Motivation, Engagement, and Mathematics Achievement: An Exploratory Study Among Chinese Primary Students

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Abstract
Student motivation and engagement have been complex issues in basic mathematics education. Based on the theory of Motivation and Engagement Wheel, this study examined the relationships among student motivation, engagement, and mathematics achievement. A sample of 1,538 Chinese primary school students participated in the survey, and motivation and engagement were assessed through their responses to the Motivation and Engagement Scale. The results largely confirmed the hypothesized relationships between motivation, engagement, and mathematics achievement. Some consistent patterns of individual differences related to gender and grade level were also revealed. Cluster analysis revealed that the category of “struggling students” showed high levels of adaptive engagement in learning, but their mathematics scores were still low, which may be correlated to their high level of maladaptive motivation and engagement. These findings provide implications for developing a more comprehensive knowledge of the nature of students’ mathematics learning motivation and improving their engagement in mathematic learning.

Keywords
China, mathematics achievement, motivation and engagement wheel, primary school students, student engagement

Introduction
Mathematics is one of the most important basic subjects in primary education. It promotes students’ abstract and logical thinking, which facilitates their academic performance in other subjects (M.-T. Wang et al., 2016). Chinese students have come out on top in mathematics in many international comparative studies such as TIMSS and PISA (D. B. Wang, 2004). However, some empirical studies have found that Chinese students’ good numeracy skills do not help them excel in solving complex open-ended problems (H. Cai et al., 2017; J. Wang & Lin, 2005), despite improvement in recent years (J. Cai et al., 2020; Ding et al., 2022). According to a survey conducted by H. Cai et al. (2017), Shanghai students’ problem-solving and critical thinking skills are weak. Although it is reported that Chinese students are better at abstract mathematics reasoning than U.S. students, they are not better at open-process problem solving (J. Wang & Lin, 2005). Yao et al. (2018) investigated students’ well-being and mathematical performance in Shanghai and found that their self-concept, motivation, and learning interest in mathematics decreased from elementary to middle school. The Chinese government attaches great importance to this issue, highlighting the need to apply learning sciences in basic education reforms (Shang et al., 2020; Zhao & Yang, 2019). Therefore, it is necessary to develop a comprehensive understanding of students’ motivation and engagement and their relationships with mathematics achievement.

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Student motivation and engagement emerged as a complex issue in basic education (Veiga, 2012). Kahu (2013) stated that motivation and engagement are inseparable, but some studies overly concentrated on the behavioral engagement and ignored motivation. Guthrie and Wigfield (2000) argued that the definition of engagement should include numerous factors, whereas in Veiga’s (2012) point of view, a prominent problem of the research on engagement evaluation was the lack of instruments with psychometric and semantic qualities. Therefore, there is a need for assessing the multidimensionality of the construct and addressing the relationship between motivation and engagement.

However, little research has been conducted on the relationship between student motivation, engagement, and mathematics achievement in Chinese primary schools. Recently, a growing body of literature on primary mathematics education has been published on a global scale (e.g., Deng et al., 2020; Dowker et al., 2019; Liu et al., 2020; L. Wang, 2021), but most of these studies have focused on students’ attitude to mathematics and their performance rather than motivation and engagement. This study explores the motivation, engagement, and math achievement of primary school students in China in order to mitigate this gap. On this basis, three research questions will be answered: (1) What is the reliability and validity of the Motivation and Engagement Scale when applied to primary school students in China? (2) Is there any difference in students’ motivation and engagement in terms of different demographic characteristics such as grade level and gender? (3) What are the characteristics of motivation, engagement, and mathematics achievement of primary students in China? The findings are expected to contribute to the knowledge building of student motivation and engagement from a multidimensional construct. Further, these results will help develop a more comprehensive understanding of students’ mathematics learning motivation and improve their engagement in mathematics.

**Literature Review**

**Theoretical Perspectives on Motivation and Engagement**

Motivation and engagement are inseparable. Motivation is students’ energy and learning drive, and engagement is defined as the behavior of working hard and efficaciously (Martin et al., 2017). This definition focuses on students’ psychological investment and efforts. Some researchers also argue that motivation and engagement are intertwined. The former comprises private psychological factors and the latter focuses on publicly observable behaviors (Reeve, 2012). Newmann (1992) emphasized that engagement means active participation in the learning process or in the tasks set rather than lack of interest, apathy, or superficial participation.

