 3 MSQ subscales together significantly predictively explained 17% of variation in Con (eta-square = 0.17, $p < 0.001$), 18% of AE (eta-square = 0.18, $p < 0.001$), and 21% of the whole SSWQ scale (eta = 0.21, $p < 0.001$). These larger effect sizes (eta-square > 0.14; Cohen, 1988) indicated that the MSQ subscales simultaneously worked together to generate large predictive and incremental effects in explaining the SSWQ total and subscales.

In the final step, the hierarchical regression results from 5000 bootstrap samples further established the MSQ's predicative and incremental validity. As demonstrated in Supplementary Table S4, MSQ's subscales MATS, MACS, and APS were included in the first, second, and third steps in each sequential regression. Specifically, MSQ's 2 subscales, MACS and APS, were statistically *positively* associated with the total SSWQ and with the 4 SSWQ subscales. In contrast, MATS was *negatively* associated with the total SSWQ and 2 SSWQ subscales (i.e., Cons and AE). These results are summarized in Table S4. The statistically significant *R*-square changes (ΔR^2) of the hierarchical linear regressions indicated that the subscales of the MSQ had established predictive and incremental validity. Nevertheless, we also found that the association between MSQ's MATS with Pur was positive but statistically insignificant with a trivial effect size.

The semi-/partial correlations (s_r/p_r; Cohen et al., 2003) further indicated predictive and incremental validity through the hierarchical linear regressions (see Supplementary Table S5). Specifically, a greater absolute value of s_r indicates a larger incremental validity. That is, the squared semi-partial correlation indicates how much *R*-square will *increase* if each MSQ's subscale is added to the regression. A greater absolute value of p_r indicates larger *predictive* validity. The squared partial correlation represents the unique contribution of an MSQ's subscale in the regression using MSQ to predict SSWQ. The subscale APS, compared with MATS and MACS, had the largest s_r and p_r values in predictive and incremental validity analyses using the SSWQ ($p_r = 0.23$, $s_r = 0.22$) and its subscales: Joy ($p_r = 0.23$, $s_r = 0.23$), Con ($p_r = 0.17$, $s_r = 0.16$), Pur ($p_r = 0.19$, $s_r = 0.18$), and AE ($p_r = 0.24$, $s_r = 0.22$). When the 3 MSQ subscales were simultaneously entered in the regression, MATS performed equally well or better than MACS to establish predictive and incremental effects on SSWQ and its subscales. For example, in predicting the SSWQ total score, MATS ($p_r = -0.12$, $s_r = -0.11$) worked comparably well as MACS ($p_r = 0.12$, $s_r = 0.11$). When predicting academic efficacy, MATS ($p_r = -0.14$, $s_r = -0.13$) outperformed MACS ($p_r = 0.08$, $s_r = 0.07$). Because APS and MACS had significantly large correlation ($r = 0.78 > 0.5$; Cohen, 1988), MACS' predictive and incremental effects were inevitably attenuated. In that situation, MATS played a supplementary role to add incremental power to negatively predict the total and sub-score of SSWQ in vocational students.

Discussion

Renshaw (2017) developed and preliminarily tested the psychometric properties of MSQ, a multidimensional mindfulness scale containing school-specific items for testing the youth's mindfulness at school. The primary goal of the current study was to examine the factor structure, reliability, and validity of the Chinese language version of the MSQ. Our study showed that the Chinese language version of MSQ is a reliable and valid instrument for assessing the mindfulness of adolescents in a school setting. Both the EFA and CFA of the current study support the 3-factor measurement structure among students. Consistent with the result of the previous study with adolescents in the USA by Renshaw (2017), the internal consistency and validity of the scale of the MSQ and its subscales (MATS, MACS, APS) are satisfactory.

The MSQ's 3 subscales in adolescent students had positively significant inter-factor correlations. However, the magnitude of the correlations was different from those in Renshaw (2017). The correlation of MATS-APS for Chinese students was attenuated compared to values in Renshaw (2017); however, the MACS-APS correlation was stronger than that reported in Renshaw (2017). The MATS-MACS correlation in Chinese students was not as strong as the value in the US student sample reported by Renshaw (2017). The attenuated relations of MATS with APS in Chinese students may suggest that attention, as a critical component in mindfulness, plays a debatable role in connecting with psychological flexibility (Lindsay & Creswell, 2017; Martínez-Rubio et al., 2021; Simione et al.,

2021; Veehof et al., 2011). In a study on participants with psychosis, for example, "observing attention" is negatively correlated with psychological flexibility when people overemphasize their internal and external experiences (White et al., 2013). Thus, we posit that cultural variations may play significant roles in these observed differences (Arthur et al., 2018; Haas & Akamatsu, 2019; Raphiphatthana et al., 2019). Furthermore, additional research could potentially elucidate cross-cultural differences to advance the field's understanding of MSQ's between-factor relationships.

The Unified Flexibility and Mindfulness model (UFM; Bergomi et al., 2013; Rogge & Daks, 2021) provided a much broader conceptualized framework of mindfulness that unifies the psychological flexibility and dimensions of mindfulness into a multistage framework. The UFM also proposed mindful acceptance and attention would facilitate the dimensions of "committed action" and "value" of psychological flexibility. Corresponding with the hypothesized structure in UFM, the present study found that psychological flexibility positively correlates with students' well-being (Daks & Rogge, 2020). In our analyses, the APS subscale stood out as a prominent predictor for both the overall SSWQ and its individual subscales including Joy of Learning, School Connectedness, Educational Purpose, and Academic Efficacy. This highlights that the Approach and Persistence subscale of MSQ may play a critical role in establishing predictive and incremental validity with the whole scale and subscales of SSWQ. A larger APS score indicates students' greater abilities to regulate and persist with behaviors that may result in potentially valuable outcomes while being adaptable to difficult life situations. The improved psychological flexibility was found to be beneficial in improving self-regulation in learning and coping with the stress among students (Asikainen et al., 2019; Hudyma, 2019).

