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ORIGINAL PAPER

Evaluation of Classroom Active Engagement in Elementary Students with Autism Spectrum Disorder

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Abstract This study evaluated the classroom measure of active engagement (CMAE), an observational tool designed to measure active engagement in students with autism spectrum disorder (ASD). Participants included 196 students with ASD and their educators ($n = 126$) who were video-recorded at the beginning of the school year. Findings documented limited active engagement overall, with students spending less than half of the observation well-regulated, productive, or independent and infrequently directing eye gaze and communicating. Confirmatory factor analysis indicated that the structure of the CMAE was represented by a 5-factor model. These findings underscore the need for improved active engagement in students with ASD and show promise for a tool to measure behaviors associated with positive educational outcomes in students with ASD.

Keywords Autism spectrum disorder · Active engagement · Emotional regulation · Classroom participation · Social connectedness · Initiating communication

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Introduction

Active engagement has been conceptualized as a dynamic construct important for learning, and researchers and policy makers have identified active engagement as a key component in effective programming for students with autism spectrum disorder (ASD; Iovannone et al. 2003; National Research Council 2001; Ruble and Robson 2007). The National Research Council (NRC 2001) has recommended that students with ASD spend a minimum of 25 h per week actively engaged in learning activities to promote positive educational outcomes including academic participation, communicative competence, and reduction of problem behaviors. However, active engagement has not been well-defined within the existing research literature and many of the tools measuring active engagement in the classroom are limited to evaluating on-task behaviors such as reading, writing, asking/answering questions, and attending to instruction (Greenwood 1996; Greenwood et al. 2002; Klem and Connell 2004). A well-defined observational measure of active engagement that is designed to address the unique learning challenges faced by students with ASD in the classroom will allow researchers to thoroughly evaluate active engagement in this population.

ASD is a neurodevelopmental disorder that is characterized by impairment in social communication and the presence of fixated interests and repetitive behaviors (American Psychiatric Association [APA] 2013). Current prevalence studies estimate that 1 in 68 children in the United States is diagnosed with ASD, with 38 % also classified in the range of intellectual disability [IQ $\leq$ 70; Centers for Disease Control and Prevention (CDC) 2014]. ASD is a complex life-long condition, and individual presentations of ASD range from mild impairment to profound disability (CDC 2014; Charman et al. 2005; Estes et al. 2011). Epidemiological studies estimate that 53–96 % of children with ASD receive special education services (Baio 2012). While recent studies of young children with ASD have indicated that significant gains in intellectual and behavioral functioning are possible with early, intensive intervention (Dawson et al. 2010; Estes et al. 2011), studies have yet to examine whether these gains persist through the school years (Kasari and Smith 2013). Research is needed to identify effective treatments for students with ASD that promote active engagement within educational settings as well as to identify important behaviors that are associated with change as a result of school-based interventions.

Students with ASD present with a unique constellation of learning challenges, which may interfere with active engagement in the classroom (Leekam et al. 2011; Richler et al. 2010; Rotheram-Fuller et al. 2010; Turner 1999). Students with ASD present with deficits in emotional regulation, the ability to regulate one's emotions and behavior. As a result, students with ASD have difficulty maintaining their physiological arousal and emotions for optimal levels of classroom engagement (Laurent and Rubin 2004; NRC 2001; Prizant et al. 2006) and experience difficulty tuning out irrelevant information and focusing on classroom content (Connor et al. 2010; Ponitz et al. 2009; Sektnan et al. 2010). With deficits in joint attention, the ability to coordinate attention between social partners and objects (Mundy and Burnette 2005), students with ASD experience deficits in social connectedness as they are less likely to look at faces or respond and attend to relevant classroom instruction than their peers. In addition, difficulty understanding and initiating nonverbal and verbal communication limit reciprocal interaction and may interfere with successful participation in classroom discussion (Dawson et al. 2004; Mundy and Burnette 2005; Rotheram-Fuller et al. 2010). Many verbal students with ASD may exhibit inflexible language and show a lack of generativity, with language consisting primarily of scripted words and phrases (APA 2013). Further, the presence of restricted and repetitive behaviors, including a restricted range of interests or insistence on sameness may also limit participation in classroom activities (Richler et al. 2010), and novel classroom activities or changes in class schedules may provoke intense, problematic behaviors (APA 2013; Richler et al. 2007; Turner 1999).

Active Engagement in General Education Classrooms

In the general education literature, active engagement has been defined as the interaction between the student's observable behaviors in response to the demands of the classroom. Measurement of active engagement has included behaviors such as attending, completing assignments, responding, following classroom instructions, and persisting through difficult tasks (Ponitz et al. 2009). Active engagement is an important variable for academic achievement with research suggesting that active engagement mediates the relation between classroom instruction and academic achievement (Greenwood 1996; Guo et al. 2011; Ponitz et al. 2009). Guo et al. (2011) documented a direct relation between reading achievement and active engagement in a sample of elementary students as measured by the Classroom Observation System for Third Grade, an observational Likert scale that measures attention and self-reliance behaviors (e.g., initiative, focus, autonomy). The authors found that high quality teacher-student interactions were associated with greater active engagement, and that more engagement was associated with better end of the year reading achievement. Similarly, Klem and Connell (2004) examined the relation between instruction and self-reported active engagement in a large sample of third–fifth grade students as measured by the Rochester Assessment Package for School–Student Self-Report (RAPS-S; Wellborn, and Connell 1998). The RAPS-S is a 13-item Likert scale that measures students' perceived ongoing engagement (effort) and reaction to challenge (coping with classroom situations) and has good reported reliability ($\alpha = 0.71$). Using the RAPS-S, the authors found a strong relation between instructional support and student-reported active engagement, and higher ratings of engagement were also predictive of better school attendance and greater achievement in reading or mathematics.

