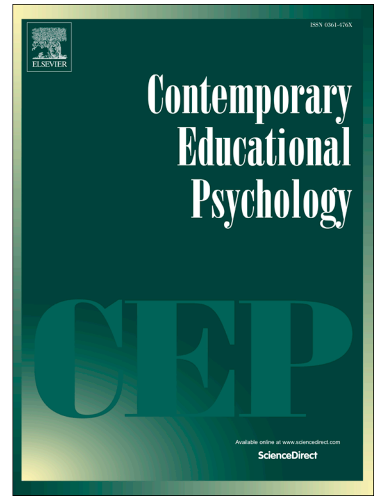
Accepted Manuscript



Homework purposes, homework behaviors, and academic achievement: Examining the mediating role of students' perceived homework quality

Pedro Rosário, José Carlos Nú ñez, Guillermo Vallejo, Tânia Nunes, Jennifer Cunha, Sonia Fuentes, Antonio Valle

PII: S0361-476X(17)30111-X
DOI: https://doi.org/10.1016/j.cedpsych.2018.04.001
Reference: YCEPS 1679

To appear in: *Contemporary Educational Psychology*

Please cite this article as: Rosário, P., Carlos Nú ñez, J., Vallejo, G., Nunes, T., Cunha, J., Fuentes, S., Valle, A., Homework purposes, homework behaviors, and academic achievement: Examining the mediating role of students' perceived homework quality, *Contemporary Educational Psychology* (2018), doi: https://doi.org/10.1016/j.cedpsych.2018.04.001

Homework purposes, homework behaviors, and academic achievement: Examining the mediating role of students' perceived homework quality

Pedro Rosário, Department of Applied Psychology, Universidade do Minho.

Address: Escola de Psicologia, Universidade do Minho, Gualtar, 4710-052 Braga (Portugal).

Email: prosario@psi.uminho.pt. Fax: 253 604 224. Phone number: +351 253 604 605.

José Carlos Núñez, Department of Psychology, Universidad de Oviedo.

Address: Plaza Feijoo s/n. 33003 Oviedo (Spain). Email: jcarlosn@uniovi.es. Fax: 985104144. Phone number: +34 985 103 217.

Guillermo Vallejo, Department of Psychology, Universidad de Oviedo.

Address: Plaza Feijoo s/n. 33003 Oviedo (Spain). Email: gvallejo@uniovi.es. Fax: 985104144. Phone number: +34 985 103 217.

Tânia Nunes, Department of Applied Psychology, Universidade do Minho.

Address: Escola de Psicologia, Universidade do Minho, Gualtar, 4710-052 Braga (Portugal).

Email: tanianunes.pf@gmail.com. Fax: 253 604 224. Phone number: +351 253 604 605.

Jennifer Cunha, Department of Applied Psychology, Universidade do Minho. Address: Escola de Psicologia, Universidade do Minho, Campus Gualtar, 4710-052 Braga (Portugal). Email: jennifer.psiminho@gmail.com. Fax: 253 604 224. Phone number: +351 253 604 605.

Sonia Fuentes, Facultad de Educación, Universidad Central de Chile. Address: Edificio Vicente Kovacevic II, Avda. Santa Isabel 1278. Email: sofu2028@gmail.com. Fax: +5625826701. Phone number: +5625826701

Antonio Valle, Departamento de Psicología Evolutiva y de la Educación, Universidad de A Coruña. Address: Universidade da Coruña, Rúa da Maestranza, 9, 15001 A Coruña. Email: vallar@udc.es. Fax: 981 167 000. Phone number: +34 981 167 000

Corresponding Author: Pedro Rosário, first author.

Abstract

A multi-level structural equation model was used to examine the relationships between the homework purposes reported by teachers (i.e. practice, preparation, participation, and personal development), homework quality perceived by students (e.g., homework related to the class material taught) and homework variables (i.e. effort, and homework performance) collected through different sources, and mathematics achievement. Participants were 4,265 6th graders and their teachers (N = 101) from 199 classes. The direct and indirect relationships between variables were analyzed. Data showed that (a) homework purposes, students' homework variables and mathematic achievement are associated, and (b) the relationship between homework purposes and mathematic achievement is mediated, by students' perception of homework quality. Research and practice implications are addressed.

Keywords: Homework purposes, homework quality, homework effort, homework performance, mathematics achievement, multilevel structural equation model

Introduction

Homework is one of the most popular, yet controversial, instructional strategies and has proved to positively impact students' performance (e.g., Fan, Xu, Cai, He, & Fan, 2017; Núñez, Suárez, Cerezo et al., 2015; Trautwein, 2007; Trautwein, Schnyder, Niggli, Neumann, & Lüdtke, 2009; Valle et al., 2015, 2016). Following Cooper, Steenbergen-Hu, and Dent (2012) we define homework as the tasks assigned by teachers to students that should be completed during non-school hours.

