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# A latent profile analysis of homework time, frequency, quality, interest, and favorability: implications for homework effort, completion, and math achievement

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**Abstract**
The major objectives of our study were (a) to identify student profiles according to five homework characteristics (homework time, frequency, quality, interest, and favorability) and (b) to examine their relationship with three critical variables in the homework process—homework effort, completion, and math achievement. Latent profile analysis (LPA) was used to examine a data set with 3018 8th graders in China. Based on these characteristics, five distinct profiles were identified: Profile 1 (*Low*), Profile 2 (*Moderate Time/High With Others*), Profile 3 (*Low Frequency/Moderate With Others*), Profile 4 (*Moderate Time/High Frequency/Low With Others*), and Profile 5 (*High Time and Frequency/Moderate With Others*). Parent education was positively associated with the two healthiest profiles (Profile 2 and Profile 5). Finally, profile membership was a significant predictor of homework effort, completion, and math achievement. Specifically, our study suggests that students can work about 30 min on math homework and achieve the same results, if they work often, with high quality, fueled by interest and favorability (compared with students who spend about 110 min on math homework). Taken together, our study provided novel insights into the combination of homework characteristics that could have significant implications for homework practice and research.

**Keywords** Person-centered approach · Homework time · Homework frequency · Homework quality · Homework interest · Homework favorability

## Introduction

Commonly defined as "tasks assigned to students by school teachers that are meant to be carried out during nonschool hours" (Cooper, 1989, p. 7), homework is a prevalent instructional activity with everyday importance for many teachers, parents, and students (Fan

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et al., 2017; Dettmers et al., 2010). It is frequently considered an important instructional strategy to promote study habits and academic achievement (Fan et al., 2017; Cooper, 1989; Yang & Tu, 2020).

Homework is a "complicated thing" (Corno, 1996), influenced by more factors than any instructional activities (Cooper, 2007). One cluster of factors that has thus far attracted the most attention in the field is homework characteristics—homework time, frequency, quality, interest, and favorability (Xu et al., 2016; Fan et al., 2017; Cooper, 1989; Cooper et al., 2006; Fernández-Alonso et al., 2015; Rosário et al., 2018; Suárez et al., 2019). Yet, much of the prior studies have used a variable-centered approach, ignoring the likelihood that different combinations of homework characteristics might exist and associate with homework behavior and student achievement.

Our current investigation attempts to address this gap in homework research, by taking a person-centered approach to the study of homework characteristics. A study such as this is timely, as many students find it more challenging to complete their homework assignments during the SARS-CoV-2 pandemic (e.g., spending more time doing homework yet with limited support traditionally provided by teachers; Suárez et al., in press; Van Lancker & Parolin, 2020).

## Homework characteristics: theoretical models and related research

Comprehensive homework models (Xu & Corno, in press; Cooper, 1989; Trautwein et al., 2006) were developed to capture a multitude of factors in the homework process. Drawn from synthesis of homework research, Cooper (1989) developed a process model of factors that influence the effectiveness of homework. Cooper posited that homework outcomes such as homework completion and student achievement could be affected by the following groups of factors: exogenous factors (e.g., gender and parent education), assignment characteristics (e.g., amount), initial classroom factors (e.g., proposed approaches), home-community factors (e.g., parental help), and classroom follow-up (e.g., teacher feedback).

Extending Cooper's work, Trautwein et al. (2006) developed a complementary homework model. Specifically, Trautwein et al. posited that academic achievement may be influenced by the following groups of variables: classroom learning environment, homework characteristics (e.g., length, frequency, and quality), student background (e.g., gender), parental involvement (e.g., homework assistance), student motivation (e.g., homework expectancy), and homework behavior (e.g., homework effort and completion).

Due to the linkage to the objectives of the current investigation, we focused on homework characteristics in the above two theoretical models along with related previous homework investigation. In Cooper's model, the amount of homework assigned or time spent on homework is conceptualized as one important homework characteristic that may influence homework completion and academic achievement. Aside from homework time, Trautwein et al. (2006) incorporated two additional homework characteristics (i.e., homework frequency and homework quality) expected to influence academic achievement (Trautwein & Köller, 2003). Trautwein et al.'s model further pointed to the significance of homework effort in the homework process, in that homework characteristics such as homework time, frequency, and quality may influence homework effort (i.e., in addition to homework completion and academic achievement in Cooper's model).

Much of the previous literature on homework characteristic variables emphasizes on the influence of homework time and frequency on student achievement. In their research synthesis, Cooper et al. (2006) examined the relation between homework time and student

achievement. Their analysis of 69 separate correlations from 32 studies yielded a weighted average correlation of 0.24. In another research synthesis, Fan et al. (2017) examined the prior studies on the homework–achievement association in math and science, based on 61 separate correlations from 28 studies. Results showed a weighted average correlation of 0.15 between homework time and student achievement and of 0.12 between homework frequency and student achievement.

Influenced by Trautwein et al.'s model (2006), an increasing number of studies have linked homework quality to homework behavior and achievement (Xu, 2016; Dettmers et al., 2010; Rosário et al., 2018). Using data from 918 middle school students, Xu (2016) reported that homework quality was positively correlated with homework effort, completion, and student achievement. Similarly, involving 4265 6th graders, Rosário et al. (2018) reported that homework quality was positively associated with homework effort and performance (including homework completion and accuracy) and that homework performance was positively related to student achievement.

Moving beyond the three homework characteristics discussed above (i.e., homework time, frequency, and quality), one emerging line of research further suggests the importance of two additional homework characteristics—homework interest and favorability (Xu, 2008; Xu & Corno, 1998; Cooper et al., 1998; Rosário et al., 2018; Suárez et al., 2019). Cooper et al. (1998) related student attitudes to homework completion and student achievement. In their study, student attitudes contained both interest items (e.g., the extent to which students like homework) and belief items (e.g., the extent to which homework helps them learn). For students in grades 6–12, their attitudes was positively related to homework completion, which in turn was positively associated with student achievement. Involving secondary school students, Xu (2011) examined empirical models of factors to predict homework completion and found that homework interest was positively associated with homework completion after controlling for other important variables (e.g., teacher feedback). Likewise, Suárez et al. (2019) reported that homework interest was positively associated with homework behavior engagement (including homework completion), which in turn was positively related to student achievement.

Homework favorability can be defined as students' favorite ratings of homework compared with subjective experiences with other competing activities during after-school hours (e.g., texting and social networking; Xu et al., 2020). It is initially informed by qualitative research with elementary and middle school students (Xu & Corno, 1998; Xu & Yuan, 2003) and followed by cross-sectional and longitudinal studies with secondary school students (e.g., Xu, 2008; Xu et al., 2020). Relevant results indicated that homework favorability had a large positive correlation with homework interest ($0.65 \leq r \leq 0.72$) yet empirically distinguishable from homework interest (Xu, 2008; Xu et al., 2016) and that homework favorability and homework interest were positively reciprocally related (Xu et al., 2020). Additionally, as students use learning strategies more in favorite than least favorite courses, and as they are more likely to obtain higher achievement in favorite courses (Ben-Eliyahu & Linnenbrink-Garcia, 2015), there is a need to include homework favorability as another important homework characteristic in our study.

This line of literature further suggests that these homework characteristics (time, frequency, quality, interest, and favorability) are significantly correlated with homework behavior (effort and completion) and student achievement. Even though a variable-centered perspective offers useful information about the linkages between each homework characteristic and homework behavior (or student achievement), it overlooks the likelihood that (a) different combinations of homework characteristic profiles may emerge, and (b) these profiles may associate with differences in homework behavior and student achievement.