Active Engagement in Students with ASD

Studies examining active engagement in students with ASD have primarily conceptualized and measured active engagement through on-task classroom behavior (Bryan and Gast 2000; Pelios et al. 2003). Using a single subject research design, Nicholson et al. (2011) measured on-task behavior in four third grade students with ASD participating in special education classrooms using the

Behavioral Observation of Students in Schools (BOSS; Shapiro 2003), an observational tool that allows for the categorization of active (i.e., writing, raising hand, answering/asking questions) and passive (i.e., attending, silent reading) on-task behavior. The authors found that students with ASD spent limited time on-task (31–48 % of time) and documented change in the percentage of time that students spent on-task immediately following intervention (Nicholson et al. 2011). Using similar methodology, Bryan and Gast (2000) documented positive change in four students with ASD by measuring timed intervals of on-task (i.e., visually attending to or manipulating classroom materials) and on-schedule (i.e., following the classroom routine) behavior with the use of an intervention support. Although limited to a specific set of behaviors, these studies provide some evidence to support the malleability of on-task behavior in students with ASD. It is important to note, however, that the students in both studies were not able to sustain the increase in on-task behavior following intervention.

Ruble and Robson (2007) studied on-task behavior by including an observational measure of congruent classroom behavior in a sample of students with ASD and students with Down syndrome. Interestingly, Ruble and Robson found that students with ASD were as likely to comply with classroom demands, exhibiting similar on-task behaviors as students with Down syndrome; however, they were less able to engage in congruent learning activities as their non-ASD peers. Ruble and Robson's study illustrates that conceptualizing engagement solely as on-task behavior may not accurately quantify active engagement in students with ASD.

The existing body of literature documents the importance of evaluating active engagement in educational settings while illustrating the need for developing a measure of active engagement better suited for students with ASD. Previous studies have provided information regarding the constellation of challenges that students with ASD exhibit in the classroom as they relate to active engagement and participation. However, the tools that have been used to evaluate active engagement in students with ASD have not been informed by research on the core and associated deficits of ASD. Although, Ruble and Robson (2007) examined congruent behavior, evaluating constructs that reflect the learning challenges students with ASD face in the classroom continues to be a need. Thus, in order to thoroughly evaluate active engagement in students with ASD, there is a need for a tool that measures student emotional regulation, classroom participation and independence, and social connectedness as well as documents the number of times students initiate communication and their flexibility to adapt to classroom changes.

Study Purpose and Research Aims

The purpose of the current study was to quantify active engagement in students with ASD within classroom activities using a multicomponent observational measure that was designed to address the learning challenges students with ASD face in the classroom. For this study, active engagement was measured using the classroom measure of active engagement (CMAE), a research tool developed for use with students with ASD. The three primary research aims were as follows:

1. to describe the variables measured in the CMAE for a sample of elementary students with ASD;
2. to examine the relations among the CMAE variables and between the CMAE variables and standardized measures of student characteristics as well as teacher report measures of social skills and problem behavior; and
3. to evaluate the factor structure of the CMAE.

Methods

Participants

The sample reported in this paper included 196 students nested within 126 teachers. Participants were recruited for the Classroom SCERTS Intervention (CSI) Project, a randomized controlled trial to evaluate the efficacy of the SCERTS Model as a school-based intervention for elementary students with ASD. Participating students met the following criteria: (1) enrolled in kindergarten, first, or second grade at the beginning of the school year in either general education or special education classrooms; and (2) had a diagnosis, either clinical or educational, of Autistic Disorder, PDD-NOS, or Asperger Syndrome as defined by the DSM-IV (APA 2002) without the presence of severe motor delay/impairment, dual sensory impairment, or history of traumatic brain injury. In addition to the above criteria, a trained clinical or educational psychologist, who demonstrated research reliability, confirmed an ASD diagnosis using the Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2002) and administered a battery of measures for all participating students. Participating students were included in the current study if they had a video-recorded observation collected at the beginning of the school year. However there are some missing data on standardized and teacher report measures. See Table 2 for the number of participants with complete data for each standardized and teacher report measure.

Participants in the current study included kindergarten through second grade students and their teachers from 56

schools across eight districts in Florida and the San Diego Unified School District in California. Students participated in both general and special education classrooms, with 45 % participating in general education classrooms at the beginning of the school year. The sample was diverse with regard to racial or ethnic background, with 43.9 % identified as Non-Hispanic White, 20.4 % as Hispanic White, 12.8 % as Black, 7.1 % as Asian, and 5.1 % as Multiracial. In addition, 10.7 % of the sample did not provide information regarding racial or ethnic background. The sample was predominately male (85 %), which is consistent with the observed 4:1 prevalence ratios for the ASD population (CDC 2014). There were no significant differences in students' racial or ethnic background, gender, or grade level between school districts, states, and classroom context. See Table 1 for sample demographic information.

The sample showed variability with regard to intellectual functioning, with 57 % exhibiting an Abbreviated Battery IQ (ABIQ) equal to or above an average score of 70 ($M = 73.64$, $SD = 20.49$) measured by the Stanford-Binet Intelligence Scale, Fifth Edition (SB-5; Roid 2003). In addition, the sample exhibited significant differences between expressive vocabulary ($M = 78.84$, $SD = 19.34$) measured by the Expressive One Word Picture Vocabulary Test (EOWPVT; Brownell 2000) and receptive vocabulary ($M = 73.92$, $SD = 24.09$) measured by the Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4; Dunn and Dunn 2007), with the mean average for expressive vocabulary significantly higher than receptive vocabulary, $F(1,191) = 12.00$, $p < 0.001$. This discrepancy in expressive and receptive vocabulary is consistent with the language profile often observed in individuals with ASD (Charman et al. 2003). Finally, the sample exhibited below average social skills ($M = 80.11$, $SD = 14.61$) measured via teacher report on the Social Skills Rating System (SSRS; Gresham and Elliott 1990) and on average were relatively well-behaved, with problematic behavior (internalizing, $M = 58.51$, $SD = 8.95$; externalizing behavior, $M = 59.46$, $SD = 8.15$) measured by the Teacher Report Form (TRF; Achenbach and Rescorla 2001) below the clinically significant range of 70 or higher. Taken together, these measures provide a good representation of early elementary students with ASD and the unique constellation of skills and challenges that they exhibit in educational settings. See Table 2 for descriptive information on standardized measures of student characteristics as well as teacher report measures of social skills and problem behavior.