The MSQ, specifically, the mindful attention scale (MATS), performed differently in the vocational students, which may be reflective of the academic and cultural differences in the population. MATS was not predictive of SSWQ's subscales, "Joy of learning," or "educational purpose." This finding is congruent with previous findings (Baer et al., 2006; Carpenter et al., 2019). Specifically, studies on FFMQ discovered that the "observing" factor (attention) is significantly related to psychological well-being in the population of meditators, but not in the populations of students or highly educated individuals (Baer et al., 2006). When the 3 MSQ subscales were simultaneously in the regression, MACS performed equally well or more powerfully than MATS to establish predictive and incremental effects on SSWQ and its subscales. This finding can be interpreted with Monitor and Acceptance Theory (Lindsay & Creswell, 2017), which posits that attention monitoring and acceptance are the fundamental mechanisms underlying the effects of mindfulness and mindfulness training. For example, acceptance skills alter how one responds to present-moment experiences and work in conjunction with attention skills in reducing affective reactivity and stress-related health consequences (Lindsay & Creswell, 2017). The current study supports the interactive Gestalt effect of acceptance and attention on well-being. More importantly, MATS cannot be evaluated out of the tri-factor structure of MSQ because attention skills are insufficient for cognitive functioning outcomes (Lindsay & Creswell, 2017). The MATS subscale holds significant importance as attention, a core feature of mindfulness, plays a critical role in fostering awareness. This underscores its essential nature in both theoretical understanding and practical application of mindfulness within the vocational student population.

MBPs in schools are becoming increasingly popular across the world (Zenner et al., 2014). However, there has been limited focus on the use of MBPs among Chinese youth at school, resulting in a lack of empirical evidence to support future intervention development (Jing et al., 2021). In terms of the necessity for cultural adaptation of existing evidence-based interventions, there is a clear need to test measurement validity cross-culturally to facilitate the extrapolation of the effectiveness of intervention in different countries (Bergomi et al., 2013). Additionally, given that adolescents may interpret the items on the mindfulness scale differently from other populations, the current study offers reliable evidence to support the MSQ is not only cultural adjustable but also adaptable for adolescents because of its school-based items (Pallozzi et al., 2017). Therefore, the results of this research suggest that the MSQ could be useful for future research regarding the relationship between mindfulness and clinical aspects, in terms of external behaviors (e.g., higher suicide rate in secondary school students), and for collecting data to the effectiveness of mindfulness intervention within the Chinese school context. However, future studies are warranted to examine the practical utility of the MSQ as outcomes measure on the school-based intervention cross-culturally and in various school settings (e.g., vocational school).

Limitations and Future Research

There are several limitations that exist in the present study. First, adolescents who attend vocational schools often are perceived as academically less competent by the main Chinese cultural values, which may result in unequal educational resources and social bias (Woronov, 2015), limited future academic success, lower level of well-being (Schoon & Silbereisen, 2009), increased life pressure, and less resilience in adversity (Chen et al., 2021; Seery & Quinton, 2016). Vocational school students in many countries (e.g., Israel, Denmark, and Dutch) faced the similar challenges

as students in China, such as high rate of dropout, lack of social support, higher frequency of suicidal behavior, and mental health problems (Andersen et al., 2015; Benatov et al., 2017; de Kroon et al., 2016). Thus, the future study may apply MSQ to students at general high schools to be able to compare with vocational school students and test the performance of MBPs among vocational students in other countries because the neglect of vocational high school students can be a global problem. Second, the current study followed Renshaw (2017) and did not include other mindfulness measures used for youth as criteria in the validity analysis. Third, the sole criterion measure, the SSWQ, is a self-report measure, which might be subject to different biases and limitations (e.g., common-method variance; Podsakoff et al., 2003; Poewakoff et al., 2012). Lastly, as Grossman and Van Dam (2011) pointed out, there is a lack of a "gold standard" to construct the mindfulness scale and most of the unidimensional scales are hard to present the mindfulness process. The novel model of MSQ proposed in this study may contribute to capturing the complexity of the mindfulness process, but further validation is required to articulate its generalizability to youth in diverse context.

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Author Contribution QW: designed and executed the study collected and analyzed the data, wrote the manuscript, contributed to the final version of the manuscript, and supervised the project. YW: designed and executed the study collected and analyzed the data, and wrote the manuscript. RF: designed and executed the study , collected and analyzed the data, searched and reviewed the literature, and wrote the manuscript. XH: designed and executed the study, searched and reviewed the literature, and wrote the manuscript. JF: contributed to the final version of the manuscript. YZ: contributed to the final version of the manuscript. RR: contributed to the final version of the manuscript. All authors approved the final version of the manuscript for submission.

Data Availability The authors were not allowed to share or upload the dataset following the ethics protocol and informed consent procedure of this study that ensured the participants that all data we collected were confidential and would not be shared. We will be glad to answer any questions about the data collected in this study and to share unpublished information on this dataset and code for data analysis.

Declarations

Ethics Approval All procedures were approved by the Institutional Review Board (IRB) at Syracuse University (Reference No. 22–173) and were in accordance with the ethical standards of the IRB and with the Helsinki Declaration of 1964 and its later amendments. Informed consent was obtained from all adolescents and their guardians included in the study.

Conflict of Interest The authors declare no competing interests.

Use of Artificial Intelligence AI was not used.

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