Our justification for studying the possible combinations of homework characteristics is further alluded to by recent studies that have attempted to identify homework profiles based on homework time and homework effort (Flunger et al., 2015, 2017; Shin & Sohn, 2019) or based on homework time and homework time management (Valle et al., 2019). As these studies have limited to one homework characteristic (i.e., homework time), and as "homework behavior cannot be fully captured by focusing solely on homework time" (Flunger et al., 2017, p. 2), it would be important to identify student profiles that draw from a broad range of homework characteristics as discussed above in our current investigation.

## The present study

The first objective was to investigate student profiles according to the possible combinations of the five homework characteristics—homework time, frequency, quality, interest, and favorability. Specifically, the present study focused on eighth graders with their mathematics homework for several reasons. First, math is a highly valued yet challenging subject across many countries (León et al., 2015; Ramirez et al., 2018). Additionally, teachers often assign more homework in math than in other school subjects (Xu, 2015; Bempechat, 2019). Finally, math becomes increasingly more complex and abstract at the eighth grade level, posing significant challenges for students to learn math concepts and follow through math assignments (Xu et al., 2022; Lee, 2009).

Since our study is the first to apply a person-centered approach to a broad range of homework characteristics, we have no specific hypothesis concerning the number of homework characteristic profiles that would emerge. On the other hand, congruent with previous studies adopting a person-centered approach drawing from homework time and homework effort/homework time management (Flunger et al., 2015, 2017; Shin & Sohn, 2019; Valle et al., 2019), several profiles may emerge, including a profile containing high homework time, a profile containing low homework time, and profiles with varying degrees of homework time and other homework characteristics.

Although it is not the focus in our study, student gender and parent education are considered key background variables in homework models (Xu & Corno, in press; Cooper, 1989; Trautwein et al., 2006), thereby having important implications for research and practice (Cooper et al., 2000; Froiland, 2021). Parents with higher education, for example, "are more likely to know something about what the children are being taught and thus able to help with homework" (Davis-Kean, 2005, p. 303). As we do not have information on how gender and parent education may influence the classification of students into profiles, it would be important to control for these two variables (i.e., incorporating them as covariates) in latent profile analysis (LPA).

The second objective was to examine how profiles related to critical variables in the homework models (Xu & Corno, in press; Cooper, 1989; Trautwein et al., 2006), including homework effort, completion, and math achievement. Congruent with previous studies in English-speaking, European, Asian, and Latin American countries (Xu, 2016; Fan et al., 2017; Ben-Eliyahu & Linnenbrink-Garcia, 2015; Cooper et al., 1998, 2006; Fernández-Alonso et al., 2019; Flunger et al., 2017; Suárez et al., 2019), we expect that a profile with a high level of homework characteristics (e.g., quality and frequency) would expend more effort, complete more homework, and score higher on math achievement than a profile with a low level of homework characteristics.

## Method

### Participants and procedures

The participants were 3018 8th graders (96 classes; 100% Han nationality) from several regions in China, including southeastern, southwestern, and central. Among these participants, 54.4% identified as male and 45.6% as female. Their mean age was 13.7 years ($SD = 0.4$). Education level was 11.4 years and 10.6 years for fathers and mothers. The overall student participation rate was 88.7%. A test of mean differences between participants ($n = 3018$) and non-participants ($n = 383$) indicated that there were no significant differences between these two groups regarding student gender ($p = 0.431$), mothers' education ($p = 0.205$), and fathers' education ($p = 0.331$).

Regarding homework practices, 76.9% participants did math homework 4 days or more a week. They spent a mean of 34 min ($SD = 25$) on math homework daily. These math homework practices are generally congruent with related studies in China (Xu et al., 2017).

We sought and gained permissions from schools and parents for their children to participate in our investigation. Informed consent was taken from students and parents according to the tenets of Helsinki Declaration. Specifically, students were informed that the purpose of the investigation is "to learn more about how you approach math homework so that teachers and your family can better help you." They were further assured that their responses were confidential and they might not answer certain items or withdraw from participation anytime. The data were collected using paper–pencil questionnaire in classrooms during normal school time at the end of October 2017. Math teachers were asked to step out of their rooms while students completed the measures.

### Measures

**Homework time** Students were asked about the following question: "On a typical day, how long does it usually take you to finish your math homework?" Responses included 1 (*none*), 2 (*1–20 min*), 3 (*21–40 min*), 4 (*41–60 min*), 5 (*61–80 min*), 6 (*81–100 min*), 7 (*101 to 120 min*), and 8 (*more than 120 min*). In line with previous work (Xu, 2010; Cooper et al., 1998), a variable relating to homework time was created by transforming each response into its midpoint (e.g., 2 = 10.5 min).

**Homework frequency** Based on extant literature (Fan et al., 2017; Fernández-Alonso et al., 2015), students were asked about the following question: "During a typical week, how often do you get math homework?" Responses included 1 (*none*), 2 (*1 day a week*), 3 (*2 days a week*), 4 (*3 days a week*), 5 (*4 days a week*), and 6 (*5 or more days a week*).

**Homework quality** It consisted of four items to assess student perceptions of quality of homework (Xu, 2016). Specifically, it assessed how well math assignments were selected, prepared, and integrated into math classes (e.g., "Our math homework assignments really help us to understand our math lessons"; $\alpha = 0.87$; $\omega = 0.87$). Responses ranged from 1 (*strongly disagree*) to 4 (*strongly agree*).

**Homework interest** It contained four items to assess student interest in math homework, informed by existing literature on intrinsic motivation and interest (Wigfield & Cambria, 2010) and homework studies (Xu et al., 2016; Cooper et al., 1998). It assessed the extent to which students enjoyed doing math homework (e.g., "I look forward to math homework"; $\alpha = 0.91$; $\omega = 0.91$). Responses varied from 1 (*strongly disagree*) to 5 (*strongly agree*).

**Homework favorability** It consisted of three items to measure participants' favorability of math assignments (Xu, 2008; Xu et al., 2020). It tapped into students' favorite ratings of math assignments, compared with their experience (e.g., motivation, attention, and moods) in other after-school activities (e.g., "My motivation to do math homework is _____ other school activities"; $\alpha = 0.83$; $\omega = 0.83$). Responses varied from 1 (*much lower than*) to 5 (*much higher than*).

**Homework effort** Three items assessed students' homework effort, drawn from prior studies (Xu, 2018; Trautwein et al., 2006). These items tapped into students' initiatives to follow through on math assignments (e.g., "I always try to finish my math assignments"; $\alpha = 0.81$; $\omega = 0.82$). Response options varied from 1 (*strongly disagree*) to 4 (*strongly agree*).

**Parent education** Students were asked about the education levels of their mothers and fathers. Response choices varied from elementary school (coded 6 years) to graduate degree (coded 19 years). As education level of mothers and fathers were highly related for our participants ($r = 0.76$, $p < 001$). A variable to represent level of parent education was developed by taking the mean of education level of each parent.

**Homework completion** Based on related studies (Xu et al., 2019; Cooper et al., 2006), students were asked about one item regarding homework completion: "Some students often complete math homework on time, others rarely do. How much of your assigned math homework do you usually complete?" Responses were 1 (*none*), 2 (*some*), 3 (*about half*), 4 (*most*), and 5 (*all*). Regarding this measure's concurrent and predictive evidence, Xu (2017) found that, consistent with theoretical prediction, it was positively correlated with homework expectancy, effort, and student achievement.