Participating teachers were predominately female (96.0 %) and ranged between 24 and 66 years of age ($M = 42.16$, $SD = 10.79$). In regards to racial and ethnic background, 61.3 % identified themselves as Non-Hispanic White, 0.8 % as Hispanic White, 3.2 % as Black, 4.8 % as Asian, 1 % as Multiracial; 29 % did not report racial or ethnic background. The participating teachers reported an average of 13.59 ($SD = 8.9$) years of teaching experience, and 42 % reported having a Master's level degree. Only two teachers reported having an ASD endorsement.

Table 1 Sample demographic information

Male[a]	84.7
Race/ethnicity[a]	
Non-hispanic white	43.9
Black	12.8
Asian	7.1
Hispanic white	20.4
Multiracial	5.1
Not reported	10.7
Grade level[a]	
Kindergarten	29.6
First grade	41.0
Second grade	29.2
Classroom setting[a]	
General education	44.9
Special education	54.6
Chronological age[b]	6.36 (1.01)

[a] Percentage, [b] Student chronological age is reported with mean age and standard deviation

Measures

The following standardized and teacher report measures were used as part of the CSI Project. In addition, continuous 60-min observations of each student were video-recorded monthly within the classroom. Data used for this study consisted of the initial scores of the standardized and teacher report measures as well as the first classroom observation recorded at the beginning of the school year, which were baseline measures for the CSI Project.

Standardized Measures

Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2002). The ADOS is a semi-structured behavior observation designed to measure ASD features. The ADOS consists of several activity modules, and the specific module administered is dependent upon the age and language level of the student. For the current study, students completed either Module 1 (little to no verbal language), Module 2 (phrase speech), or Module 3 (fluent speech). Using the revised algorithms, the ADOS yields three scores: Social Affect (SA), Restricted and Repetitive Behavior (RRB), and a combined total score (Gotham et al.

Table 2 Standardized measures of student characteristics and teacher report measures of social skills and problem behavior

Standardized measures	*M*	*SD*	Teacher report measures	*M*	*SD*
SB-5 ($n = 191$)			SSRS ($n = 183$)		
ABIQ	73.64	20.49	SS	80.11	14.61
ADOS			PB	111.40	11.67
SA	11.53	4.04	ABC	89.39	12.56
RRB	4.10	2.17	TRF ($n = 187$)		
Total	15.53	5.26	IB	58.51	8.95
PPVT-4 ($n = 192$)	73.92	24.09	EB	59.46	8.15
EOW ($n = 192$)	78.84	19.34	PBC	63.01	7.49

n values reflect the number of participants with available data. Stanford–Binet Intelligence Scale, Fifth Ed (SB-5), *ABIQ* abbreviated battery IQ, *ADOS* autism diagnostic observation schedule, *SA* social affect, *RRB* restricted and repetitive behaviors, *Total* total algorithm score, *PPVT-4* peabody picture vocabulary test, *EOW* expressive one word picture vocabulary test, *SSRS* social skills rating system, *SS* social skills scale, *PB* problem behavior scale, *ABC* academic competence scale, *TRF* teacher report form, *IB* internalizing behavior, *EB* externalizing behavior, *PBC* problem behavior composite score

2007) and provides algorithm total cut-offs for the classifications of nonspectrum, autism spectrum, and autism. The ADOS has strong psychometric properties and is considered the "gold standard" measure for determining autism diagnostic status.

Stanford-Binet Intelligence Scale, Fifth Edition (SB-5; Roid 2003). The SB-5 is a standardized measure for evaluating intellectual ability in a broad age range of individuals. Using the procedure outlined in the manual, two routing subtests of the SB-5 were administered (Nonverbal and Verbal) and used to calculate each student's Abbreviated Battery IQ (ABIQ; Roid 2003). The SB-5 was validated using a large, nationally representative sample and has been shown to have good internal consistency and test–retest reliability, with reliability coefficients ranging from 0.95 to 0.98 (Roid 2003).

Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4; Dunn and Dunn 2007). The PPVT-4 is a norm-referenced measure for assessing receptive vocabulary in a broad age range of individuals and yields standard scores. The PPVT-4 was validated on a large national sample and has been shown to have good psychometric properties, with reported reliability and validity coefficients in the 0.90 range (Dunn and Dunn 2007).

Expressive One Word Vocabulary Picture Test, Fourth Edition (EOWVPT-4; Brownell 2000). The EOWPT-4 is a standardized measure for assessing expressive vocabulary skills beginning in early childhood and yields standardized scores. The EOWVPT-4 has been normed on a large nationally representative sample and has good reported psychometric properties, with reliability coefficients for internal consistency ranging from 0.93 to 0.97 and test–retest reliability coefficients also in the 0.90 range (Brownell 2000).

Teacher Report Measures

Social Skills Rating System (SSRS; Gresham and Elliott 1990). The SSRS is a comprehensive teacher rating measure of social behaviors in individuals between 3 and 18 years of age. Teachers rate the occurrence and importance of social skills, problem behaviors, and academic competence. The social skills scale measures classroom behaviors including cooperation, self-control, and responsibility; the problem behaviors scale measures behaviors that may interfere with positive social interaction including externalizing and internalizing behaviors; and the academic competence scale measures academic functioning including reading and mathematics skills, motivation, and cognitive development. The SSRS is a widely used tool and has good overall reliability, with coefficients in the 0.90 range for the social skills and academic competence scales and the 0.80 range for the problem behavior scales (Gresham and Elliott 1990). The test was standardized on a large national sample.