Fredricks et al. (2004) and Fredricks, Filsecker, and Lawson (2016) identified three distinct but interrelated components of engagement: behavioral engagement, emotional engagement, and cognitive engagement. Behavioral engagement focuses on participation, effort, and persistence in academic and social activities; emotional engagement encompasses the positive and negative emotions associated with others in education (e.g., teachers, peers, etc.) and the feelings that reflect the inclination to learn; cognitive engagement can be defined as the mental investment and efforts to grasp complex ideas or concepts and to develop self-regulatory skills and metacognitive strategies (Fredricks, Wang, et al., 2016).

The multifaceted theory of motivation and engagement indicates that studying student engagement from a single perspective is limited. Motivation and engagement include enabling and impeding dimensions (Martin, 2009). The need for a change of perspective from a behavioral to a psychological perspective is therefore critical (Yin, 2018; Yin & Wang, 2016).

**A Multidimensional Construct of Student Motivation and Engagement**

Considering the importance of educational and psychological contexts, more attention to student motivation and engagement in basic education is in need (Greeno, 1998; Martin, 2009; Pintrich, 2003). However, many studies of motivation and engagement are fragmented (Martin, 2009), underlining the urgency to attaining more integrative approaches to measure and theorize motivation and engagement. A motivation and engagement wheel was developed by Martin (2007) to integrate multiple perspectives about motivation and engagement.

The Motivation and Engagement Wheel includes two levels of factors: the integrative four higher-order level of factors and 11 lower-level factors. Martin (2007) argued that learning and achievement require attention to motivation and engagement, both of which can also be divided into adaptive and maladaptive dimensions. On the ground of this argument, the wheel includes a) adaptive motivation (self-belief, valuing, and learning focus); (b) adaptive engagement (planning, task management, and persistence); (c) maladaptive motivation (anxiety, failure avoidance, and uncertain control); and (d) maladaptive engagement (self-sabotage and disengagement).

Martin developed a series of questionnaires accompanying the Motivation and Engagement Wheel. The questionnaires have been used in primary schools, high schools, and universities/colleges (Martin, 2009). Martin and his colleagues have sought to apply the MES in mathematics, English, and other disciplines (Green et al.,
Individual Differences in Student Motivation, Engagement, and Mathematics Achievement

A salient and prevalent challenge for teachers in classrooms is that students often lack sufficient motivation and engagement (Fredricks et al., 2016). Generally, students with high levels of motivation and engagement are more likely to achieve higher scores and pursue higher education (Fredricks et al., 2004). Therefore, enhancing students’ motivation and engagement is the center of teaching research (Marzano et al., 2018). A recent study has shown that students’ perceptions of mathematics in primary schools can influence their motivation and engagement and their willingness to participate in mathematics academic activities (Lazarides et al., 2020).

Student mathematics achievement is influenced by many factors and motivation is placed at the center. It is argued that students who are motivated will pay more attention to mathematics learning, and as a result, they will have higher mathematics scores (Putwain et al., 2018). On the contrary, students with low motivation or negative feelings, such as anxiety, will have a hard time getting good mathematics performance (Rodríguez et al., 2020). However, the results from empirical studies are mixed. For example, a study on 262 pairs of same-sex twins who are an average of 12.25 years old has shown an inverted-U relationship between anxiety and mathematics performance. All participants had high intrinsic mathematics motivation. This study also reveals a moderate negative association between mathematics anxiety and mathematics performance among participants with low intrinsic mathematics motivation (Z. Wang et al., 2015). Hence, the relationship between student motivation and mathematics achievement is not simply linear.

In terms of grade level, students’ motivation and engagement fluctuate frequently with grade levels (Fredricks et al., 2004; Patall et al., 2018). In particular, this occurs during the transition from elementary to middle school. This is particularly the case during the transition from primary to middle school (Skinner et al., 2008). Some studies have found students’ interests in mathematics decrease while mathematics anxiety grows with the increase of grade level (Plenty & Heubeck, 2011, 2013). However, some studies report that the indicators of mathematics motivation rise before they decline (Fredricks & Eccles, 2002; Jacobs et al., 2002). These results demonstrate that students’ mathematics motivation may develop in a mixed pattern (Chouinard & Roy, 2008; Watt, 2004).

In terms of gender difference, previous studies showed that girls tend to embody fewer positive attitudes toward mathematics than boys, particularly lower motivation and higher mathematics anxiety (Rodríguez et al., 2020), whereas boys tend to have stronger mathematics self-efficacy and intrinsic interest than girls (Plenty & Heubeck, 2011). Research also suggests that gender difference in mathematics ability is minimal during early childhood and does not consistently increase until middle to late adolescence (Robinson & Lubienski, 2011).

