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The Sensory Classroom Teacher Questionnaire: A tool for assessing conducive classroom conditions for children with ADHD

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Physical classrooms provide immense sensory stimulation to children and inform behaviour, cognitive processes and psychological state of mind. Children diagnosed with any subtype of attention-deficit hyperactivity disorder (ADHD) are more likely to exhibit sensory integration/processing impairments that contribute to inappropriate behavioural and learning responses. Teachers need good information and user-friendly psycho-educational instruments to meet the needs of children diagnosed with any ADHD subtype. The Sensory Classroom Teacher Questionnaire (SCTQ) utilises ADHD symptomatology to evaluate learning spaces that support children in regulating their response to sensory input. We report on the piloted design and refinement of the SCTQ based on best practices. A convenience sample of South African early childhood teachers administered the first (n = 313) and second (n = 72) versions of the SCTQ at various primary schools. Cross-disciplinary specialists appraised the SCTQ for content validity, while the Rasch rating scale model was applied to assess internal construct reliability and validity. The structure of the latent constructs was assessed using Bayesian confirmatory factor analysis. Following the first pilot, we refined the SCTQ by combining or deleting unnecessary items and reducing the five-point Likert scale to a three-point scale. Revising the Likert scale in version one was necessary to improve category functioning. Adjusting the three-point scale in the revised SCTQ indicated good item and scale functioning. We show the conceptual framework, refinement process, all results and the most recent version of the SCTQ for teachers to use and educational researchers to adapt further.

Keywords: Attention-deficit hyperactivity disorder (ADHD); early childhood development and education (ECDE); inclusive communal learning spaces; Sensory Classroom Teacher Questionnaire (SCTQ); psycho-educational assessment instruments; sensory integration/processing; sensory ergonomics; South Africa.

Introduction

Children instinctively observe and process sensory stimuli as indicators of how to act, feel and behave (López et al., 2018; Mahdjoubi & Akplotsyi, 2012). Children can subconsciously judge if a communal learning space is supportive of their educational and developmental needs (Davies, 2020; DuPaul & Stoner, 2015). Children whose central nervous system is challenged to integrate and process sensory stimuli might interpret their classroom conditions as unconducive. Feeling uncomfortable in their learning environment will affect their behaviour, learning and well-being (Ayres, 1979; Zimmer et al., 2012). Therefore, educators play a vital role in designing conducive communal learning spaces so that children can best absorb, retain and process new information.

Attention-deficit hyperactivity disorder and sensory processing disorder

Difficulty in integrating and processing environmental and sensory information has been observed in various neurodevelopmental disorders, especially attention-deficit hyperactivity disorder (ADHD) (Ghanizadeh, 2011; Zimmer et al., 2012). The American Psychiatric Association (APA, 2013) considers ADHD the most prevalent psychiatric disorder among the young child population. In a communal classroom of ± 30 children, two to three are diagnosed with ADHD (Barkley, 2018; Micoulaud-Franchi et al., 2016), increasing the likelihood for them also to experience sensory integration or processing difficulties (Ghanizadeh, 2011). Table 1 summarises the responses and characteristics the child is confronted with to a different degree, intensity and nature.

TABLE 1: Attention-deficit hyperactivity disorder characteristics and sensory processing disorder response regulation.

Attention-deficit hyperactivity disorder	Sensory processing disorder
(i) *Inattentiveness:* denoted as disorganised behaviour	(i) *Sensory over-responsivity:* rapid and acute response
(ii) *Impulsivity:* signifying unruly behaviour	(ii) *Sensory under-responsivity:* unaware or delayed response
(iii) *Hyperactivity:* indicated as disruptive behaviour	(iii) *Sensory seeking:* crave sensory stimulation
Subtypes: Predominantly inattentive; predominantly hyperactive-impulsive; and combined subtype	Subtypes: Sensory modulation disorder; sensory-based motor disorder; and sensory discrimination disorder

Sensory ergonomics as an intervention approach in early education

Professionals can benefit from using psychometric-founded instruments to interpret environmental and sensory stimuli to adapt to communal spaces, for example, the Classroom Climate Scale (López et al., 2018), Classroom Sensory Environment Assessment (Miller-Kuhaneck & Kellehers, 2018) and the Sensory Gating Deficit and Distractibility Questionnaire for adults with ADHD (Micoulaud-Franchi et al., 2016). However, these mentioned instruments focus predominantly on a specific aspect of sensory integration (e.g. environmental design) or an age group (adults), which does not cater for the needs of a South African early childhood teacher.