**Math achievement** Standardized math achievement was assessed nearly 8 months following the administration of the measures. The assessment was aligned with national curriculum (Li & Li, 2018) to measure knowledge and skills at the grade level (e.g., fraction, linear function, triangle, parallelogram, parallelogram, quadratic radical, and data analysis). It contained multiple-choice and short-answer questions, and students were given 120 min to work on the test. The reliability estimate (coefficient alpha) was 0.88.

## Data analyses

LPA was used to investigate student profiles according to five homework characteristics—homework time, frequency, quality, interest, and favorability. All analyses were conducted with robust maximum likelihood estimator in M*plus* 7.2. As students were nested in classes, the standard errors were adjusted by using the command "type is complex" in M*plus*. Our study contained very few missing data, ranging from 0.00 to 2.12%

($M = 0.71\%$). We applied full information maximum likelihood (FIML) to handle with missing data, as FILM is found to produce unbiased estimates (Marsh et al., 2016).

The decision for selecting the optimal number of profiles was based on multiple fit indices, interpretability, and parsimony (Xu, 2022; Valle et al., 2019). These indices include the Akaike information criterion (AIC), Schwartz's Bayesian information criterion (BIC), sample-size adjusted BIC (SSA-BIC), and Lo-Mendell-Rubin adjusted likelihood ratio test (LMRT).

Lower values on AIC, BIC, and SSA-BIC represent better fit. A significant $p$ value for LMRT means that a k-profile model yields better fit to the data than a k-1-profile model. We generated elbow plots of the AIC, BIC, and SSA-BIC to provide a graphic summary of these indices to facilitate the model selection. The profile at the point with which the slope of the plots noticeably flattens is considered additional indicator of an appropriate solution (Morin & Marsh, 2015). Entropy value (varying from 0 to 1) measures classification uncertainty ($> 0.70$ representing adequate classification accuracy; Jung & Wickrama, 2008).

We applied the 3-step procedure to perform the covariate and distal outcome testing (Asparouhov & Muthén, 2014). In step 1, the LPA was conducted with only the five homework characteristics. In step 2, a "most likely class" variable was created based on the LPA. In step 3, the auxiliary variables were incorporated for investigation. In particular, in a multinomial logistic regression model, we incorporated two covariates—gender and parent education—as predictors of latent profiles using the R3STEP procedure. We then used the DU3STEP procedure (assuming unequal variances and means in each profile), specifying homework effort, completion, and math achievement as three distal outcome variables. A Wald chi-square test was used to assess the equality of means of the three distal outcome variables across latent profiles.

## Results

### Descriptive statistics

Table 1 provides descriptive statistics. Overall, low to positive moderate relations were found among the measures used in the LPA.

### Identification of student profiles

Table 2 displays the fit of profile models. As additional profiles were extracted, the AIC, BIC, and SSA-BIC kept decreasing, and the LMRT continued to show significant differences. Yet, slopes of the elbow plots seemed to flatten around the five-profile model (see Fig. 1). Even though the five-profile model had one profile less than 5% of the cases (4.47%), compared with the four-profile model (Fig. 3), this profile exhibited rather distinctive information regarding homework time (students in this profile spending 110 min on math homework, over 3 standard deviations above the mean; see Table 6 and Fig. 4).

The three-profile model (Fig. 2) had the highest entropy (0.935) among all these models, and it included one similar profile (i.e., with one profile of students spending 108 min on math homework). Yet, as shown in this model, students in three different profiles did not show much differences in homework quality ($z = -0.52$ to 0.12), homework interest ($z = -0.37$ to 0.08), and homework favorability ($z = -0.30$ to 0.16). This indicates that,

**Table 1** Descriptive statistics

| Variable | *M* | *SD* | Skew | Kurtosis | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Gender[a] | − 0.04 | 0.50 | 0.18 | − 1.97 | — | | | | | | | | |
| 2 Parent education | 10.99 | 3.14 | 0.62 | − 0.30 | .01 | — | | | | | | | |
| 3 Homework time | 34.12 | 24.74 | 1.69 | 3.85 | .00 | .03 | — | | | | | | |
| 4 Homework frequency | 5.20 | 1.33 | − 1.64 | 1.67 | .02 | .14† | .12† | — | | | | | |
| 5 Homework quality | 3.15 | 0.61 | − 0.65 | 1.05 | .09† | .16† | .04* | .24† | — | | | | |
| 6 Homework interest | 3.22 | 0.89 | − 0.39 | 0.20 | .01 | .13† | .09† | .15† | .43† | — | | | |
| 7 Homework favorability | 2.83 | 0.90 | 0.01 | − 0.22 | .02 | .12† | .10† | .13† | .32† | .61† | — | | |
| 8 Homework effort | 3.19 | 0.60 | − 0.74 | 1.34 | .05* | .15† | .14† | .22† | .42† | .42† | .31† | — | |
| 9 Homework completion | 3.97 | 0.95 | − 0.87 | 0.38 | .06† | .13† | .04* | .19† | .31† | .31† | .28† | .32† | — |
| 10 Math achievement | 63.33 | 26.43 | − 0.81 | − 0.20 | .04* | .24† | .13† | .33† | .30† | .26† | .19† | .28† | .21† |

[a]Gender was dummy coded (− 0.50 = male; 0.50 = female)

*$p < .05$. †$p < .01$

**Table 2** Fit indices for models containing one to six profiles

| | Profiles | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| AIC | 59,637.545 | 57,606.405 | 56,730.557 | 55,301.580 | 54,663.578 | 54,208.413 |
| BIC | 59,697.668 | 57,702.603 | 56,862.829 | 55,469.926 | 54,867.998 | 54,448.907 |
| SSA-BIC | 59,665.894 | 57,651.765 | 56,792.926 | 55,380.959 | 54,759.967 | 54,321.811 |
| Entropy | —— | 0.917 | 0.935 | 0.827 | 0.848 | 0.845 |
| LMRT | —— | 2001.506*** | 869.756*** | 697.199*** | 615.875*** | 457.646*** |
| Profile sizes | 3018 | 611; 2407 | 2369; 489; 160 | 494; 202; 1607; 715 | 202; 1559; 491; 631; 135 | 100; 289; 1545 304; 135; 645 |
| Profiles with $n \leq 5\%$ | 0 | 0 | 0 | 0 | 1 | 2 |

BLRT is not available for the clustering option in M*plus*

*** $p < .001$

among others, the students in the largest profile in the three-profile model ($n = 2369$; 78.5%) can be further classified into different profiles. This information, along with our previous discussion relating to the elbow plots, suggested that the five-profile solution seemed to be the optimal choice for our study.

Regarding the classification accuracy of our five-profile model (Table 2), the entropy was 0.848, thus having a high level of entropy. Table 3 presents the classification accuracy of the five-profile model and the number of students in the five profiles. The table's main diagonal displays the coefficients relating to each profile to which students were assigned.