In short, despite some studies have examined the characteristics of students’ mathematics motivation and engagement, but few have reached consensus. The current study aims to address this gap by exploring individual differences in students’ mathematics motivation, engagement, and mathematics achievement.

Methods

Participants

The research reported in this paper is part of the China Learning Plan project—a 10-year project carried out by the Learning Sciences Lab of X University. This study involves a sample of students from two primary schools located in the suburban area of Beijing, the capital of China. The two schools are in the same district, have comparable levels of social and economic background, and adopt the same mathematics textbooks.

A questionnaire survey was anonymously administered to fourth to sixth grade students in the autumn of 2018. Students in grades 1 to 3 were not invited to participate in the survey, considering the limited reading ability of younger students. With the consents of the students, this study collected the responses of all the fourth to sixth grade students in these two primary schools. The questionnaire with more than 5% of questions unanswered was considered invalid. The final sample comprised 1,538 students, including 738 females and 800 males. There were 609 (39.6%) students in the fourth grade, 372 (24.2%) in the fifth grade, and 557 (36.2%) in the sixth grade. Participants were between 9 and 12 years old.
Materials and Research Procedures

The 44-item MES scale developed by Martin (2007) was adopted in this study to measure the Chinese primary students’ motivation and engagement. As stated previously, the MES contains both adaptive and maladaptive dimensions, and each dimension consists of motivation and engagement components. It has four higher-order factors and 11 first-order factors (details can be found on this website http://www.lifelongachievement.com). Participants were asked to score on a 5-point Likert scale from 1 (disagree strongly) to 5 (agree strongly).

The original scale MES is an English language instrument. To ensure the quality of the Chinese version of the questionnaire, two researchers who are proficient in both Chinese and English translated the scale MES from English to Chinese and back translated it.

Students’ mathematics achievement was calculated by their mathematics scores in the final exam—a written test to examine what students had learned during the semester. Usually, in China, the education department of each city or region gathers subject experts from different schools to design the exam questions at the end of each term. The test scores are important indicators of students’ academic performance.

This study obtained ethical approval from the first author’s university. We collected the data in the Autumn semester of 2018-2019. A few research assistants helped collect the participants’ consents and administered the questionnaire to the participants. The questionnaire was anonymously conducted.

Data Analysis

This study conducted confirmatory factor analyses (CFA) and structural equation modeling (SEM) using Mplus 7.4. The method of estimation was maximum likelihood. CFA was used to study the relationships between a set of observed variables and a set of continuous latent variables (Muthén & Muthén, 1998). When using CFA and SEM, a hypothesized model was compared to the observed data (Barrett, 2007).

Several indices were used to show the robustness of the fit in the CFA and SEM analyses. Chi-square test statistics were used to assess model fit along with goodness-of-fit indices such as the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), and the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR). CFI and TLI values above 0.90 (Marsh et al., 2004) and 0.95 (Hu & Bentler, 1999) indicated acceptable and great fit respectively, whereas the RMSEA below or near 0.05 signified an acceptable fit of data to a model (Browne & Cudeck, 1992). Composite reliability (CR) was the combination of the reliability of all variables, indicating internal consistency. To evaluate convergent validity, the average variance extracted (AVE) for each construct was evaluated against its correlation with the other constructs. Fornell and Larcker (1981) stated that the CR of the latent variables should reach .60, while the AVE should reach .50, and .36 to .50 was acceptable. Factor loading was the correlation of the variable and the factor, and the squared loading was the amount of the variables accounted for the factor. Hair (2019) asserted that loadings 0.50 or greater are considered practically significant, and factor loadings in the range of 0.30 to 0.40 are considered to meet the minimal level for interpretation of the structure. A smaller loading was permitted when either a large sample size or a large number of variables are analyzed.

The descriptive analysis and correlations analysis of the variables were performed. To examine the differences among genders and various grade levels, factor analysis of variance (ANOVA) was conducted. Finally, to determine the characteristics of students within the sample, a cluster analysis was conducted.

Results

Scale Validation and Descriptive Statistics

The MES scale had a clear theoretical lineage, thus, CFA rather than exploratory factor analysis was adopted to examine the construct validity. Under the consideration of the hierarchical structure of the Motivation and Engagement Wheel, the hierarchical second-order model of the MES scale was examined and found to reach an acceptable level of data fit ($\chi^2/df = 3.22$, CFI = 0.92, TLI = 0.91, RMSEA = 0.038, SRMR = 0.055).