In the first step of homework, teachers are expected to design the homework tasks (Cooper, 2001). One of the most important actions at this stage is to set clear purposes for homework. Homework purposes may be defined as the reasons or objectives underlying each task (Epstein & Van Voorhis, 2001; Rosário, Núñez, Vallejo, Cunha, Nunes, Mourão et al., 2015), and are expected to help teachers select congruent homework tasks. Extant literature has indicated the importance of homework purposes to academic success (e.g., Epstein & Van Voorhis, 2001; Lee & Pruitt, 1979). In fact, as Epstein & Van Voorhis (2012) alerted, when homework tasks are consistent with the teachers' intended purposes, students are more prone to understand homework goals and are likely to engage more deeply in the tasks.

However, assigning homework with clear purposes may not be sufficient to promote the students' involvement. For example, literature has stressed the homework quality perceived by middle school students' as a strong predictor of students' homework behaviors (e.g., Dettmers et al., 2010; Trautwein & Lüdtke, 2007, 2009; Trautwein, Lüdtke, Schnyder, & Niggli, 2006). The former may be defined as the students' perception of teachers' "careful selection and preparation of appropriate and, to some extent, interesting tasks that reinforce classroom learning" (Dettmers et al., 2010, p. 468). So, as suggested by extant literature, the homework quality perceived by students may be a key component to understand the relationships between homework variables, students’ homework behaviors and achievement (Dettmers et al., 2010).

Notwithstanding, and despite the importance of the homework purposes set by teachers and the homework quality perceived by students on homework variables and academic achievement, to authors’ best knowledge, no studies have yet analyzed the associations between these variables in the same study. This would be particularly important in elementary school because in this school level there are mixed findings regarding the benefits of homework (see Cooper, Robinson, & Patall, 2006; Fan et al., 2017).

The current study extends prior research, analyzing variables of two important homework models proposed by Cooper (2001) and Trautwein and colleagues (2006). These two models provide a relevant theoretical framework for the present study. Grounded in these models the current study aims to explore the mediating role of students’ perceived homework quality in the relationship between teachers’ homework purposes (i.e. practice, preparation, participation, and personal development), students’ homework behaviors (i.e. homework effort) and performance (i.e. frequency of homework completion, completion rate, timeliness, accuracy and presentation of mathematical thinking), and mathematics achievement. Analyzing these relationships is expected to add to the literature because while teachers set purposes for the homework and may select congruent homework tasks, the students need to understand assignments as interesting and useful to their learning and to display positive homework behaviors (e.g., effort), otherwise the purposes set may not be positively linked to academic achievement.

Theoretical Homework Models

The homework process involves a multitude of factors with a high degree of complexity (Cooper, 2001; Cooper et al., 2006; Corno, 1996; Regueiro et al., 2015; Trautwein & Köller, 2003; Warton, 2001). The homework models by Cooper (2001) and by Trautwein, Lüdke, Schnyder, & Niggli (2006), though parsimonious, include major variables of the homework process related to all of the people involved (i.e. teachers, students, and parents).

Cooper (2001) proposed a model comprising several factors that may influence the effectiveness of homework: exogenous factors (i.e. students' characteristics, domain and grade level), and endogenous factors (i.e. homework assignment characteristics, initial classroom factors that facilitate the homework completion, home-community factors, and classroom follow-up). Homework assignment characteristics (i.e. amount, purpose, skill area used, degree of individualization, degree of student choice, completion deadlines, and social context) were reported to be related to homework effectiveness on students' outcomes (e.g., achievement, homework completion) (Cooper, 2001).

Trautwein, Lüdke, Schnyder et al. (2006) proposed a homework model with six groups of variables: learning environment, students' characteristics, parental behavior, homework motivation, homework behavior, and achievement. For reasons of parsimony, and due to the link to the current study objectives, only the first group of variables (learning environment) will be addressed. This group includes antecedent variables of homework characteristics considering class and student levels (e.g., homework frequency and length, homework quality, homework control, and adaptivity) in relation to students' homework behaviors and achievement (Trautwein, Lüdke, Schnyder et al., 2006).

In sum, both models (i.e. Cooper 2001; Trautwein, Lüdke, Schnyder et al., 2006) are focused on similar variables, though holding different levels of specification. Cooper's model (2001) described the homework purposes, but so far, the model has not been tested as a whole. Trautwein and colleagues' work over the past decade has acknowledged the importance of the characteristics of homework assignments defined by teachers and perceived by students. However, they did not examine teachers' and students' reports on this variable in the same study. This latter line of research has also stressed the need to study the relationships between homework characteristics (e.g., purposes), students' homework behaviors and student achievement, to further understand the impact of homework on students' learning (Trautwein, Niggli et al., 2009).