## Five student profiles of homework characteristics

Table 4 contains the mean scores of students assigned to the five profiles. Figure 4 presents a graphic depiction of the profiles using z-scores. Profile 1 included 6.7% of the students ($n = 202$) and could be referred to *Low* due to the low mean scores across all five homework characteristics ($z = -0.41$ to $-2.72$). Profile 2 consisted of 51.7% of the cases ($n = 1559$) and could be referred to *Moderate Time/High With Others* because this profile had high mean scores on four homework characteristics ($z = 0.38$ to 0.49) and homework time was near the overall mean ($z = -0.10$). Profile 3 included 16.3% of the cases ($n = 491$) and could be referred to *Low Frequency/Moderate With Others* because homework frequency was more than one standard deviation lower than the overall mean ($z = -1.21$) and the means on the other four homework characteristics were near the overall means ($z = -0.07$ to $-0.23$). Profile 4 included 20.9% of the cases ($n = 631$) and could be referred to *Moderate Time/High Frequency/Low With Others* because this profile had high mean on homework frequency ($z = 0.46$), moderate mean on homework time ($z = -0.21$), and low means on the other three characteristics ($z = -0.54$ to $-0.98$). Profile 5 consisted of 4.5% of the cases ($n = 135$) and could be referred to *High Time and Frequency/Moderate*

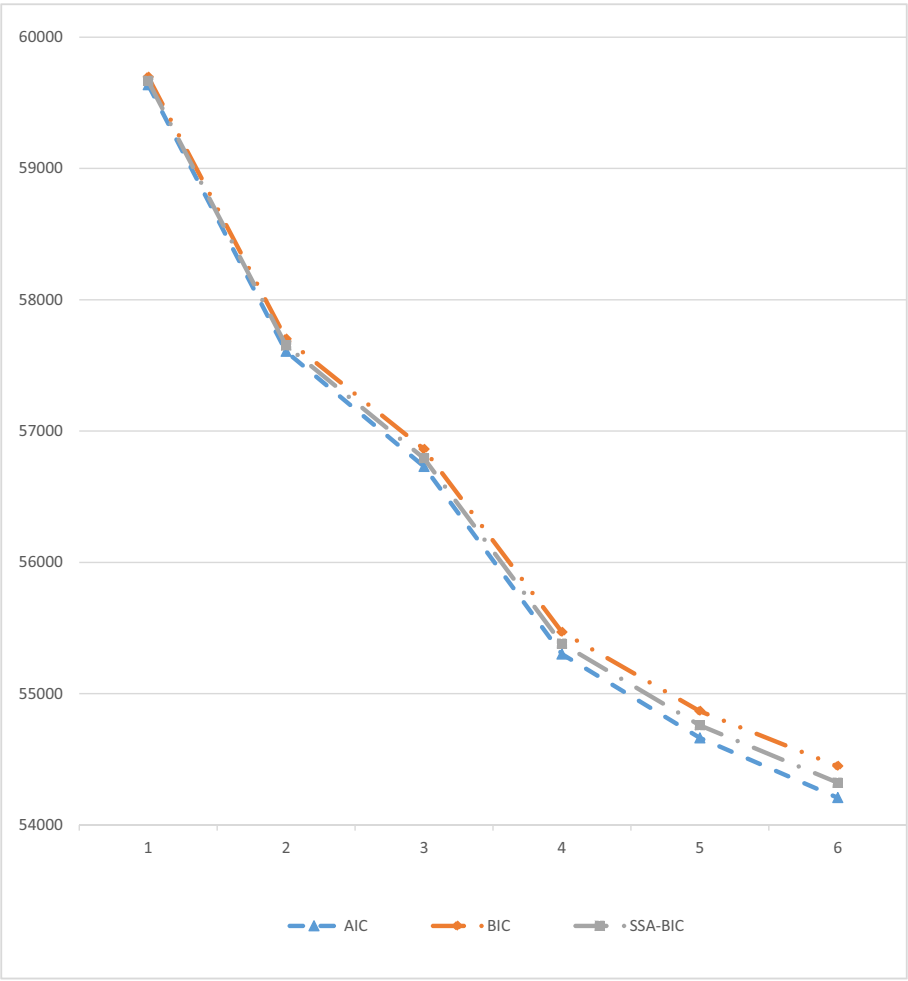



**Fig. 1** Elbow plots for AIC, BIC, and SSA-BIC

*With Others* because they had high means with homework time and frequency ($z = 0.47$ to 3.09) and the mean scores on the other three characteristics were near the overall means ($z = -0.07$ to 0.21).

## Multinomial logistic regression results by gender and parent education

Table 5 presents multinomial logistic regression results by gender and parent education. Out of the ten comparisons among the five empirically deprived profiles, we found insignificant differences among any of these comparisons by gender. These findings indicated that gender was not significantly associated with profile membership.