Table 1 presents the reliabilities and descriptive statistics of the measures in this study. All the CR of the variables was higher than .60, indicating that all the subscales achieved a high level of internal consistency. The AVE of factor valuing, self-belief, and anxiety were low, but close to .36, and the AVE of other variables reached .36, showing that all the subscales reached an acceptable level of convergent validity. Moreover, all the CFA loadings reached 0.40, which implied that the model met the criterion for factor loading.

Correlations Between Student Motivation, Engagement, and Mathematics Achievement

The correlation between students’ mathematics scores and motivation and engagement is shown in Table 2. The results suggest that adaptive factors (AM and AE) were positively related to mathematics scores, while the two maladaptive factors (MM and ME) were negatively related to mathematics scores. The correlation matrix for
the four factors is presented in Table 2. The two adaptive and the two maladaptive factors exhibited strong and positive correlations as expected. Comparatively, the adaptive factors generally exhibited weak and negative correlations with the maladaptive factors, despite the fact that all correlations were statistically significant.

Comparison of Gender and Grade Differences

ANOVA was used to examine the differences of mean in terms of gender and grade level. Both main and interaction effects were assessed. Table 3 presents the comparison results for the MES factor means.

As indicated in Table 3, the effect of gender difference on learning focus, persistence, planning, self-sabotage, adaptive engagement, and maladaptive engagement was found significant. Male students scored lower on learning focus \((F(1, 1,530) = 7.45, p < .05, \eta_p^2 = .005)\), persistence \((F(1, 1,530) = 8.57, p < .05, \eta_p^2 = .006)\), planning \((F(1, 1,530) = 15.74, p < .001, \eta_p^2 = .010)\), adaptive engagement \((F(1, 1,530) = 12.30, p < .001, \eta_p^2 = .008)\) and higher on self-sabotage \((F(1, 1,530) = 8.33, p < .05, \eta_p^2 = .005)\), maladaptive engagement \((F(1, 1,530) = 6.42, p < .001, \eta_p^2 = .004)\) than females.

It is also shown in Table 3 that significant grade-level differences were found for disengagement, learning focus, persistence, planning, self-belief, valuing, adaptive motivation, and adaptive engagement. The fourth-grade students reported significant lower scores on disengagement \((F(2, 1,530) = 3.01, p < .05, \eta_p^2 = .004)\) than the students in sixth grade. The fourth-grade students scored higher on learning focus \((F(2, 1,530) = 11.00, p < .001, \eta_p^2 = .014)\), persistence \((F(2, 1,530) = 15.92, p < .001, \eta_p^2 = .020)\), and adaptive motivation \((F(2, 1,530) = 12.34, p < .001, \eta_p^2 = .020)\) than students in senior grades. Furthermore, the fourth-grade students were found to report significant higher scores on planning and adaptive engagement than students in fifth grade and sixth grade, and the fifth-grade

| Scale | M  | SD | CR | AVE | CFA loadings M (range) |
|-------|----|----|----|-----|------------------------|
| V     | 4.45 | 0.55 | .67 | .34 | 0.58 (0.49–0.73) |
| SB    | 4.42 | 0.61 | .68 | .35 | 0.59 (0.49–0.70) |
| LF    | 4.38 | 0.62 | .74 | .42 | 0.65 (0.59–0.78) |
| P     | 4.16 | 0.71 | .75 | .43 | 0.66 (0.64–0.69) |
| TM    | 4.15 | 0.81 | .75 | .50 | 0.71 (0.68–0.77) |
| PL    | 3.98 | 0.89 | .86 | .61 | 0.78 (0.73–0.81) |
| A     | 2.54 | 0.99 | .61 | .34 | 0.58 (0.54–0.63) |
| FA    | 3.02 | 1.12 | .82 | .53 | 0.73 (0.64–0.76) |
| UC    | 2.60 | 1.04 | .75 | .43 | 0.64 (0.45–0.74) |
| D     | 1.63 | 0.69 | .71 | .38 | 0.61 (0.52–0.69) |
| SS    | 2.94 | 0.94 | .69 | .37 | 0.60 (0.45–0.70) |
| AM    | 4.41 | 0.50 | .93 | .83 | 0.91 (0.86–0.99) |
| AE    | 4.10 | 0.66 | .85 | .65 | 0.80 (0.63–0.97) |
| MM    | 2.72 | 0.83 | .86 | .67 | 0.80 (0.57–0.97) |
| ME    | 2.28 | 0.66 | .61 | .45 | 0.64 (0.49–0.80) |