Delaying interventions will increase the prospects of children with ADHD being unsuccessful in their school trajectory (Huerta, 2017). Therefore, looking to early childhood teachers as 'path changers' is not unfounded. Introducing young children to quality learning environments is not a luxury but rather a necessity. Learning spaces ought to be perceived as emotionally safe, socially smart, environmentally friendly and cognitively supportive (Jensen, 2003). Ergonomics for children integrates a wide swath of disciplines (e.g. psychology, rehabilitation, education, architecture, law) to ensure developmentally appropriate practices (Lueder & Rice, 2007). More specifically, *sensory ergonomics* is considered a trusted strategy to cater for children's special educational and developmental needs by constructing conducive classroom conditions (Lombard, 2015; eds. Lueder & Rice, 2007). Studying children's ability to self-regulate physical, emotional and cognitive responses (sensation) within the learning environment (ergonomics) sheds insight into whether their sensory nervous system is promoting or hindering their functioning (Brown, 2002; Lombard, 2015).

Early childhood education challenges in South Africa

Early childhood education in South Africa, also known as Foundation Phase, is children's first *compulsory* entry to schooling. Six-year-old children enter the schooling system as preschoolers in an informal classroom before transitioning to a more formal school setting in subsequent grades. Although informal (Grade R) schooling and formal (Grades 1–3) schooling are clustered as early childhood education, the curriculum design, pedagogical approach, teaching and learning support material, and classroom setup for preschoolers and schoolers differ significantly (Van Heerden & Du Preez, 2021). Herewith some challenges teachers in South African schools come to face:

Firstly, it is not uncommon for developing countries to have mainstream and multi-aged classrooms in the early years that are significantly larger ($n = \geq 45$) than international classrooms ($n = \pm 24$) (Howie et al., 2017), suggesting that larger classes increase the likelihood of hosting more children with ADHD (Perold, Louw, & Kleynhans, 2010). Secondly, South African teachers are often situated in disempowering learning environments in terms of physical size, socio-economic status, high child-to-teacher ratios, limited access to multidisciplinary teams for guidance and a lack of developmentally appropriate resources and equipment (Balfour, Mitchell, & Moletsane, 2008). Thirdly, Foundation Phase teachers may not be well informed about neurological disorders (e.g. ADHD, sensory processing disorder [SPD] and associated subtypes) and interdisciplinary interventions (e.g. sensory ergonomics) to adapt to learning environments (Brown, 2002; Perold et al., 2010). Fourthy, optimising an environment for rich sensory stimuli and SPD is the specialisation field of registered occupational therapists (Ayres, 1979; Lombard, 2015), leaving South African teachers to decipher child–environment synergy for themselves. Fifthly, too few training opportunities for continuous professional teacher development (CPTD) is offered to broaden their knowledge and skills on special educational needs (De Clercq & Phiri, 2013). Lastly, teacher-friendly psycho-educational resources to assist teachers in creating conducive learning environments are rarely freely available.

Research gap and contribution

Considering all mentioned dichotomies, a prospect is offered to recouple cross-disciplinary knowledge systems to promote conducive classroom conditions for children with ADHD who could also experience sensory integration/processing challenges. The nexus this article would like to present is a well-designed psycho-educational assessment instrument for Grade 1–3 teachers when creating inclusive, conducive and sensory ergonomic learning spaces for children diagnosed with ADHD. The researchers designed an instrument that assesses environmental conditions which teachers could use to enhance the classroom climate.

This study's main objectives and processes are as follows:

1. conceptualising a psycho-educational instrument guided by principles of sensory ergonomics, sensory integration/processing and the triad of characteristics of children with ADHD symptoms
2. analysing and refining the Sensory Classroom Teacher Questionnaire (SCTQ) through two rounds of piloting
3. offering an inclusive and pedagogical practice-oriented psycho-educational assessment instrument for early childhood teachers.