Homework Purposes, homework behaviors and academic achievement

Cooper (2001) proposed that homework may address either instructional or non-instructional purposes. The model is comprised of four instructional purposes (i.e., the practice or review of the material learned in class; the preparation of the material to be learned in the following classes; the extension, meaning the transfer and application of previous learning to new situations; and the integration, meaning homework tasks that demand different competences as, for instance, project) and five non-instructional purposes (i.e., parent-child communication, fulfilling directives, punishment, and community relations). Based on previous research (e.g., Epstein & Becker, 1982; Corno, 2000), Epstein and Van Voorhis (2001, 2012) suggested ten purposes for homework practice, preparation, participation, personal development organized into three main categories: instructional (purposes related to the instructional process, e.g., practice, preparation, participation, personal development), communicative (purposes related to the communication between students-teachers-parents), and political (purposes related to school homework polices).

Using a multilevel model, Trautwein, Niggli et al., (2009) examined homework purposes, referred to as *homework objectives* (i.e., drill and practice, closing the achievement gap, motivation, school-home link) in relation with homework behaviors. Findings indicated that 8th grade students of French as a second language who were assigned homework tasks with a high emphasis on motivation (e.g., homework designed to promote students' responsibility and autonomy, and increase students' interest in the subject - similar to the personal development purpose of Epstein & Van Voorhis, 2001) achieved more and displayed more effort than the students assigned homework with a high emphasis on drill and practice. It should also be noted that the explained variance at the student level was lower than that at the teacher level (Trautwein, Niggli, et al., 2009), which highlights the importance of the teacher's role and the in-class learning environment to the homework effectiveness.

Studies with experimental or quasi-experimental designs showed the effectiveness of homework purposes on students' academic achievement (Foyle, Lyman, Tompkins, Perne, & Foyle, 1990). Foyle et al. (1990) found that homework with the purpose of practice (condition 1) and preparation (condition 2), combined with cooperative learning increased 5th graders' social studies achievement as compared to the control group. Recently, Rosário, Núñez, Vallejo, Cunha, Nunes, Mourão et al. (2015) found that homework assignments with the purpose of promoting the transfer of learning (i.e. extension) had a stronger positive impact on 6th graders' mathematics achievement than homework with the purpose of practice or preparation.

Students' perceived homework quality, homework behaviors and academic achievement

In a research conducted in a French as a foreign language class, Trautwein, Lüdke, Schnyder et al. (2006) analyzed the impact of the homework quality perceived by 8th graders on their homework behavior (i.e., effort). Findings showed that homework quality positively predicted students' efforts at individual and class levels. However, when motivational variables were included as mediators, the predictive effects of homework quality decreased at student level, but no association was found at class level. In 2007, Trautwein and Lüdtke examined to what extent students from 8th and 9th grades perceived homework assignments as "well-prepared and interesting" (p. 435). These authors found that homework quality predicted students' effort in six school subjects (mathematics included). Two years later, the same authors used two subscales to assess effort: homework compliance (i.e., careful and honest homework completion) and percentage of homework tasks attempted (i.e., tasks in which students worked very hard). Once again, homework quality showed a positive association with students' homework compliance at both individual and class levels in all school subjects analyzed (Trautwein & Lüdtke, 2009).

More recently, a multilevel study with 9th and 10th graders examined the association between students' perceived homework quality and homework motivation (i.e., homework expectancy and value beliefs), homework behaviors (i.e., time on homework and homework effort), and mathematics academic achievement (Dettmers et al., 2010). Data showed that students who perceived homework as *well selected by teachers* reported higher homework motivation and homework behavior at both class and individual level. Later achievement (10th grade) was only predicted at class level. Findings of the study conducted by Dettmers and colleagues in 2011 showed that homework perceived by the students as well selected: (i) was positively related with students' homework effort; (ii) had elicited less negative emotions toward homework at both student and class levels; and (iii) had increased academic achievement at class level.

In general, prior research focused on homework (Dettmers et al., 2010, 2011; Trautwein & Lüdtke, 2007, 2009; Trautwein, Köller, Schmitz, & Baumert, 2002; Trautwein, Lüdtke, Schnyder, et al., 2006) has consistently highlighted the relevance of the middle and high school students' perception of homework quality.