Note: Factor loadings were shown in the completely standardized form. CFA loadings reflect the range of indicator loadings for each construct. V = valuing; SB = self-belief; LF = learning focus; P = persistence; TM = task management; PL = planning; A = anxiety; FA = failure avoidance; UC = uncertain control; D = disengagement; SS = self-sabotage; AE = adaptive engagement; ME = maladaptive engagement; AM = adaptive motivation; MM = maladaptive motivation.

| MATH | AE | ME | AM | MM |
|------|----|----|----|----|
| MATH | —  | .136** | —  | —  |
| AE   | .207** | —  | .193** | —  |
| ME   | —  | .225** | —  | .233** |
| AM   | .227** | .717** | —  | .569** |
| MM   | —  | —  | .211** | —  |

Note. MATH = mathematics score; AE = adaptive engagement; ME = maladaptive engagement; AM = adaptive motivation; MM = maladaptive motivation.

* p < .05. ** p < .01.
Table 3. Gender and Grade Differences.

| Variables | Group | M   | SD  | F    | Effect                  |
|-----------|-------|-----|-----|------|-------------------------|
| A Gender  | M     | 2.60| 1.00| 3.59 |                         |
|           | F     | 2.49| 0.97|      |                         |
| Grade G4  | 2.50  | 0.99| 0.89|      |                         |
| G5        | 2.58  | 0.98|      |      |                         |
| G6        | 2.56  | 0.99|      |      |                         |
| Gender × grade | M | 1.65| 0.72| 0.83 |                         |
|           | F     | 1.61| 0.67|      |                         |
| Grade G4  | 1.58  | 0.71| 3.01*| G4 < G6 |                 |
| G5        | 1.63  | 0.70|      |      |                         |
| G6        | 1.68  | 0.67|      |      |                         |

| Gender × grade | M | 3.01| 1.16| 0.59 | G4(F) < G6(F); F(G4) < M(G4) |
| Grade G4      | 3.07| 1.18| 1.05|      |                         |
| G5            | 3.01| 1.10|      |      |                         |
| G6            | 2.97| 1.07|      |      |                         |

| Gender × grade | M | 4.34| 0.66| 6.21*| M > F(G4) |
| Grade G4      | 4.47| 0.57| 11**| G4 > G5, G6 |                 |
| G5            | 4.31| 0.63|      |      |                         |
| G6            | 4.32| 0.66|      |      |                         |

| Gender × grade | M | 4.11| 0.73| 8.57*| M < F |
| Grade G4      | 4.29| 0.66| 15.92**| G4 > G5, G6 |                 |
| G5            | 4.11| 0.75|      |      |                         |
| G6            | 4.06| 0.73|      |      |                         |

| Gender × grade | M | 3.90| 0.92| 15.74***| M < F |
| Grade G4      | 4.14| 0.83| 20.66**| G4 > G5, G6 |                 |
| G5            | 3.96| 0.86|      |      |                         |
| G6            | 3.82| 0.93|      |      |                         |

| Gender × grade | M | 4.41| 0.62| 0.37 |                         |
| Grade G4      | 4.42| 0.61|      |      |                         |
| G5            | 4.43| 0.58|      |      |                         |
| G6            | 4.34| 0.66|      |      |                         |

| Gender × grade | M | 3.00| 0.97| 8.33*| F(G4), F(G5) > F(G6) |
| Grade G4      | 2.96| 0.98| 0.40 |      |                         |
| G5            | 2.92| 0.95|      |      |                         |
| G6            | 2.92| 0.90|      |      |                         |

| Gender × grade | M | 4.12| 0.83| 2.52 |                         |
| Grade G4      | 4.19| 0.79|      |      |                         |
| G5            | 4.18| 0.77|      |      |                         |
| G6            | 4.10| 0.83|      |      |                         |

| Gender × grade | M | 2.60| 1.04| 0.01|                         |
| Grade G4      | 2.67| 1.08| 2.40|      |                         |
| G5            | 2.53| 1.01|      |      |                         |
| G6            | 2.56| 1.00|      |      |                         |

| Gender × grade | M | 0.98 |       |      |                         |

(continued)
students scored higher on planning (F(2, 1,530) = 20.66, p < .001, $\eta^2_p = .026$) and adaptive engagement (F(2, 1,530) = 12.34**, p < .001, $\eta^2_p = .020$) than fifth-grade students. The sixth-grade students had significant lower scores on self-belief (F(2, 1,530) = 8.74, p < .001, $\eta^2_p = .011$) and valuing (F(2, 1,530) = 8.55, p < .001, $\eta^2_p = .011$) than students in other grades.