Methods

Evidence of behaviour was systematically and objectively gathered, and items were created from which inferences can

be drawn (Du Preez & De Klerk, 2019; Murphy & Davidshofer, 2005). Mixed methods research is considered appropriate and is necessary for instrument conceptualisation, development and validation (Zhou, 2019) as it enables test developers to be iterative and intentional in abstracting, simplifying and categorising qualitative and quantitative evidence (Du Preez & De Klerk, 2019). The three phases used to develop this instrument are proposed by Creswell and Plano Clark (2017) in combination with a sequential mixed methods research design. These phases are given as follows:

1. qualitatively defining the latent constructs of the instrument
2. qualitatively conceptualising and revising items from a psycho-philosophical viewpoint
3. quantitatively piloting the instrument.

This study followed best practices in validating scales, by means off: item generation based on theory, improving content validity aided by subject-matter experts, pretesting items, item reduction and refinement, and piloting the instrument for reliability, validity and dimensionality (Boateng, Neilands, Frongillo, Melgar-Quiñonez, & Young, 2018).

Conceptualising the psycho-educational instrument

Evidence for instrument validity commences with an adept conceptualisation phase that requires identifying a suitable conceptual or theoretical framework, relevant extensive scholarly literature and a panel of experts to scrutinise the construct(s) and provide feedback on the content validity (Du Preez & De Klerk, 2019; Michell, 1997; Zhou, 2019). Existing scholarly theories were utilised to generate items for the SCTQ to measure sensory ergonomics as a latent construct. The SCTQ is based on meaning-making frameworks about sensory integration/processing, sensory ergonomics and the triad characteristics of ADHD. Modulating sensory input is imperative for everyday functioning as it influences productivity, focus, attention, communication and interaction (Alnajjar et al., 2015; APA, 2013; Brown, 2002; Lombard, 2015), hitherto a challenge for children with ADHD.

Factual statements (items) were derived from literature and categorised into subscales to represent the dimensions of the latent construct. The aim was to create concise and unambiguous items that would measure one central idea and remain consistent with the purpose of the measurement (Murphy & Davidshofer, 2005; eds. Schweizer & DiStefano, 2016). The final version of the SCTQ is summarised in Table 2, listing the construct, then the question number and the item statement followed by Likert scale options. The questionnaire is self-administered and can be used by early childhood teachers themselves or informed observers.

As presented in Table 2, the three underlying latent constructs, or subscales, represent the conceptual framework. These latent constructs offer item statements that suggest practical ways to adapt, change and manipulate the existing communal learning space. Sensory integration/processing interventions assist children with ADHD in modifying and regulating their own social and academic behaviour, which they find challenging, as alluded to in the triad of characteristics. The instrument is a multidimensional questionnaire that assesses aspects of overarching sensory ergonomics in the early childhood classroom. The SCTQ's constructs are given as follows:

1. *Attention (co)regulation*: Teacher and peers can model, coach or assist the child with ADHD to manage his or her deployment of attention, by offering a learning space that is supportive of maintaining attention, staying alert and

TABLE 2: The Sensory Classroom Teacher Questionnaire (Final version).

Latent construct	Item no.	Item statement: Look at the classroom. Can you or the teacher provide:	Not at all	Somewhat	Completely
Attention (co) regulation	Q1	Sensory signal to indicate transition	1	2	3
	Q2	Designated area to use and explore sensory input (e.g. sight, sound, touch, movement)	1	2	3
	Q3	Alternative and creative seating surface or formation	1	2	3
	Q4	Access to nondistracting sensory tools, material, resources	1	2	3
	Q5	Daily or routine schedule placed in designated area	1	2	3
	Q6	Labelling of both resources and the designated areas	1	2	3
	Q7	Self-management plan, goal planner, behaviour or token chart	1	2	3
	Q8	Designated area or space that caters for preferred sensory input	1	2	3
Learning space design	Q9	Age-appropriate resources and furniture	1	2	3
	Q10	Functional and adjustable curtains, blinds or covers	1	2	3
	Q11	One undecorated wall or vertical surface	1	2	3
	Q12	Age-appropriate rule or behavioural chart placed in designated area	1	2	3
	Q13	Adjustable light devices to regulate light quantity and quality	1	2	3
	Q14	Different sensory input you can see, hear and feel	1	2	3
	Q15	Regulate body temperature, room temperature and airflow	1	2	3
Sensory modulation and synergy	Q16	Organised, manageable and sensible classroom layout	1	2	3
	Q17	Specific allocated area or space for personal belongings and resources	1	2	3
	Q18	Noninterfering and functioning electronic devices, appliances and apparatus	1	2	3
	Q19	Seated away from doorways, windows or transition entrances	1	2	3
	Q20	Seated close to self-regulated, focused and tolerant peers	1	2	3
	Q21	Seated away from communal spaces or disruptive or exhibition areas	1	2	3
	Q22	Removing unrelated or unnecessary learning resources or stationery	1	2	3
	Q23	Designated space to release pent-up energy	1	2	3
	Q24	Designated space with resources to relax in	1	2	3