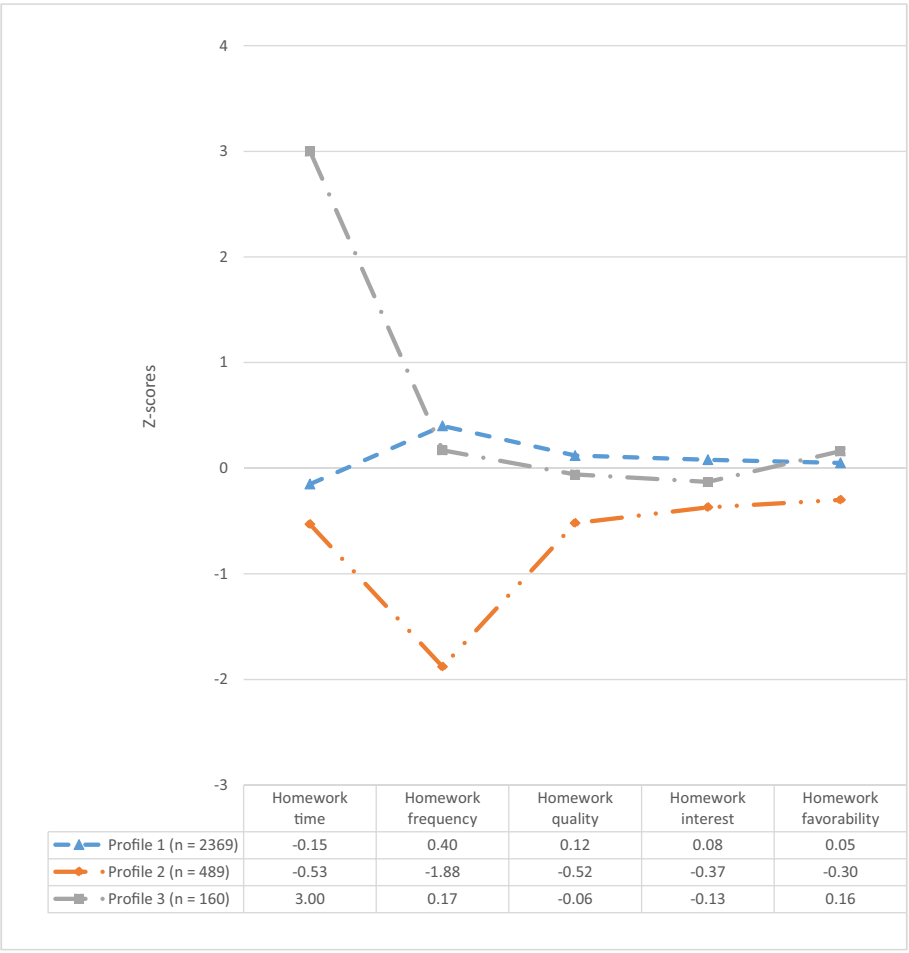



**Fig. 2** Homework characteristics: three-profile model

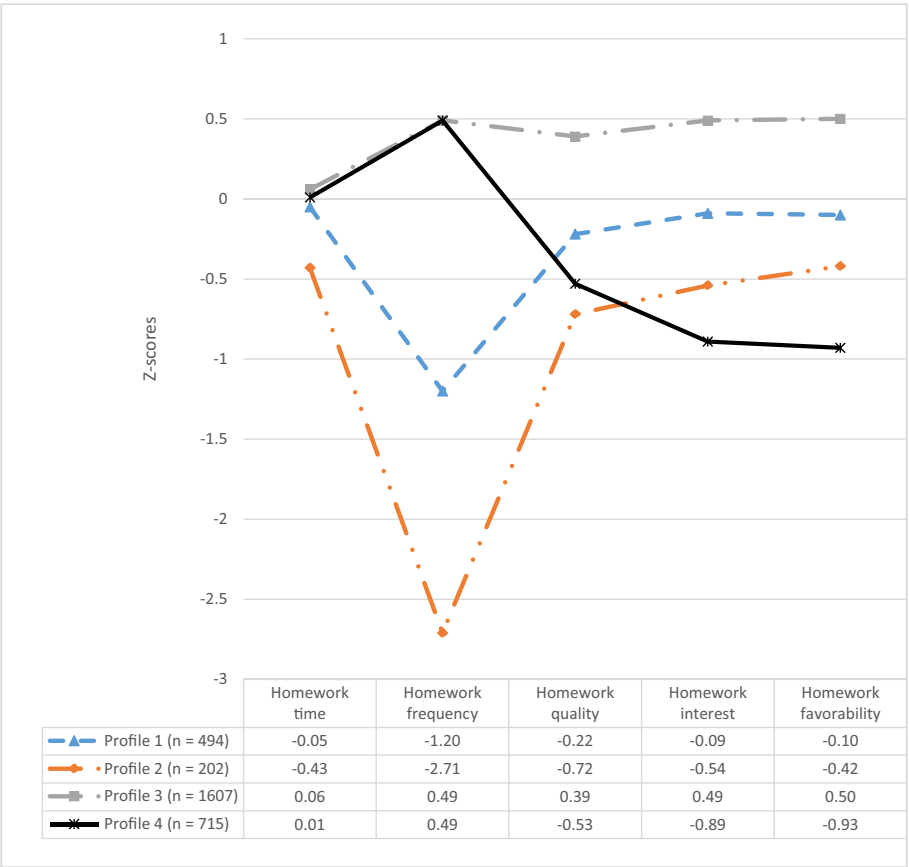
**Table 3** The classification accuracy of students in the five profiles

| | Profiles | | | | | *n* | % |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | |
| 1. *Low* | **0.996** | 0.000 | 0.004 | 0.000 | 0.000 | 202 | 6.69 |
| 2. *Moderate Time/High With Others* | 0.000 | **0.882** | 0.001 | 0.115 | 0.003 | 1559 | 51.66 |
| 3. *Low Frequency/Moderate With Others* | 0.001 | 0.000 | **0.998** | 0.000 | 0.000 | 491 | 16.27 |
| 4. *Moderate Time/High Frequency/Low With Others* | 0.000 | 0.189 | 0.001 | **0.809** | 0.002 | 631 | 20.91 |
| 5. *High Time and Frequency/Moderate With Others* | 0.000 | 0.062 | 0.002 | 0.012 | **0.925** | 135 | 4.47 |

Boldface: The coefficients associated with the profiles to which students were classified

**Table 4** Description of latent profiles

| Profile | Homework time *M* (*S.E.*) | Homework frequency *M* (*S.E.*) | Homework quality *M* (*S.E.*) | Homework interest *M* (*S.E.*) | Homework favorability *M* (*S.E.*) |
|---|---|---|---|---|---|
| 1. *Low* | 23.26 (2.81) | 1.58 (0.07) | 2.70 (0.08) | 2.73 (0.10) | 2.45 (0.08) |
| 2. *Moderate Time/High With Others* | 31.83 (0.87) | 5.86 (0.02) | 3.38 (0.05) | 3.63 (0.08) | 3.23 (0.09) |
| 3. *Low Frequency/Moderate With Others* | 32.42 (1.71) | 3.59 (0.03) | 3.01 (0.03) | 3.14 (0.05) | 2.75 (0.06) |
| 4. *Moderate Time/High Frequency/Low With Others* | 29.11 (1.10) | 5.84 (0.02) | 2.88 (0.09) | 2.54 (0.16) | 2.12 (0.14) |
| 5. *High Time and Frequency/Moderate With Others* | 110.33 (18.20) | 5.82 (0.05) | 3.09 (0.08) | 3.25 (0.12) | 3.00 (0.12) |



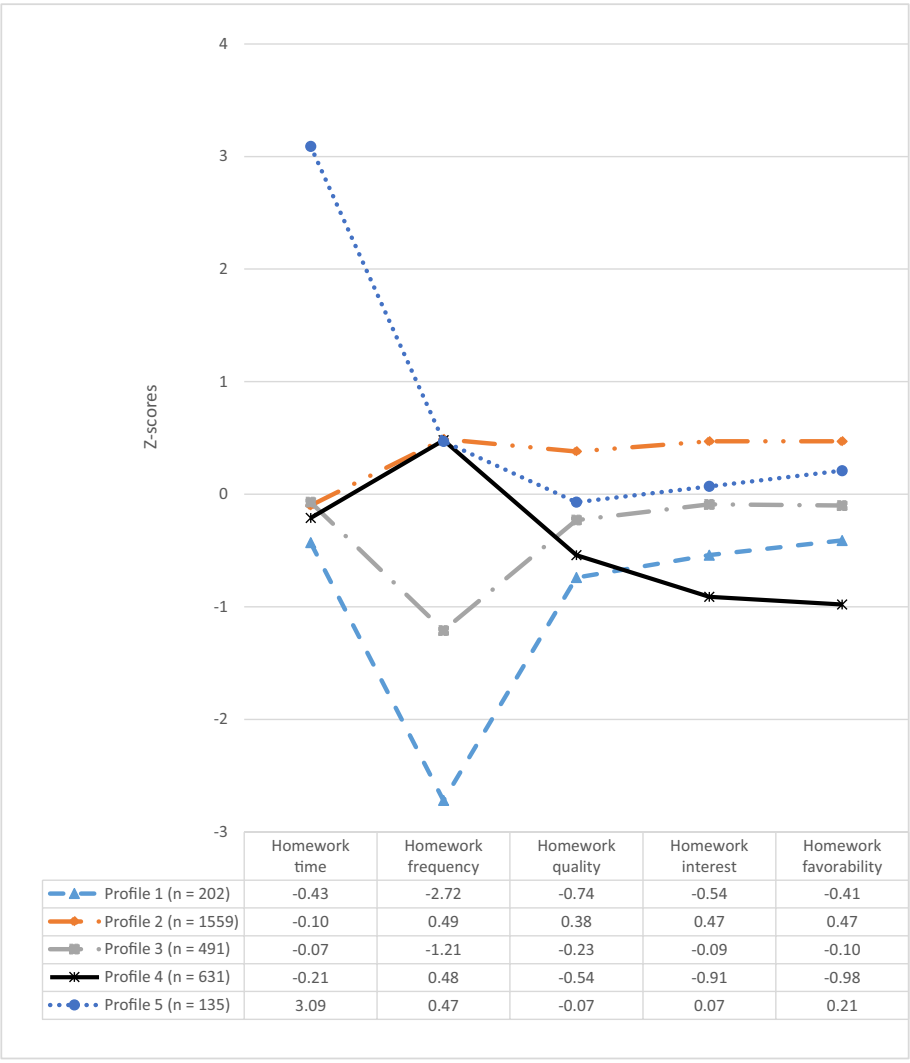

| | Homework time | Homework frequency | Homework quality | Homework interest | Homework favorability |
|---|---|---|---|---|---|
| Profile 1 (n = 494) | -0.05 | -1.20 | -0.22 | -0.09 | -0.10 |
| Profile 2 (n = 202) | -0.43 | -2.71 | -0.72 | -0.54 | -0.42 |
| Profile 3 (n = 1607) | 0.06 | 0.49 | 0.39 | 0.49 | 0.50 |
| Profile 4 (n = 715) | 0.01 | 0.49 | -0.53 | -0.89 | -0.93 |