Major interaction effects were found between gender and grade level on factors of disengagement, failure avoidance, learning focus, persistence, task management, planning, anxiety, failure avoidance, uncertain control, disengagement, self-sabotage, adaptive motivation, adaptive engagement, and maladaptive motivation. Simple effects analyses were used to further investigate the interaction between gender and grade level. Male students scored higher on disengagement (F(1, 1,530) = 6.84, p < .05, $\eta^2_p = .004$), failure avoidance (F(1, 1,530) = 6.42, p < .05, $\eta^2_p = .004$), and maladaptive motivation (F(1, 1,530) = 7.19, p < .05, $\eta^2_p = .005$) than female students in fourth grade. The sixth-grade female students scored higher on disengagement (F(2, 1,530) = 6.61, p < .001, $\eta^2_p = .009$) than fourth-grade female students. Female students in sixth grade scored lower on self-belief (F(2, 1,530) = 11.66, p < .001, $\eta^2_p = .015$) than female students in other grades.

These results demonstrated that students’ adaptive motivation and engagement decreased as grade levels increased, and that female students reported stronger learning focus, persistence, planning, and less maladaptive motivation and self-sabotage than male students. In addition, these results indicated that female students outperformed male students in fourth grade, but the difference became smaller for the fifth- and sixth-grade students.

### Cluster Analysis

To distinguish the characteristics of the students in the sample, k-mean clustering was conducted after centering the scale means of four integrative factors: adaptive motivation, maladaptive motivation, adaptive engagement, and maladaptive engagement.

| Variables | Group | M    | SD   | F    | Effect          |
|-----------|-------|------|------|------|-----------------|
| V         | Gender | M    | 4.43 | .56  | 1.34            |
|           |       | F    | 4.47 | .54  |                 |
|           | Grade | G4   | 4.51 | .51  | 8.55**          | G4, G5 > G6 |
|           |       | G5   | 4.45 | .53  |                 |
|           |       | G6   | 4.38 | .60  |                 |
| AM        | Gender | M    | 4.39 | .51  | 3.25            |
|           |       | F    | 4.44 | .49  |                 |
|           | Grade | G4   | 4.49 | .46  | 12.34**         | G4 > G5, G6 |
|           |       | G5   | 4.40 | .49  |                 |
|           |       | G6   | 4.34 | .54  |                 |
| AE        | Gender | M    | 4.04 | .67  | 12.30**         | M < F       |
|           |       | F    | 4.16 | .64  |                 |
|           | Grade | G4   | 4.20 | .61  | 15.71**         | G4 > G5 > G6 |
|           |       | G5   | 4.08 | .64  |                 |
|           |       | G6   | 3.99 | .70  |                 |
| MM        | Gender | M    | 2.74 | .83  | 0.20            |
|           |       | F    | 2.70 | .83  |                 |
|           | Grade | G4   | 2.75 | .86  | 0.50            |
|           |       | G5   | 2.71 | .83  |                 |
|           |       | G6   | 2.70 | .81  |                 |
| ME        | Gender | M    | 2.32 | .69  | 6.42*           | M > F(G4)   |
|           |       | F    | 2.24 | .63  |                 |
|           | Grade | G4   | 2.27 | .68  | 0.38            |
|           |       | G5   | 2.27 | .65  |                 |
|           |       | G6   | 2.30 | .65  |                 |
| Gender × grade | M    | 1.88 |      |      |                 |

Note: Factor loadings were shown in a completely standardized form. CFA loadings reflect the range of indicator loadings for each construct. Coding for gender, 1 = male, 2 = female. V = valuing, SB = self-belief, LF = learning focus, P = persistence, TM = task management, PL = planning, A = anxiety, FA = failure avoidance, UC = uncertain control, D = disengagement, SS = self-sabotage, AM = adaptive motivation, AE = adaptive engagement, MM = maladaptive motivation, ME = maladaptive engagement.

*p < .05. **p < .01. ***p < .001.
and maladaptive engagement. A three-cluster solution, suggested by the elbow method (Aslam et al., 2020), was adopted at the k-mean. Figure 1 presents the cluster analysis results.

As indicated in Figure 1, in terms of motivation and engagement, the three categories of students exhibited different characteristics. The first category consisted of 681 students (44.3%) who are classified as “active students.” They had the average higher levels of adaptive factors (adaptive motivation and engagement) and the average lower levels of maladaptive factors (maladaptive motivation and engagement). The second category contained 441 students (28.7%). Categorized as “passive students,” they had a below-average level of adaptive motivation and engagement, and an above-average level of maladaptive motivation and engagement. The third category comprised 416 students (27.0%) who had above-average levels of both adaptive motivation and engagement and maladaptive motivation and engagement. These students were designated as “struggling students.”