directing attention to task goals, and ignoring distracting or irrelevant stimuli. The maximum score for the section is 24.
2. *Learning space design*: Teachers, in collaboration with the school principal, staff and/or colleagues, intentionally consider which developmentally appropriate educational material, equipment and beautifications can be utilised in the communal learning space to produce a sense of security, inclusiveness, safety and sensory synergy. The maximum score for the section is 21.
3. *Sensory modulation and synergy*: A child with ADHD utilises his or her communal learning space to organise and regulate his or her reaction to the sensory stimuli in an adaptive manner. A child with ADHD can uphold a functional level of attentiveness or alertness (alone or with help from a peer) to respond appropriately to the present sensory stimuli. The maximum score for the section is 27.

Please note that the olfactory system (smell and taste) is not included for manipulation, as Lombard (2015) strongly advises to keep it neutral or natural.

Sampling of the panel of experts, fieldworkers and teacher participants

A purposive and convenience sampling technique was used to recruit the panel of experts, fieldworkers and teacher participants.

Firstly, researchers consulted with the panel of experts to appraise the content validity of the SCTQ and its generated statements (items). The panel of experts was multidisciplinary, including two early childhood specialists, one registered occupational therapist, two registered educational psychologists and one research psychologist. Secondly, a protocol document was compiled and the fieldworkers were trained on handling topics such as ethical procedure to obtain informed consent, ensuring safe and anonymous participation, how to self-administer the SCTQ, authoring a qualitative interview report and capturing the raw data in Microsoft Word and Excel. The fieldworkers were qualified early childhood teachers enrolled for their postgraduate studies in Learning Support. They were authorised by the Department of Basic Education to visit any primary school in South Africa and issue a copy of the registered ethics certificate granted by the University of Pretoria's Ethics Committee of the Faculty of Education. Thirdly, the participants, who self-administered the SCTQ, were qualified and appointed in-service teachers within the early childhood sector either in Grade 1, 2 or 3. The participants were mainly female, as most South African teachers in Foundation Phase are women (Petersen, 2014; Sak, 2015). The teacher participants' biographical profiles are tabulated in Table 3.

As depicted in Table 3, both rounds of piloting presented a teacher sample profile of having less experience in teaching in the early years; schools with more nongovernment income and; teachers perceiving their ADHD knowledge as adequate.

TABLE 3: Biographical profile of teacher participants.

Biographical components	Category	Pretest of items sample		Piloting of the SCTQ sample	
		%	*n*	%	*n*
Type of school	Fee-paying	71	222	81	57
	Non-fee paying	28	88	19	13
Teaching experience	Less than 11 years' experience	60	188	86	60
	More than 11 years' experience	40	125	14	10
Knowledge about ADHD	Expert	4	11	24	17
	Novice	34	106	0	-
	Sufficient	62	194	76	54

Note: Samples for the pretest of items and pilot.
SCTQ, Sensory Classroom Teacher Questionnaire; ADHD, attention-deficit hyperactivity disorder.

Data analysis

Qualitative content analysis

A panel of subject-matter experts were assembled to assess the quality of the SCTQ items as a qualitative content validation method. The feedback generated from the panel of experts provided qualitative evidence for content validity (Zhou, 2019). The cross-disciplinary specialists commented on the SCTQ's purpose, the phrasing of items and the items' relevance to measuring the constructs. The panel examined the length, appropriateness and format of the instrument used to improve, reduce and refine the items after the first round of data collection. As for the fieldworkers, who observed the completion of the SCTQ by the teacher participants, they generated a report on additional information about observations and discussions on (co)regulation to effect attention, such as sensory signals, labelling and schedules; learning space design elements, including regulating sensory inputs through less decoration, providing age-appropriate resources and offering input that the child can see, hear or feel; and regulation of overall functioning by becoming aware of sensory properties that may compromise sensory synergy, for example, seating arrangements, transition areas and designated areas. Rasch measurement theory (RMT) was used as the guiding psychometric model to refine and assess the internal reliability and validity of the SCTQ (Bond & Fox, 2015; Retief, Potgieter, & Lutz, 2013). Bayesian confirmatory factor analysis (CFA) was used to assess the structure of the latent traits (Taylor, 2019).