Teacher Report Form (TRF; Achenbach and Rescorla 2001). The TRF is a teacher-rated tool that evaluates maladaptive behavior and emotional problems as well as academic behaviors in students between 6 and 18 years of age. The TRF assesses behaviors and derives total scores across two comprehensive areas; internalizing behaviors (i.e., anxious, depressive, and over-controlled) and externalizing behaviors (i.e., aggressive, hyperactive, noncompliant, and under-controlled). It is important to note that within the current sample, 23 % of the students were under 6 years of age, with 14 % at or above 5.5 years. However, given the differences in scales and content across the two forms of the TRF, the 6–18 year version was used for all students to allow for continuity of the measure across the

sample. Scores are represented as T-scores, which have a mean of 50 and a standard deviation of 10. The TRF is a widely used tool that has been found to have strong psychometric properties, with reported reliability coefficients above the 0.90 range (Achenbach and Rescorla 2001).

Classroom Observations

The current study used a 60-min video-recorded observation of each student in the classroom, collected at the beginning of the school year. Teachers were asked to choose a minimum of three activities from a list of eight common classroom activities that were most reflective of their daily routine to participate in during the 1 h video-recorded observation: literacy, mathematics, other academics, meals and snacks, arts and crafts, recreation and leisure, duties and chores, and transitions. A videographer, blind to research objectives and questions, scheduled the video-recorded observation.

Trained undergraduate research assistants coded the baseline 60-min video-recorded observations using Noldus Observer® Video-Pro Software to first identify the categories of activities. After activities were identified in the full 60-min observation, a 15-min sample of the data was systematically selected for further coding. This selection was made by identifying the first three different activities that were a minimum of 5 min in duration (e.g., 5:00 literacy + 5:00 mathematics + 5:00 transition = 15 min). If a video-recorded observation did not include a minimum of three activities, 7.5 min of each activity was selected for coding. All of the baseline video-recorded observations included at least two activities selected for coding, with literacy activities most frequently observed followed by transitions and mathematics. After this procedure, an author on this paper blind to intervention condition and trained undergraduate research assistants blind to intervention condition and study hypotheses coded the 15-min sample according to the CMAE guidelines using Noldus Observer® Video-Pro Software.

The Classroom Measure of Active Engagement

The CMAE was developed for use in the CSI Project as an observational research tool to measure and document change in student active engagement as a result of implementation of the SCERTS Model (Prizant et al. 2006). The SCERTS Model is a comprehensive intervention that prioritizes the support of emotional regulation and social communication for successful interaction and classroom participation. Active engagement was conceptualized in terms of the following five themes: Emotional Regulation, Classroom Participation, Social Connectedness, Initiating Communication, and Flexibility. These five themes were comprised of nine CMAE variables that have been identified in the research literature as core learning challenges for students with ASD: Emotional Regulation, Productivity, Independence, Responding, Eye Gaze, Directed Communication, Generative Language, Flexible Behavior, and Flexible Attention. The CMAE quantifies active engagement within classroom activities by measuring the amount of time students with ASD spend in well-regulated, productive, and independent states, the number of instances students spontaneously direct communication, produce generative language, and shift eye gaze toward others, and the percentage of time students respond to verbal bids for interaction and exhibit flexible behavior in response to classroom changes and bids to shift attentional focus. See the CMAE coding definitions included in "Appendix".

Inter-Rater Reliability of the CMAE

Inter-rater reliability between coders was first established for all variables (selection of classroom activities and each of the CMAE variables) using percent agreement, with coders achieving a minimum criterion of 80 % agreement for each variable across 10 consecutive video-observations. Once acceptable levels of reliability were established, inter-rater reliability for selection of activity was calculated using percent agreement and Cohen's Kappa coefficients for 15 % of the data and yielded an average percentage score of 80 % and an average kappa coefficient score of 0.73. Inter-rater reliability for the CMAE variables was calculated for 20 % of the data using percent agreement, which yielded an average score at or above 80 % for each of the CMAE variables (range = 80–88) excluding Flexible Attention (76 %). Intraclass correlation coefficients (ICCs) were also calculated for each of the CMAE variables and indicated good consistency across the coders for each behavior (range = 0.74–0.99). Cohen's Kappa coefficients were used for activity selection; however they were not used to calculate inter-rater reliability for the CMAE variables because they cannot be calculated for variables that do not yield a finite number of instances, such as directing eye gaze or communication toward others.

Results

Preliminary Analyses

Distribution properties of each of the CMAE variables were examined through descriptive statistics, visual inspection of histograms, and bivariate scatterplots. Two univariate outliers, defined as data outside the range of the mean plus or minus three standard deviations, were identified for both Generative Language and Eye Gaze and

brought within three standard deviations from the mean. Further, one bivariate outlier was observed between Independence and Flexible Behavior. After addressing the outliers, each of the CMAE variables was normally distributed (skewness and kurtosis values less than 2).

Descriptive Information of the CMAE at the Beginning of the School Year

From the 15-min sample, students with ASD spent a minority of the time in a well-regulated (M = 5:42 min:sec, SD = 3:29) and productive state (M = 5:56, SD = 3:14) and the least amount of time in an independent state (M = 3:14, SD = 2:36). Students also exhibited a relatively low average number of instances of directed communication (M = 6.90, SD = 5.74), generative language (M = 5.16, SD = 5.93), and eye gaze (M = 11.31, SD = 10.63). Additionally, a percentage score was derived from the number of times students physically or verbally responded (M = 50.39, SD = 20.19) to the total number of verbal bids for interaction (M = 49.19, SD = 27.95, range = 6–160). It is important to note that although responses were contingent on the teachers' verbal bids for interaction, the definition of responses did not require students' to demonstrate comprehension of the bid. A percentage score was also calculated for the number of times students exhibited flexible behavior (M = 75.26, SD = 25.31) when faced with classroom changes (M = 5.84, SD = 3.23, range = 1–22) and flexible attention (M = 53.33, SD = 30.11) when requested to shift attentional focus (M = 6.34, SD = 8.01, range 1–38). From the total sample, nine students did not have an opportunity to change materials or shift attentional focus during the classroom observation, so the percentage score for these observations was coded as missing data in further analyses. Controlling for grade level in order to account for the influence of classroom differences that students in kindergarten—second grade may experience (Locke et al. 2012; Tucker et al. 2002), there were no group differences documented on any of the CMAE variables between students participating in general and special education settings, $F(1, 185) = 0.24$–3.48, all $p > 0.05$.