**Fig. 3** Homework characteristics: four-profile model

As also shown in Table 5, students with higher parental education were less likely to be in Profile 1 (*Low*; $b = -0.16$, SE = 0.04, $p < 0.001$, OR = 0.85), in Profile 3 (*Low Frequency/Moderate With Others*; $b = -0.13$, SE = 0.03, $p < 0.001$, OR = 0.88), and in Profile 4 (*Moderate Time/High Frequency/Low With Others*; $b = -0.08$, SE = 0.03, $p = 0.001$, OR = 0.92) in reference to Profile 2 (*Moderate Time/High With Others*). Additionally, students with higher parental education were more likely to be in Profile 5 (*High Time and Frequency/Moderate With Others*) than in Profile 1 (*Low*; $b = 0.12$, SE = 0.06, $p = 0.027$, OR = 1.13) and in Profile 3 (*Low Frequency/Moderate With Others*; $b = 0.09$, SE = 0.05, $p = 0.046$, OR = 1.09).

## Differences among profiles on the distal outcomes

We investigated equality of the means on the distal outcomes (i.e., homework effort, completion, and math achievement) across profiles. Table 6 shows the means of the distal outcomes across the profiles. Table 7 includes chi-square tests of pairwise comparisons between the profiles.




| | Homework time | Homework frequency | Homework quality | Homework interest | Homework favorability |
|---|---|---|---|---|---|
| Profile 1 (n = 202) | -0.43 | -2.72 | -0.74 | -0.54 | -0.41 |
| Profile 2 (n = 1559) | -0.10 | 0.49 | 0.38 | 0.47 | 0.47 |
| Profile 3 (n = 491) | -0.07 | -1.21 | -0.23 | -0.09 | -0.10 |
| Profile 4 (n = 631) | -0.21 | 0.48 | -0.54 | -0.91 | -0.98 |
| Profile 5 (n = 135) | 3.09 | 0.47 | -0.07 | 0.07 | 0.21 |

**Fig. 4** Homework characteristics: five-profile model

Our findings revealed that profile membership was significantly related to homework effort, completion, and math achievement. The effect size was of medium magnitude for homework effort ($d = 0.55$) and homework completion ($d = 0.42$) and between medium and large for math achievement ($d = 0.70$). Concerning homework effort, Profile 2 and Profile 5 had higher scores than Profile 4 and Profile 3, which in turn had significantly higher scores than Profile 1. This pattern of results held for homework completion, except that Profile 2 had higher scores than Profile 5 and that there were no significant differences among Profile 3, Profile 4, and Profile 5. Finally, this pattern of results held for math achievement,

**Table 5** Multinomial logistic regression predicting profile membership

| Ref. profile | | | Estimate | *S.E* | Est./*S.E* | *p* | Odds ratio |
|---|---|---|---|---|---|---|---|
| Profile 1 | | | | | | | |
| | Profile 2 | Gender | 0.23 | 0.17 | 1.36 | 0.175 | 1.26 |
| | | Parent education | 0.16 | 0.04 | 4.01 | < 0.001 | 1.17 |
| | Profile 3 | Gender | 0.15 | 0.18 | 0.83 | 0.406 | 1.16 |
| | | Parent education | 0.03 | 0.04 | 0.75 | 0.454 | 1.03 |
| | Profile 4 | Gender | 0.21 | 0.22 | 0.96 | 0.336 | 1.23 |
| | | Parent education | 0.08 | 0.04 | 1.80 | 0.072 | 1.08 |
| | Profile 5 | Gender | − 0.28 | 0.28 | − 0.99 | 0.322 | 0.75 |
| | | Parent education | 0.12 | 0.06 | 2.22 | 0.027 | 1.13 |
| Profile 2 | | | | | | | |
| | Profile 3 | Gender | − 0.08 | 0.13 | − 0.619 | 0.536 | 0.92 |
| | | Parent education | − 0.13 | 0.03 | − 4.733 | < 0.001 | 0.88 |
| | Profile 4 | Gender | − 0.02 | 0.15 | − 0.114 | 0.909 | 0.98 |
| | | Parent education | − 0.08 | 0.03 | − 3.192 | 0.001 | 0.92 |
| | Profile 5 | Gender | − 0.51 | 0.27 | − 1.924 | 0.054 | 0.60 |
| | | Parent education | − 0.03 | 0.04 | − 0.961 | 0.337 | 0.97 |
| Profile 3 | | | | | | | |
| | Profile 4 | Gender | 0.06 | 0.15 | 0.404 | 0.686 | 1.06 |
| | | Parent education | 0.05 | 0.03 | 1.466 | 0.143 | 1.05 |
| | Profile 5 | Gender | − 0.43 | 0.26 | − 1.658 | 0.097 | 0.65 |
| | | Parent education | 0.09 | 0.05 | 1.995 | 0.046 | 1.09 |
| Profile 4 | | | | | | | |
| | Profile 5 | Gender | − 0.49 | 0.28 | − 1.753 | 0.080 | 0.61 |
| | | Parent education | 0.05 | 0.04 | 1.064 | 0.288 | 1.05 |

Profile 1 = *Low*; Profile 2 = *Moderate Time/High With Others*; Profile 3 = *Low Frequency/Moderate With Others*; *Profile 4* = *Moderate Time/High Frequency/Low With Others*; *Profile 5* = *High Time and Frequency/Moderate With Others*

except that Profile 4 had higher scores than Profile 3. Taken together, these findings provided additional empirical support for the validity of the five-profile model.

## Discussion

### Summary of findings

The present study makes a significant contribution in understanding homework characteristics by applying a person-centered approach to generate profiles of homework time, frequency, quality, interest, and favorability. Our results provide clear empirical support for meaningful differences in homework characteristics between subgroups of students, as the findings revealed five distinct homework characteristics profiles, as parent education was significantly related to profile membership, and as profile membership was a significant predictor of homework effort, completion, and math achievement.