Rasch rating scale model

Rasch analysis is a family of probabilistic models that assess items and instruments (Andrich & Marais, 2019; Linacre, 2021). Rasch measurement theory evaluates the psychometric properties of the items by modelling the log-odd probability of each rating selected by the teachers who endorsed the construct overall (Boone, Staver, & Yale, 2014). Rasch unidimensional models for measurement (RUMM 2030) software was utilised (Andrich, Sheridan, & Luo, 2009). The model, item, person and category fit, and invariance and dimensionality were investigated (Andrich et al., 2009). Descriptive statistics were calculated in IBM's Statistical Package for the Social Sciences (SPSS). Adequate evidence for

internal reliability and validity of inferences required (Bond & Fox, 2015):

1. *Data fit to model:* chi-square goodness-of-fit statistic not significant
2. *Items to fit the model:* small and nonsignificant residual values (< ± 2.5)
3. *Likert scale categories:* ordered monotonically and contribute to the measurement
4. *Lack of significant secondary constructs:* unidimensionality assessed with principal component analysis (PCA) and eigenvalues below 2
5. *Reliability indices:* above 0.70
6. *Differential item functioning (DIF) absent:* Bonferroni corrected *p*-values nonsignificant.

Bayesian confirmatory factor analysis

A Bayesian analysis was used to conduct the CFA because of the ordered-categorical nature of the data (Arbuckle, 2017). Bayesian analysis outperforms maximum likelihood when items have fewer than four categories (Stenling, Ivarsson, Johnson, & Lindwall, 2015). In IBM Amos (Arbuckle, 2021), the Markov Chain Monte Carlo algorithm is applied and considered to offer advantages to CFAs with categorical data (Taylor, 2019). The CFA was used to assess the structural validity of the instrument. A null hypothesis approach was used with noninformative priors. The Bayesian model would indicate a good fit for the CFA when (Gelman, 2013; Harindranath & Jayanth, 2018):

1. The posterior predictive *p* is close to or equal to the value of 0.5.
2. The 95% highest posterior density interval does not contain a 0.
3. The convergence statistics (CS) were below 1.100 as required.

Ethical considerations

Ethical approval was obtained from the University of Pretoria, Faculty of Education, Ethics Committee (reference number: UP09/04/01).

Results

The results are presented as two rounds of quantitative data collection. After pretesting the items in the first round, considerable instrument refinement was carried out. The final version was qualitatively examined by subject-matter experts and piloted on another Grade 1–3 in-service teacher sample. The second version is considered the final to-date version and evidence from both rounds of piloting (see Table 2).

Pretesting of Sensory Classroom Teacher Questionnaire items

The combination of Rasch statistics, qualitative interviews of the fieldworkers and the review of the items by panel experts led to the revision of the instrument (Cavanagh & Romanoski, 2006; eds. Cavanagh & Waugh, 2011). The first version of the SCTQ had 55 items, and the model fit was significantly different from the data ($p < 0.05$). Four items had significant fit residuals, indicating potential problems. Thirty-one out of the original 55 items displayed disordered thresholds and categories, with less than 10% of participants endorsing the option. The five-point Likert scale categories were combined into three categories, which resulted in a better fit and no disordered categories. Differential item functioning was detected for five items compared to all the demographic characteristics. The refining of the items resolved the DIF. Principal component analysis in RUMM 2030 was used to investigate unidimensionality, and the three factors were confirmed to be independent. The cross-disciplinary panel of experts revised the first version of the SCTQ so that items could be combined or deleted. The revised instrument has 24 items and an improved overall RMT fit ($\chi^2 = 132.744$, $p = 0.015$).

Pilot of Sensory Classroom Teacher Questionnaire

The next round of data collection for the SCTQ revealed that each construct fit the Rasch model, had acceptable reliability and was unidimensional (Table 4).