Table 4 presents the distribution of the three categories of students in different grades and their average mathematics scores. The results implied that “active students” have higher mathematics scores (85.3, 84.9, and 85.0) in fourth to sixth grades. The “struggling students” have relatively lower mathematics scores (79.3, 77.9, and 79.3) in fourth to sixth grades. The “passive students” scored the lowest in mathematics (77.6, 80.0, and 78.6) in fourth to sixth grades.

Compared to the other two categories of learners, the performance on the adaptive factors of “struggling students” was quite well and even close to that of the “active students.” However, they scored very high on the maladaptive motivation and engagement factors. These results reflect some characteristics of the Chinese students’ mathematics learning.

Discussion

Using the MES scale, this study explored the issue of Chinese primary students’ motivation and engagement and their relations to mathematics achievement. To the best of our knowledge, this is the first study to apply the MES scale to student engagement research in the context of Chinese primary schools. The results revealed some characteristics and individual differences in students’ motivation and engagement, which brings implications for improving the quality of mathematics teaching in China.

Based on the CFA results of this study, the model fitted the data well, and the reliability of all subscales in the model was acceptable. The results support the psychometric properties of the scale, suggesting it can be applied to research relating to student engagement in primary schools. However, it should be noted that item 43 (“I worry about school and schoolwork”) in the MES scale had a low factor loading value which suggests that this item may be inappropriate for measuring the anxiety of primary school students in China. This result is consistent with the findings from the research on Chinese students in Hong Kong. That study reported that the CFA loading of anxiety was the second lowest (Martin & Hau, 2010). In Martin et al.’s (2018) research of high school students in Jamaica, they also found the similar issue that the CFA loading of anxiety (ranging 0.35–0.61) was the lowest.

Individual Differences in Chinese Primary School Students’ Motivation and Engagement

In terms of gender and grade level, there are consistent patterns in terms of students’ motivation and engage-
ment. In line with the findings of Martin (2009) and Plenty and Heubeck (2013), the results of this study demonstrated that adaptive motivation and engagement decreased as their grade levels increased. Specifically, the fourth-grade students tended to be more motivated and engaged as they scored higher on learning focus, persistence, planning, self-belief, and valuing than students in fifth and sixth grade. As to the maladaptive motivation and engagement, there were no significant differences between different grades. The only difference was that the sixth-grade students reported greater disengagement than the fourth-grade students. One possible reason for this is that mathematics becomes more challenging in higher grades. The perception that mathematics is complicated may discourage certain students from learning the subject. Another possible reason is that students in the sixth grade are under pressure due to the secondary school entrance exam, which increases students’ maladaptive motivation and negative feelings. In addition, increasing peer pressure and parents’ expectations, which increase with age, may also affect students’ motivation to learn mathematics.

On gender difference, this work found that female students reported stronger learning focus, persistence, planning, and less maladaptive motivation and self-sabotage than male students, which is different from previous findings (e.g., Plenty & Heubeck, 2011; Robinson & Lubienski, 2011; Rodriguez et al., 2020). The interaction between gender and grade level revealed that only fourth-grade male students had higher disengagement and maladaptive motivation than their female counterparts, however, the fifth- and sixth-grade students did not show significant gender difference. Also, female students in sixth grade showed more disengagement than fourth-grade female students. Female students performed not as well as they were in fourth grade, and male students did not show significant changes when heading to higher grade level. In short, these results indicated that female students outperformed male students in fourth grade, but the difference became smaller for the fifth- and sixth-grade students. In line with the previous studies (Fredricks & Eccles, 2002; Jacobs et al., 2002), these results indicate that the gender gap tends to narrow over time.

**The Need for a Multidimensional Perspective on Student Engagement**

This study is a step forward in exploring the multidimensional construct of student engagement. These findings demonstrate the need to study student motivation and engagement in primary schools from a different perspective (Greeno, 1998; Martin, 2009; Pintrich, 2003). In this regard, the MES scale is a desirable instrument for measuring elementary students’ motivation and engagement because it supports the multidimensionality of students’ motivation and engagement, which consists of cognitive, emotional, and behavioral dimensions in adaptive and maladaptive aspects. The multidimensional factor structure helps this study to show the complexity of students’ engagement in primary schools.