Correlational Analyses Between the CMAE Variables

Relations between the CMAE variables were examined using Pearson product-moment correlation coefficients for normally distributed data and are presented in Table 3. Multiple significant correlations were observed between the CMAE variables, with the strongest relations observed between Productivity and Independence ($r = 0.66$, $p < 0.001$), Productivity and Responding ($r = 0.51$, $p < 0.001$), and Directed Communication and Generative Language ($r = 0.56$, $p < 0.001$) and Eye Gaze ($r = 0.48$, $p < 0.001$).

Correlational Analyses Among CMAE Variables and Standardized Measures

Because of the moderate to large significant correlations that were observed between the standardized measures and intellectual functioning (range $r = 0.321$–0.821, all $p < 0.01$) as well as the small to moderate significant correlations observed between the teacher report measures and the CMAE variables with intellectual functioning (range $r = 0.143$–0.513, all $p < 0.05$), partial correlations controlling for ABIQ were used to examine relations between the CMAE variables and additional measures. After controlling for ABIQ, multiple small, negative significant correlations were observed between the CMAE variables and measures of ASD symptoms as well as small, positive significant correlations between the CMAE variables and measures of vocabulary, social skills, and problem behavior. Interestingly, there was a moderate, positive significant correlation between Generative Language and receptive vocabulary ($r = 0.32$, $p < 0.001$) as well as a small, positive significant correlation with expressive vocabulary ($r = 0.17$, $p < 0.05$). A positive, significant correlation was also observed between the CMAE variables, Productivity, Responding, and Directed Communication, and receptive vocabulary as measured by the PPVT ($r = 0.18$, $p < 0.05$; $r = 0.16$, $p < 0.05$; $r = 0.15$, $p < 0.05$) as well as many of the CMAE communication variables and social skills as measured by the SSRS. Finally, there was a negative significant correlation observed between the CMAE variables, Emotional Regulation and Flexible Behavior, and externalizing behavior as measured by the TRF ($r = -0.18$, $p < 0.05$; $r = -0.19$, $p < 0.01$). See Tables 4 and 5 for the partial correlations between the CMAE variables and the standardized and teacher report measures.

Model Specification and Identification

Each model, excluding the single indicator models, met the recommended model identification assumptions using the t-rule, 3-indicator rule, and the scale dependency rule (Kline 2011). The models that included a single indicator factor were identified by fixing the error term of the single indicator factor (Kline 2011). All models included a correlated error term between Eye Gaze and Directed Communication since there was conceptual overlap between the two coding definitions. Conceptualization of the following models were guided by the theoretical framework of the

Table 3 Pearson correlations between CMAE variables

CMAE variables ($n = 196$)	1	2	3	4	5	6	7	8
1. Well-regulated								
2. Productive	0.39***							
3. Independent	0.44***	0.66***						
4. Responding	0.29***	0.51***	0.35***					
5. Eye gaze	0.12	0.24***	0.03	0.28***				
6. Dir. comm.	0.12	0.26***	0.02	0.37***	0.48***			
7. Generative	0.14*	0.38***	0.20**	0.38***	0.30***	0.56***		
8. Flexible behavior	0.26***	0.24***	0.20**	0.19**	0.18**	−0.01	0.07	
9. Flexible attention	0.19**	0.15*	0.18*	0.15*	0.16*	0.07	0.09	0.31***

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

Table 4 Partial correlations between CMAE variables and standardized measures of autism symptoms, receptive vocabulary, and expressive vocabulary

CMAE variables ($n = 179$)	ADOS SA	ADOS RRB	ADOS Total	PPVT-4	EOW
Well-regulated	−0.13	0.01	−0.09	0.03	0.05
Productive	−0.17*	−0.11	−0.17*	0.18*	0.09
Independent	−0.10	−0.04	−0.12	0.11	0.15*
Response	−0.19**	−0.14	−0.18*	0.16*	0.00
Eye gaze	−0.18*	−0.07	−0.20**	0.14	0.07
Dir. communication	−0.14	−0.07	−0.12	0.15*	0.01
Generative	−0.15*	−0.07	−0.13	0.32***	0.17*
Flexible behavior	−0.07	−0.18**	−0.12	0.09	0.04
Flexible attention	−0.18*	−0.20**	−0.21**	0.19**	0.07

SB-5 ABIQ partial correlations controlling for abbreviated IQ, *ADOS* autism diagnostic observation schedule, *SA* social affect, *RRB* restricted and repetitive behavior, *Total* total score, *PPVT-4* peabody picture vocabulary test, *EOW* expressive one word picture vocabulary test

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

Table 5 Partial correlations between the CMAE variables and teacher report measures of social skills and problem behavior

CMAE variables	SSRS SS ($n = 168$)	SSRS PB ($n = 168$)	TRF Internal ($n = 171$)	TRF External ($n = 171$)	TRF Total ($n = 171$)
Well-regulated	0.20**	−0.11	−0.07	−0.18*	−0.14
Productive	0.09	−0.10	−0.05	−0.08	−0.09
Independent	0.08	0.01	0.06	−0.06	−0.03
Response	0.19*	−0.08	−0.01	−0.06	−0.00
Eye gaze	0.16*	−0.03	0.02	0.03	0.04
Dir. communication	0.19**	0.03	−0.07	0.06	0.04
Generative	0.19**	0.04	−0.05	0.03	0.01
Flexible behavior	0.18*	−0.14	−0.13	−0.19**	−0.16*
Flexible attention	0.20**	−0.15	−0.14	−0.13	−0.17*

SSRS social skills rating system, *SS* social skills scale, *PB* problem behavior scale, *TRF* teacher report form, *Internal* internalizing behavior, *External* externalizing behavior, *Total* internalizing and externalizing composite score

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

SCERTS Model as used in the CSI Project. Model specifications are indicated below.