Four items were identified that had problematic categories. Reliability indices were above 0.700 and deemed acceptable (Linacre, 2021). Differential item functioning was absent for grade, school type, teacher knowledge of ADHD and teaching experience. The second version of the SCTQ showed evidence of internally reliable and valid inferences to assess classroom sensory ergonomics in the classroom. The individual item fit statistics are shown in Table 5 with their standard error (SE), fit residual values, degrees of freedom (*df*), chi-square and probability values.

As seen in Table 5, none of the items had fit residuals above or below 2.5, and none of the items significantly misfit the Rasch model.

The correlations among the latent traits are shown in Table 6. As derived from the Rasch logit conversion, the constructs had moderate to strong relationships (0.378–0.628). The logit scales ranged from –3 to +5, and attention (co)regulation was the most difficult to implement in the classroom ($M = 0.361$, SE = 1.426).

TABLE 4: Rasch analysis findings for three Sensory Classroom Teacher Questionnaire constructs.

Subscale	Rasch model fit (χ^2)	*df*	*p*	Reliability (person)	Reliability (item)	Eigenvalues (PCA)	Item fit residuals range
Learning space design	16.944	14	0.259	0.730	0.700	1.872	-0.674 to 1.519
Sensory modulation and synergy	18.099	16	0.318	0.822	0.779	1.915	-0.283 to 0.929
Attention (co) regulation	15.3292	16	0.500	784	0.708	1.806	-0.799 to 1.138

df, degrees of freedom; PCA, principal component analysis.

TABLE 5: Item location, standard error and fit residuals.

Item no.	Location	SE	Residual	*df*	Chi Sq	Prob
1	0.184	0.392	0.209	16.430	1.468	0.476
2	0.836	0.346	-0.175	16.430	0.283	0.814
3	0.015	0.333	0.122	17.210	1.738	0.461
4	0.244	0.333	-0.235	16.430	0.705	0.648
5	0.240	0.366	-0.799	16.430	2.327	0.126
6	-0.664	0.344	1.138	16.430	1.075	0.574
7	-0.667	0.349	1.071	16.430	5.990	0.106
8	-0.190	0.405	0.388	17.210	1.743	0.401
9	-1.112	0.413	0.693	14.880	3.742	0.200
10	-0.089	0.353	0.100	14.140	0.219	0.835
11	0.336	0.342	0.995	14.140	0.130	0.928
12	-0.762	0.387	0.262	14.140	0.781	0.712
13	0.681	0.381	-0.674	9.670	1.838	0.187
14	0.426	0.372	0.036	14.880	4.822	0.036
15	0.520	0.319	1.519	14.140	5.414	0.123
16	-4.333	0.610	0.312	12.880	4.599	0.104
17	-0.038	0.451	-0.195	10.610	0.231	0.872
18	0.118	0.359	-0.283	12.880	1.635	0.390
19	0.379	0.482	0.062	12.880	1.698	0.416
20	0.000	0.365	-0.100	12.880	0.785	0.712
21	-0.430	0.434	0.929	12.880	3.015	0.478
22	2.698	0.513	-0.145	12.120	3.216	0.121
23	1.605	0.404	0.866	12.880	2.920	0.288

SE, standard error; *df*, degrees of freedom; Chi Sq, chi-square; Prob, probability.

TABLE 6: Means, standard deviations, minimum, maximum and correlations between constructs.

Latent constructs	Mean	SD	Min	Max	1	2	3
1. Attention (co)regulation	0.361	1.426	-3.090	4.350	-	0.378**	0.628**
2. Learning space design	1.153	1.395	-2.090	4.140	0.378**	-	0.440**
3. Sensory modulation and synergy	1.631	1.822	-2.800	5.130	0.628**	0.440**	-

SD, standard deviation.

**, Correlation is significant at the 0.01 level (two-tailed).

An examination of the items and latent trait structures was conducted with a Bayesian CFA. The posterior predictive *p* is close to 0.50 ($p = 0.38$). The 95% highest posterior density interval did not contain a 0. All items had convergence statistics lower than 1.1. The posterior predictive p showed a good fit, but the model could be improved. One item did not significantly load onto its factor, question 6 ('labelling of resources and designated areas'). The convergence statistics were acceptable for the specified structure.