**Table 6** Outcome variables for student profiles

| | Profile 1: ($n=202$) *M* (*SE*) | Profile 2: ($n=1559$) *M* (*SE*) | Profile 3: ($n=491$) *M* (*SE*) | Profile 4: ($n=631$) M (*SE*) | Profile 5: ($n=135$) *M* (*SE*) | Overall chi-square test value ($df=4$) | Effect size (*d*) |
|---|---|---|---|---|---|---|---|
| Homework effort | $2.80^{a}$ (0.06) | $3.36^{c}$ (0.02) | $3.08^{b}$ (0.03) | $3.02^{b}$ (0.03) | $3.30^{c}$ (0.05) | 215.711*** | 0.55 |
| Homework completion | $3.38^{a}$ (0.09) | $4.18^{c}$ (0.02) | $3.85^{b}$ (0.04) | $3.79^{b}$ (0.04) | $3.92^{b}$ (0.08) | 130.304*** | 0.42 |
| Math achievement | $39.92^{a}$ (2.14) | $70.78^{d}$ (0.63) | $53.19^{b}$ (1.27) | $60.64^{c}$ (1.14) | $66.20^{d}$ (2.34) | 331.364*** | 0.70 |

Profile 1 = *Low*; Profile 2 = *Moderate Time/High With Others*; Profile 3 = *Low Frequency/Moderate With Others*; *Profile 4* = *Moderate Time/High Frequency/Low With Others*; *Profile 5* = *High Time and Frequency/Moderate With Others*

Means with a different superscript in a row were significantly different at $\alpha < .05$

***$p < .001$

**Table 7** Chi-square tests of all pairwise comparisons

| | Pairwise comparison | Chi-square test, *p*-value |
|---|---|---|
| Homework effort | 1 vs. 2 | 83.861, $p < .001$ |
| | 1 vs. 3 | 18.401, $p < .001$ |
| | 1 vs. 4 | 12.116, $p < .001$ |
| | 1 vs. 5 | 38.949, $p < .001$ |
| | 2 vs. 3 | 86.650, $p < .001$ |
| | 2 vs. 4 | 117.694, $p < .001$ |
| | 2 vs. 5 | 1.092, $p = .296$ |
| | 3 vs. 4 | 2.278, $p = .131$ |
| | 3 vs. 5 | 13.562, $p < .001$ |
| | 4 vs. 5 | 21.461, $p < .001$ |
| Homework completion | 1 vs. 2 | 67.920, $p < .001$ |
| | 1 vs. 3 | 20.458, $p < .001$ |
| | 1 vs. 4 | 16.024, $p < .001$ |
| | 1 vs. 5 | 18.261, $p < .001$ |
| | 2 vs. 3 | 44.789, $p < .001$ |
| | 2 vs. 4 | 68.289, $p < .001$ |
| | 2 vs. 5 | 9.090, $p = .003$ |
| | 3 vs. 4 | 1.171, $p = .279$ |
| | 3 vs. 5 | 0.517, $p = .472$ |
| | 4 vs. 5 | 2.024, $p = .155$ |
| Math achievement | 1 vs. 2 | 190.604, $p < .001$ |
| | 1 vs. 3 | 28.311, $p < .001$ |
| | 1 vs. 4 | 73.577, $p < .001$ |
| | 1 vs. 5 | 68.658, $p < .001$ |
| | 2 vs. 3 | 153.677, $p < .001$ |
| | 2 vs. 4 | 52.420, $p < .001$ |
| | 2 vs. 5 | 3.538, $p = .060$ |
| | 3 vs. 4 | 19.140, $p < .001$ |
| | 3 vs. 5 | 23.767, $p < .001$ |
| | 4 vs. 5 | 4.546, $p = .033$ |

To sum up, we identified different combinations of five homework characteristics as meaningful profiles relative to key homework behavior and outcomes based on comprehensive homework models (Xu & Corno, in press; Cooper, 1989; Trautwein et al., 2006) and related prior studies (e.g., Xu et al., 2016; Rosário et al., 2018; Suárez et al., 2019). Particularly, findings revealed these homework characteristics profiles: Profile 1 (*Low*; 6.7%), Profile 2 (*Moderate Time/High With Others*; 51.7%), Profile 3 (*Low Frequency/Moderate With Others*; 16.3%), Profile 4 (*Moderate Time/High Frequency/Low With Others*; 20.9%), and Profile 5 (*High Time and Frequency/Moderate With Others*; 4.5%). As can be seen from the above five profiles, a vast majority of students in our study (93.3%) had uneven profiles on homework characteristics, as marked by relatively high scores on some homework characteristics and low scores on others. This pattern of results suggests that these homework characteristics (time, frequency, quality, interest, and favorability) provide meaningful profile differentiation.

### Interpretation

Because this is the first investigation that applied the LPA to a broad spectrum of homework characteristics, we have no specific hypothesis concerning the number of homework characteristics profiles that would exist. On the other hand, in line with our general expectation as informed by prior studies (Flunger et al., 2015, 2017; Shin & Sohn, 2019; Valle et al., 2019), we identified profiles containing high homework time (i.e., *High Time and Frequency/Moderate With Others*), low homework time (i.e., *Low*), and moderate homework time (i.e., *Moderate Time/High With Others, Low Frequency/Moderate With Others, Moderate Time/High Frequency/Low With Others*).

Following that, we examined whether gender and parent education would be associated with profile membership, something that has not been tapped into in prior homework research. The results that students with higher parent education were more likely to be in two healthiest profiles (Profile 2 and Profile 5) are congruent with previous studies. For example, Froiland and Davison (2016) reported that parent education predicted long-term math achievement via parent expectations, student intrinsic motivation to learn, and engaging with challenging courses over 3 years.

We further examined differences among these profiles relating to homework effort, completion, and student achievement. Congruent with our general expectation based on prior research (Xu, 2016; Fan et al., 2017; Ben-Eliyahu & Linnenbrink-Garcia, 2015; Flunger et al., 2017; Suárez et al., 2019), we found that students in Profile 2 (i.e., *Moderate Time/High With Others*) exerted more homework effort, completed more homework, and obtained higher scores on math achievement test than students in Profile 1 (i.e., *Low*). Given these results, the distribution of students among these five profiles appears optimal in that the least desirable profile (i.e., *Low*) had the least percentage of students (6.7%) and that the most desirable profile (i.e., *Moderate Time/High With Others*) had the most percentage of students (51.7%).

It is worth noting that, along with students in Profile 5 (i.e., *Moderate Time/High With Others*, a small group of students (4.5%) in Profile 5 (i.e., *High Time and Frequency/Moderate With Others*) had comparable means in two out of the three distal outcomes (i.e., homework effort and math achievement; Table 6). This implies that, for students in this profile, high homework time may compensate for a moderate level of homework quality, interest, and favorability. For a large group of students (51.7%) in *Moderate Time/High With Others*, this also suggests that a high level of homework frequency, quality, interest, and favorability may compensate for a moderate level of homework time—one possible explanation that we did not find a profile with a high level of homework characteristics across homework time, frequency, quality, interest, and favorability. Given there appeared to be a very large difference between moderate homework time ($M = 31.83$ min; $SD = 0.51$) and high homework time ($M = 110.33$ min; $SD = 2.12$) in the above two profiles (Profiles 2 and 5; see Table 4), it suggests that one can accomplish more in less time, in part due to greater attention, engagement, and flow when autonomously motivated (e.g., fueled by interest and favorability). Consequently, it would be more beneficial and cost-effective for teachers to design math homework assignments of high frequency, quality, interest, and favorability rather than high quantity.

Regarding students in Profile 3 (*Low Frequency/Moderate With Others*) and Profile 4 (*Moderate Time/High Frequency/Low With Others*), it appeared that both two profiles functioned quite comparably; they had similar means in two out of three distal outcomes (homework effort and completion) and with math achievement favoring Profile 4. This

suggests that high homework frequency may compensate for moderate homework time and for low quality, interest, and favorability, whereas low homework frequency may undermine a moderate level of homework time, quality, interest, and favorability (Fig. 4).

Previous studies adopting a variable-centered perspective find that homework frequency (in comparison with homework time) plays a more significant role in student achievement (e.g., Fernández-Alonso et al., 2015; Trautwein, 2007). Applying a person-centered approach, our present investigation offers novel insights into one possible explanation for this finding in that high homework frequency may compensate for moderate homework time and for low homework quality, interest, and favorability (Profile 4), whereas low homework frequency may undermine moderate homework time, quality, interest, and favorability (Profile 3). On the other hand, high homework time in Profile 5 (*High Time and Frequency/Moderate With Others*) may not necessarily lead to higher student achievement as compared with moderate homework time in Profile 2 (*Moderate Time/High With Others*).