5-Factor Model

The 5-factor model was consistent with the five themes of active engagement used in the CSI Project to promote and maximize active engagement within classroom activities. The 5-factor model consisted of five latent factors: Emotional Regulation, Classroom Participation, Social Connectedness, Initiating Communication, and Flexibility. The Emotional Regulation latent factor consisted of the single indicator Emotional Regulation. The Classroom Participation latent factor consisted of two indicators: Productivity and Independence. The Social Connectedness latent factor consisted of Responding and Eye Gaze. The Initiating Communication latent factor consisted of Directed Communication and Generative Language, and the Flexibility latent factor consisted of Flexible Behavior and Flexible Attention.

4-Factor Model

The 4-factor model was similar to the 5-factor model with the exception that the Social Connectedness and Initiating Communication latent factors were combined to comprise one Communication latent factor. The Communication latent factor therefore consisted of: Responding, Eye Gaze, Directed Communication, and Generative Language.

2-Factor Model

In the 2-factor model, the nine indicators were modeled within two latent factors. The first latent factor consisted of five indicators potentially related to classroom participation: Emotional Regulation, Productivity, Independence, Flexible Behavior, and Flexible Attention. The second latent factor consisted of four indicators related to communication in the classroom: Responding, Eye Gaze, Directed Communication, and Generative Language.

1-Factor Model

The 1-factor model included one latent factor with nine observed indicators: Emotional Regulation, Productivity, Independence, Responding, Eye Gaze, Directed Communication, Generative Language, Flexible Behavior, and Flexible Attention.

Confirmatory Factor Analysis

A series of confirmatory factor analyses were conducted to evaluate the absolute and relative fit of each model using Mplus software (Muthen and Muthen 1998). Aggregate analysis with the Maximum Likelihood Robust (MLR) estimator was used to address the nested nature of the data as well as the presence of missing data. Results indicated that the 5-factor model evidenced good absolute fit to the data, $\chi^2 = 37.21(17)$, RMSEA = 0.08, CFI = 0.95, SRMR = 0.05, and the best relative fit to the data when compared with the competing models using AIC and BIC values. The Satorra–Bentler Scaled Chi-square Difference test indicated significant differences between the 5-factor model and each of the competing models, providing further support that the 5-factor model evidenced the best relative fit to the data when compared with the competing models. See Table 6 for model fit statistics and Fig. 1 for the standardized estimates of the 5-factor model.

Discussion

This study evaluated the CMAE as a multicomponent measure of active engagement in a large, diverse sample of students with ASD. Similar to previous studies, this study documented that students with ASD exhibited limited overall active engagement in classroom activities (Bryan and Gast 2000; Nicholson et al. 2011). The current study contributes to previous research by operationalizing a multifaceted definition of active engagement and providing psychometric information on behaviors identified as core learning challenges in individuals with ASD. Confirmatory factor analysis indicated that the factor structure of the CMAE was best represented by a 5-factor model consistent with the themes of active engagement used in the CSI Project. These findings provide evidence for including students' emotional regulation, classroom participation,

Table 6 Model fit statistics using the maximum likelihood robust (MLR) estimator

Index	5-Factor	4-Factor	2-Factor	1-Factor
χ^2	37.21	74.83	90.29	122.64
df	17	21	25	26
SF	1.02	0.99	0.99	1.08
AIC	16,859.62	16,887.78	16,895.51	16,936.07
BIC	16,980.92	16,995.96	16,990.58	17,027.86
RMSEA	0.08	0.11	0.12	0.14
C.I.	0.04–0.11	0.09–0.14	0.09–0.14	0.11–0.16
*P*close-fit H_0	0.09	<0.00	0.00	0.00
CFI	0.95	0.86	0.83	0.75
SRMR	0.05	0.07	0.08	0.10

χ^2 chi-square value, *SF* scaling correction factor, *AIC* Akaike, *BIC* Bayesian, *RMSEA* root mean square error of approximation, 90 % confidence interval, probability RMSEA $\leq$ 0.05 (*P*close-fit H_0), *CFI* comparative fit index, *SRMR* standardized root mean square residual