Firstly, following the Motivation and Engagement Wheel, an ideally engaged student should score high on the adaptive factors and low on the maladaptive factors (Martin, 2009). As shown in Table 1, students participating in this study had higher scores on the adaptive factors, but their scores on some maladaptive factors were not as low as expected, such as failure avoidance and self-sabotage. In addition, the cluster analysis results showed that “passive students” and “struggling students” made up 55.7% of the sample, which means that many students in this sample scored high on maladaptive factors. The result revealed that most of these Chinese primary school students scored high on both adaptive and maladaptive factors. These findings alert us to pay attention to the quality of mathematics learning in Chinese primary schools.

Secondly, the multidimensional construct of the MES scale is conducive to assessing the discrepancies between students’ motivation and behavioral engagement. Our cluster analysis identified an interesting category of students, namely “struggling students.” Compared to the other two categories of learners, their performance on the adaptive factors was quite well and even close to that of the “active students.” However, contrary to our expectation, they scored very high on the maladaptive motivation and engagement factors, even surpassing the “passive students.” In view of mathematics scores, “active students” scored highest and “passive students” scored lowest. In contrast to previous findings that students with adaptive engagement could get high scores in mathematics (Putwain et al., 2018), this study found that for the “struggling students” who had a high adaptive engagement, their mathematics scores were almost as low as those of the “passive students.”

In our opinion, the results of “struggling students” reflect the influence of the Chinese sociocultural context on students’ motivation and engagement. As stated in the literature published in recent years, student engagement is highly influenced by sociocultural contexts (Kahu 2013; Martin, Yu, & Hau, 2014). Chinese culture emphasizes the importance of diligence and hard work (Li, 2012) and these learning virtues have deeply affected students’ learning behaviors (Lau & Chan, 2001). Therefore, Chinese students tend to keep trying despite their low efficacy (Hau & Ho, 2008). This cultural environment may contribute to the construction of struggling students. To survive in an environment that honors these
learning virtues, they need to depict themselves as a diligent learner, despite the obstacles and psychological burdens they face. However, hard work alone, as shown in this study, does not necessarily help “struggling students” get high scores in mathematics.

**Limitations and Directions for Future Work**

Two research limitations need to be acknowledged. The first limitation relates to the sample of the study. All participants were primary students in Beijing, which limits the generalizability of the findings of this study. Therefore, future research is expected to enlarge the sample size and magnify the regional diversity to obtain a representative sample.

Second, this study was cross-sectional. Little can be concluded about the causal relationship between students’ motivation, engagement, and mathematics achievement. To help verify the relationship, future studies should use a longitudinal research design.

**Conclusion and Research Implications**

This study lifts a veil on the relations between motivation, engagement, and mathematics achievement of Chinese primary school students. These findings have some implications for improving mathematics teaching and learning in China.

First, this study confirmed the reliability and validity of the MES scale and highlighted the need for a multidimensional perspective on student engagement. The multidimensional factor structure helps us depict a comprehensive profile of Chinese students’ motivation and engagement. The study found students scored high on both adaptive and maladaptive factors, indicating that Chinese primary school students’ engagement is not as ideal as it looks. The scores on maladaptive factors (i.e., failure avoidance and self-sabotage) highlight the necessity to help Chinese primary school students in learning mathematics. More guidance on the effective learning strategies of mathematics should be provided for them. Future research can explore students’ motivation and engagement from a multidimensional perspective.

Secondly, the current study found that the dominant position of female students in adaptive factors diminishes with the increase of grade level, narrowing the gap between gender. Overall, student adaptive motivation decreased with the increase of grade level. These findings suggest that there is a need to innovate learning methods for primary school students when they move to higher grades. For example, teachers can design gamification learning activities to boost male student learning interest and adopt cooperative learning in senior grades to encourage female students to tackle maladaptive motivation.

Finally, this study found that “struggling students” constituted a large proportion of the sample, revealing some problems in Chinese primary mathematics education. Some students seem to study hard, but their grades fall short of expectations. In China, good grades are important for students to gain recognition from adults and to keep good relationships with their parents (Ding et al., 2022; Pan & Zaff, 2017). The examination-oriented education may depress students’ intrinsic learning motivation, which also seems to answer the question of why Chinese students have proficient numeracy skills but not lead in solving open-ended complex problems (H. Cai et al., 2017; J. Cai et al., 2020). Therefore, it is an urgent task for teachers to change their conceptions of mathematics teaching. Compared with goods grades, it is more important for mathematics teachers to cultivate primary students’ curiosity, interest, and adaptive motivation in mathematics learning.

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