Recent research indicates the important role of homework quality, interest, and favorability in homework behavior and student achievement (Xu, 2008, 2016; Cooper et al., 1998; Fernández-Alonso et al., 2015; Rosário et al., 2018; Suárez et al., 2019). Instead of focusing on the contribution of each of these separate homework characteristics to homework behavior and student achievement, we examined the likelihood that distinct combinations of homework characteristic profiles may emerge and relate differences in homework behavior and student achievement. Our results relating to the five profiles indicated that homework quality, interest, and favorability tended to function together, and that they exerted a powerful and positive influence on homework behavior and student achievement (Table 6). This is vividly illustrated in Fig. 4 relating to the two largest profiles—*Moderate Time/High With Others* (Profile 2; 51.1% of the sample) and *Moderate Time/High Frequency/Low With Others* (Profile 4; 20.1%)—in which both profiles had a moderate level homework time and a high level homework frequency. Yet, students in a profile with a high level of homework quality, interest, and favorability (*Moderate Time/High With Others*) were more likely to exert homework effort, to complete more homework, and score higher in math achievement than students in a profile with a low level of homework quality, interest, and favorability (*Moderate Time/High Frequency/Low With Others*).

## Implications for practice

Provided the most desirable profile is Profile 2 (*Moderate Time/High With Others*) in that a high level of homework frequency, quality, interest, and favorability may compensate for a moderate level of homework time, it would be beneficial to put more emphasis on homework frequency, quality, interest, and favorability when designing homework assignments. First, it would be beneficial to assign more frequent and high quality homework. Specifically, consistent with previous research on autonomy supportive teaching in math (e.g., promoting intrinsic motivation to learn math; Froiland et al., 2016), it would be beneficial for teachers to make close linkage between math homework assignments and math materials covered in the lessons and to help students see and understand this linkage from their perspectives. It would also be helpful to encourage students to share their perspectives on what constitutes high quality homework assignments, which could provide teachers with a better understanding of how to design and modify homework assignments according to the needs, concerns, and expectations of their students.

Furthermore, it would be important to pay close attention to student interest when teachers design homework assignments (e.g., content interest and activity interest), in line with the call from researchers over the last two decades (Corno & Xu, 2004; Xu et al., 2020; Epstein & Van Voorhis, 2001). At the same time, it would be equally important to pay close attention to students' homework favorability when they do homework during after-school hours, particularly as (a) homework is frequently viewed by students as one of the least favorable activities in their life (e.g., compared with schoolwork, maintenance, or leisure activities; Xu et al., 2016; Verma et al., 2002) and as (b) there are positive reciprocal influences between homework favorability and interest (Xu et al., 2020). Because both homework and other attractive activities often occur in home settings, parents are in a prime position to assist students develop a more favorable attitude towards homework. Consistent with research-based intervention studies (e.g., promoting homework autonomous motivation and engagement; Froiland, 2021; Moè et al, 2018), it would be especially helpful for parents to help students to develop a more favorable approach towards math homework, by encouraging them to take homework initiatives such as managing time spending on homework and its attractive alternatives. "If adolescents realize that they still have opportunities for other attractive activities during the week, they may be less conflicted and sidetracked by thoughts of competing activities while doing daily homework, thereby viewing homework tasks in a less unfavorable light" (Xu, 2008, pp. 1199–1200).

Given our findings regarding five distinct profiles and their differential linkages to homework effort, completion, and student achievement, teachers need to pay close attention to the specific needs of students in each profile when approaching homework. In particular, teachers need to devote more close attention to students in Profile 1 (i.e., *Low*) across these homework characteristics (time, frequency, quality, interest, and favorability). Additionally, whereas teachers may want to pay more attention to homework frequency for students in Profile 3 (*Low Frequency/Moderate With Others*), it would be more beneficial to devote special attention to homework quality, interest, and favorability for students in Profile 4 (*Moderate Time/High Frequency/Low With Others*). Furthermore, the above recommendations are applicable to both boys and girls, given our result that gender was not significantly related to profile membership. On the other hand, as students with higher parent education were more likely to be in the more desirable profiles (i.e., *Moderate Time/High With Others*), it would be helpful for teachers to play more close attention to students with lower parent education (e.g., relating to homework frequency, quality, and interest).

## Limitations and further investigation

Several possible limitations need to be acknowledged when interpreting our results. First, the current investigation is limited to a cross-sectional analysis. Although math achievement was assessed approximately 8 months later, we do not have data with repeated measures of the five homework characteristics. Second, certain homework characteristics (e.g., homework frequency) included in the PLA may also function as class variables. Hence, it is likely that the selected profile model, a consequence of the LPA at the student level, is not fully replicated if these variables are considered both at the student and class levels. Third, although our current study incorporated gender and parent education as covariates, it would be beneficial to study other important covariates (e.g., student ability or prior achievement) in further investigation.

Because this is the first investigation that used the LPA to examine a broad range of homework characteristics (time, frequency, quality, interest, and favorability), it would be

informative to replicate our study in diverse settings. In particular, it would be beneficial to carry out a study such as this in cross-cultural settings, as some homework characteristics such as homework time and interest may be shaped by cultural differences (Xu et al., 2016). In addition, it would be beneficial to pursue this line of research at the elementary and high school levels, as the effect of homework on academic achievement can be moderated by school level (Fan et al., 2017; Cooper et al., 2006). Furthermore, as certain homework characteristics such as homework frequency may play a more important role in math achievement (e.g., short and frequent assignments rather than few and long assignments; Fan et al., 2017; Cooper, 2007), it would be vital to replicate our study in other achievement domains.

Moreover, as parent education was associated with healthiest profiles in our sample, as the quality of parental homework involvement (e.g., autonomy support) plays a more vital role in student achievement (Xu et al., 2017; Dettmers et al., 2019; Moroni et al., 2015), there is a need to link the quality of parental homework involvement to students' homework profiles in future investigation (e.g., to include both autonomy support and parent education as covariates). This line of investigation is especially significant, as (a) recent studies have identified two major issues relating to homework during the SARS-CoV-2 pandemic—the ambiguity in homework assignments and the decrease of student interest in homework (Cui et al., 2021; Zaccoletti et al., 2020)—and as (b) the role of parental homework involvement has become increasingly important during the pandemic (e.g., parental support and supervision; Suárez et al., in press; Xia, 2020). Finally, given our findings regarding the two largest profiles (i.e., students in *Moderate Time/High With Others* putting forth more effort, completing more homework, and scoring higher in math than students in *Moderate Time/High Frequency/Low With Others*), it would be intriguing to conduct qualitative research with students in these two profiles in particular, to better understand their perspectives concerning how homework quality, interest, and favorability function along with homework frequency and time.

## Declarations

**Competing interests** The author declares no competing interests.

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*Current themes of research:*

Teaching and learning in the school, home, and online settings, in home-school relationships, and in partnerships with families from diverse cultural backgrounds.

*Most relevant publications in the field of Psychology of Education:*

Fan, H., Xu, J., Cai, Z., He, J., & Fan, X. (2017). Homework and students' achievement in math and science: A 30-year meta-analysis, 1986-2015. *Educational Research Review*, *20*, 35-54. https://doi.org/10.1016/j.edurev.2016.11.003.
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