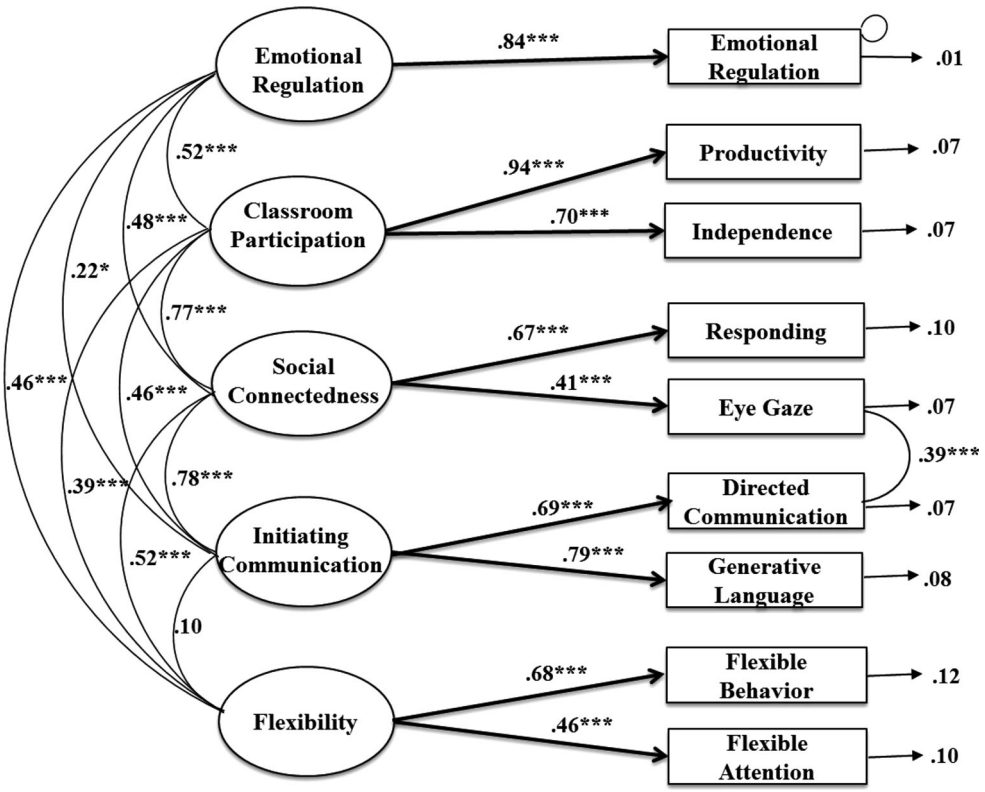

Fig. 1 Confirmatory factor analysis of the 5-factor model of the classroom measure of active engagement with standardized estimates. The single indicator factor was identified by fixing the error term of the single indicator factor. $*p \leq 0.05$; $**p \leq 0.01$; $***p \leq 0.001$

social connectedness, initiating communication, and flexibility when measuring active engagement in students with ASD—behaviors that may be important for documenting change in classroom performance of students' with ASD in the early elementary years.

Active Engagement in Students with ASD

Emotional Regulation

In contrast to previous research examining active engagement in students with ASD, this study included a measure of emotional regulation, defined as the students' ability to regulate their emotional states to match the classroom demands. Results indicated that students spent less than half of the observed time in a well-regulated state, which is not surprising given that deficits in the development of emotional regulation are related to core deficits of ASD. However, these findings are concerning because well-developed regulatory skills have been found to be important for participation and learning in educational settings (Connor et al. 2010; Guo et al. 2011; Ponitz et al. 2009; Tucker et al. 2002). Studies have suggested that students who exhibit limited regulatory skills upon school entry are less prepared for learning and at risk for school failure and peer rejection (Connor et al. 2010; McClelland et al. 2006; Ponitz et al. 2009). Future research is needed to investigate how deficits in emotional regulation observed in students with ASD affect classroom performance and learning in order to support positive educational outcomes and decrease problematic behaviors.

Classroom Participation

Similar to Ruble and Robson's (2007) findings, this study found that students with ASD spent less than half of the observed time productively and independently participating in classroom activities. Active participation has been found to be an important predictor for academic success (McClelland et al. 2006); thus, these findings taken together with Ruble and Robson's previous findings provide support for including a measure of productivity and independence when evaluating active engagement in students with ASD. It was also noted that during this baseline classroom observation, some students were given educational supports to increase participation and/or independence within activities. However, with such limited time spent productively and independently participating in activities, it highlights the need to provide better support for students with ASD in the classroom. In addition, this study found that on average, students' social skills, such as the ability to cooperate with peers and accept others' ideas, were below average as reported by both teachers and parents. This is concerning given the results of studies that

suggest that well-developed social skills are important for classroom participation and academic learning (Arnold et al. 2012; Mashburn et al. 2009; Montroy et al. 2014). Future research is essential to investigate the impact of students' social skills on classroom participation and active engagement in students with ASD. Hence, providing educational interventions that support key social skills may contribute to successful active engagement and learning in educational settings for students with ASD.

Social Connectedness and Initiating Communication

Students with ASD responded to about half of the observed verbal bids for interaction, infrequently directed communication, and rarely used generative language. Although social communication skills are a core deficit of ASD, the lack of observed communication skills may be problematic for classroom participation and academic success (Kasari and Smith 2013; Richler et al. 2010). It is important to note that the number of opportunities for interaction varied across observations, with some students receiving many opportunities to respond during interaction and others very little (range = 6–160). This may be due to a difference in the number of teachers and students between general and special education classrooms, with a higher teacher to student ratio typically observed in special education settings (CDC, 2012). It was noted that at times multiple teachers in special education classrooms directed language toward the student simultaneously, which may be especially problematic since language difficulties are commonly observed in students with ASD. Further research is needed to examine the relation between student responses and the number of verbal bids for interaction to determine whether a high frequency of teacher verbal bids encourages student responding or further contributes to a lack of social reciprocity between teachers and students with ASD.

Flexibility

Students with ASD exhibited relatively more flexible behavior when faced with changes in materials (about 75 % of the observed time) than requests to shift attentional focus (about 50 % of the observed time). However, when interpreting these findings, it is important to note that students were given fewer opportunities for classroom material changes than requests to shift attentional focus. The limited ability to shift attentional focus found in this study is consistent with the current research literature characterizing the phenotype of individuals with ASD (Volkmar et al. 2014). However, there are many possible explanations for why students within this study had difficulty shifting attentional focus in the classroom, such as a limited ability to understand the language used in the classroom or follow classroom directions, pragmatic deficits, difficulty with social reciprocity, or difficulty shifting from a preferred topic or object. Given the dynamic nature of the classroom environment, shifting attention toward relevant classroom content may have important implications for active engagement and classroom performance in students with ASD. Future research is needed to more thoroughly understand the reasons why students with ASD have difficulty shifting attention in educational settings as well as research to support improvement in flexible behavior and attention.

Examination of the Classroom Measure of Active Engagement

The observed relations among the CMAE variables provide important descriptive information about students with ASD in elementary school settings. Time spent in a well-regulated state was related to time spent in a productive and independent state. Being in a well-regulated state was also related to the number of times students produced generative language as well as the percentage they responded during interaction and exhibited observed flexible behavior and attention. Consistent with the SCERTS Model, this may indicate that being in a well-regulated state may provide a foundation for using or developing more sophisticated skills, including communication and flexibility. Alternately, this finding may suggest that skills in communication and/or flexibility may be essential for students to effectively regulate their emotions. In addition, the observed relations between the CMAE variables and standardized measures of autism symptoms and vocabulary as well as teacher report measures of social skills and problem behavior provide preliminary support for the operationalization and validation of the CMAE constructs, indicating that the CMAE measures constructs related to validated tools yet provides new information through the use of direct observation of student behavior rather than standardized or teacher report measures.