Discussion

Sensory integration/processing is a reserved and specialised field of occupational therapists, which leaves South African teachers less likely to benefit from such a knowledge system to create conducive classroom conditions for children with ADHD. With the development of this psycho-educational instrument, South African early childhood teachers can now (re)design their learning spaces from sensory ergonomics and sensory integration and processing standpoints, which are sensitive to the special educational and developmental needs of learners with ADHD (see Table 1).

The first round of excessive statements (items) included in the SCTQ is based on scholarly literature and was appraised by a panel of cross-disciplinary experts. The first version had an excessive number of items recommended in practice, which according to Liu (2020) is common when designing a new instrument. The pretesting of these items led to refinement and reduction of the items through Rasch analysis and panel of experts content analysis. The second version of the instrument was piloted on a smaller sample of in-service early childhood teachers, and evidence was found for the internal reliability and validity of the SCTQ's items. The structure of the latent constructs was established with a Bayesian CFA, and the model fit was considered adequate. The results from the pilot showed that valid and reliable inferences could be derived from the psycho-educational instrument for effecting attention (co)regulation, learning space design and sensory modulation and synergy. However, the loadings of items onto the latent traits could be further explored in future studies to derive a more robust model with larger samples and re-examine the categories. The questionnaire presents best practices and thus identifies potential areas which require attention to create conducive classroom conditions using sensory ergonomics.

The sequential mixed methods research design for scale development integrated scientific reality with psychometric validity. Mixing modes of inquiry occurred at four levels, namely conceptual, operational, piloting and analysis. The conceptual framework of the psycho-educational instrument is based on theories on sensory integration and processing, sensory ergonomics, and the triad characteristics of ADHD.

The study's limitations are that the assessment instrument was piloted twice in South African schools that were well resourced and self-rated by teachers who had less than 11 years of experience in teaching in the early years. Another limitation is that the predictive validity of the instrument has not yet been examined. Future research should include applying the SCTQ in a wider variety of contexts and testing the predictive validity of the instrument through longitudinal studies.

The study has implications for early childhood education practices, as teachers need psycho-educational instruments to evaluate communal learning spaces to reassess their conducive conditions. Teachers could use the SCTQ as a guide to (re)design classroom spaces that reflect sensory ergonomics and inclusive education principles.

Conclusions

Empowering early childhood teachers to create conducive learning environments will create a sense of belonging, safety and inclusion among children diagnosed with ADHD who could also experience sensory integration and processing challenges. The early childhood teacher should serve as a gatekeeper by becoming more aware of the child–environment relationship by using the SCTQ psycho-educational tool with instrument for assessing conducive classroom principles. The SCTQ utilised sensory integration and processing, sensory ergonomics and the triad characteristics of ADHD as the meaning-making framework. The SCTQ offers guidelines on how to adapt, change or manipulate the learning environment

to meet the needs of children with special educational and developmental requirements. The sensory ergonomics construct was operationalised by assembling a cross-disciplinary panel of experts for their qualitative content validity input and applying RMT and Bayesian CFA. The designed SCTQ is 'quantitatively defensible and qualitatively meaningful' (Bond & Fox, 2015, p. 329). Utilising RMT provided evidence for the instrument's internal validity and reliability and offered additional guidance to cross-disciplinary specialists. Teachers and researchers can use the current instrument to gauge and plan effecting attention (co)regulation, learning space design and sensory modulation and synergy for the child diagnosed with ADHD. Thus, the teacher, researcher or observer can screen for irrelevant and undesirable environmental stimuli by becoming the synergy mediator before the child with ADHD enters the communal learning space. To amplify the importance of this topic in early childhood education, this article concludes with a quote from Jensen (2003):

> Environments are the medium in which we live. We can feel them every day, all day long. At school only the quality of the teacher is a greater determinant of student success than the environment. One environment brings out the best in us and another brings out the worst in us. They can be nourishing or toxic, support or draining. Environments are never neutral. How important are they? How important is water to fish? (p. v)

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Competing interests

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Authors' contributions

H.d.P. conceived the presented idea, designed the methodology and was responsible for data collection, data capturing and introduction. C-M.C. conducted the analysis and wrote the methods and results section. Both authors were involved in writing the discussion and conclusions.

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Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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