Confirmatory factor analysis indicated that the 5-factor model evidenced the best fit to the data, with all nine of the observed CMAE variables significantly loading onto each of the latent factors. However, some behaviors contributed more variance to the latent factor than others. For example, Responding contributed more variance than Eye Gaze to the Social Connectedness latent factor and Flexible Behavior contributed more variance than Flexible Attention to the Flexibility latent factor. This could be due to the nature of the classroom, indicating that the classroom context may be an important component for engagement and learning. Indeed, a recent study by Cosier et al. (2013) illustrated the importance of the classroom context for learning as they found that students who participated in

general education classrooms showed greater academic gains than students in special education classrooms. Future research is needed to evaluate the role of the classroom context in relation to active engagement for students with ASD as well as the possible influence that grade level, learning context, and/or student developmental characteristics may have on model fit of the CMAE.

Strengths and Limitations

This study included a large and diverse sample of students with ASD within general and special education classrooms, which supports generalizability to the larger ASD population in elementary school settings. The sample was relatively high functioning (57 % exhibiting an ABIQ score equal to or above 70) compared to epidemiological estimates (CDC 2014) and notably variable with regard to language and social skills as well as the presence of problematic behavior and autism symptoms, which is reflective of the variability characteristic of individuals with ASD. Further, a broad range of reliable and valid standardized measures were used to characterize the sample, and diagnoses were confirmed using a reliable "gold standard" diagnostic instrument. This study examined classroom observations of students with ASD using software that allows for detailed examination of active engagement, and the narrow age range of participants allows these findings to capture the nature and character of active engagement in early elementary school classrooms for students with ASD. Strong inter-rater reliability on each of the observed variables supports the integrity of the current findings.

The current study has limitations that are important to acknowledge. The CMAE was used to measure active engagement within classroom activities, which provides an index of classroom performance for students with ASD in educational settings. However, because additional measures of student academic performance were not included within the current study, future research is needed to document the relations between the CMAE and additional measures of classroom academic performance. A limitation of this study is that the CMAE was evaluated only for students with ASD. In future research, use of the CMAE in a sample of students with typical development would be of interest in order to provide a standard against which to gauge the active engagement of students with ASD. Further, although the variability in cognitive and developmental abilities observed within this sample is consistent with research documenting the ASD phenotype, an important consideration in the current paper, this variability presents a challenge statistically. Future research is needed to explore the student and classroom characteristics that may impact classroom active engagement. Finally, the CMAE was developed as a research tool and has limited utility beyond the research laboratory; however, it is currently being used to guide the development of a clinical tool that will measure classroom active engagement using a Likert scale. This tool will increase the utility of the CMAE to classroom teachers and service providers in educational settings.

Educational Implications and Future Directions

Efforts to increase active engagement in students with ASD in educational settings are critical in order to promote positive educational outcomes (Iovannone et al. 2003; Kasari and Smith 2013; NRC 2001). Evaluation of the factor structure of the CMAE provides insight into the structure of a unique classroom tool for measuring active engagement in elementary students with ASD. As part of the ongoing CSI Project, further research will be conducted to evaluate the utility of the CMAE to detect change in active engagement as a result of intervention for students with ASD. Further, conducting a profile analysis using the CMAE would allow for possible subgrouping of active engagement and further help explain how students with ASD change over time as a result of intervention. Finally, future research is needed to identify whether active engagement varies across classroom activities, learning contexts, and level of student developmental functioning.

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Author Contributions All authors contributed sufficiently to the manuscript. Because this study was part of the larger CSI Project, LM, CS, and AW were responsible for the study design, participant recruitment, and overseeing of the project. NS, LM, and AW were responsible for the conceptualization and design of the CMAE. NS was involved in coding of the observational data, data analysis, interpretation of the findings, and writing of the manuscript. VR was involved in data analysis, interpretation of the findings, and writing of the manuscript. All authors read and approved the manuscript.

Appendix

See Table 7.

Table 7 The classroom measure of active engagement

Emotional Regulation		
Emotional Regulation	The student's ability to manage emotional states to match the demands of the physical and social environment (e.g., using calming strategies to manage frustration; seeking out support from the classroom teacher in situations when feeling upset)	Emotional Regulation yields the duration of time the student spends in a well-regulated state
Classroom Participation		
Productivity	The student is actively performing roles within an activity and using materials in an appropriate manner—roles can be motoric or social	Productivity yields the duration of time spent in a productive state
Independence	Self-initiated management of materials and participation within classroom activities (e.g., placing items in backpack, passing out materials, completing an assignment)	Independence yields the duration of time spent in an independent state
Social Connectedness		
Responding	The student's physical and social responses following clear expectant language. Reponses do not need to demonstrate comprehension or compliance	Responding yields the percentage of times that the student responds to expectant language
Eye Gaze	Each instance of clear eye gaze directed toward a communicative partner's face. The partner's face does not have to be showing, but enough of the partner's body must be showing to confirm that the student is looking at the partner's face	Eye Gaze yields a count of the number of instances the student looks at the faces of others
Initiating Communication		
Directed Communication	A vocalization, verbalization, or communicative gesture directed toward another person to serve a communicative function (adapted from the Communication and Symbolic Behavioral Scales-Developmental Profile, Wetherby and Prizant 2002)	Directed Communication yields the number of instances the student directs clear communication toward others
Generative Language	The student's production of spoken, written, and gestural language that is used in a flexible and creative manner	Generative Language yields a count of the number of instances the student exhibits generative language
Flexibility		
Flexible Behavior	The student's ability to change in response to classroom changes including, activity changes (from one activity to another), location changes (from one place to another), and material changes (accepting new materials or using materials in a new way)	Flexible Behavior yields the percentage of time that the student exhibits flexible behavior
Flexible Attention	The student's ability to shift attentional focus when presented with opportunities to change (e.g., classroom teacher suggesting the student attend to another book)	Flexible Attention yields the percentage of time that the student exhibits flexible attention

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