Homework purposes and homework quality

Literature suggests that teachers should dedicate the same attention to the preparation of homework design as to other instructional or classroom practices (Cooper, 2001; Epstein & Van Voorhis, 2012). According to Epstein and Van Voorhis (2012), high quality homework assignments undertake clear purposes, which is likely to influence students' homework involvement. In fact, these purposes should be clearly communicated to students so they can perceive homework as useful and meaningful (Carr, 2013).

These propositions are consistent with extant research showing that variables related to instruction (e.g., teachers' classroom goals structure) are positively related to high school students' perception of instruction instrumentality (Hardré, Crowson, Debacker, & White, 2007; Walker, 2012).

The present study

The homework process begins with the selection of the homework tasks assigned by teachers (e.g., Cooper, 2001). Despite the importance of this step on the homework process (e.g., selection of purposeful tasks matching the difficulty of the tasks with the students level of knowledge), the design of homework tasks (especially the role of various homework purposes on students' homework behaviors and academic outcomes) has received little attention from researchers (Bas, Sentürk, & Cigerci, 2017; Epstein & Van Voorhis, 2012). Extant literature reports a few studies analyzing the impact of homework purposes on elementary school students' variables (see Foyle et al., 1990; Rosário, Núñez, Vallejo, Cunha, Nunes, Mourão et al., 2015). All these studies were run in controlled conditions, so current literature lacks studies that help understand the homework purposes usually set for the homework assignment. For this reason, the current study examined the naturally occurring associations of the homework purposes (see Trautwein, Niggli, et al., 2009). Analyzing the mediating role of the students' perception of homework quality between the homework purposes set by the teachers, the students' homework behaviors and academic achievement could help shed light on the complex process of homework at elementary school. Findings are expected to help deepen the understanding of the benefits of the homework assigned in school and to improve the ecological validity of findings. In the following subtopics, relevant methodological decisions are addressed.

Instructional homework purposes and perceived homework quality

The present study examined instructional purposes for homework assignments because these are the purposes most frequently set by teachers for the homework assigned (Cooper et al., 2006; Danielson et al., 2011; Foyle, et al., 1990; Kaur, 2011; Trautwein, Niggli et al., 2009). Research has shown that instructional purposes are positively related to the material covered in the assessment tests as well as students' academic achievement (e.g., Cooper et al., 2006; Muhlenbruck, Cooper, Nye, & Lindsay, 2000; Rosário, Núñez, Vallejo, Cunha, Nunes, Mourão et al., 2015). To the authors' knowledge, this is the first study examining the relationships between homework purposes and students' homework quality using a multilevel structural equation model.

Grade level

Meta-analyses examining the influence of school levels in the relationship between homework and academic performance showed mixed results (e.g., Cooper et al., 2006; Fan et al., 2017). The classic work by Cooper et al. (2006) found a negative relationship between homework and academic achievement for elementary school students. However, a recent meta-analysis focused on math and science homework from elementary to high school (Fan et al., 2017) and found that the relationship between homework and achievement was stronger in elementary school.

Moreover, prior research addressing students' homework behaviors and students' perceived homework quality examined data in middle and high school but not in elementary school (e.g., Dettmers et al., 2010; Trautwein & Lüdtke, 2007, 2009; Trautwein, Lüdtke, Schnyder et al., 2006). Elementary school trains children in fundamental skills and knowledge areas and sets the basis for future learning; so it is important to look further into the students' homework behaviors at this school level.

Finally, the sixth grade was selected because it is the final grade level of elementary school in the Portuguese educational system, and students complete a national standardized exam in mathematics at the end of the school year (June). This exam counts for 30% of the students' overall mathematics grade. Moreover, teachers in Portugal often use homework assignments to prepare students for the exam and to help maximize their students' academic performance (Rosário, Núñez, Vallejo, Cunha, Nunes, Mourão et al., 2015).

Focus on mathematics

The current research focused on mathematics due to its relationship with other subjects (e.g., science, technology) and its importance in professional development (e.g., see Hagger, Sultan, Hardcastle, & Chatzisarantis, 2015; OECD, 2013). Mathematics is also a school subject that utilizes a fair amount of homework (e.g., Rønning, 2011; Xu, 2015). Still, to the authors' knowledge, only the study by Rosário, Núñez, Vallejo, Cunha, Nunes, Mourão et al. (2015) has examined the impact of homework purposes on this subject.

Combination of data sources

Trautwein and Lüdtke (2007) noted that teachers' reports can be an important source of information to accurately assess the characteristics of homework assignments. For this reason, in the current study, the homework purposes were assessed by the teachers. The literature has defended the need to consider the students' perspective of the homework assignments (e.g., Landers, 2013; Warton, 2001) because the students are active players in their learning process (e.g., Trautwein & Lüdtke, 2007). In fact, literature recognizes the advantage of collecting and combining reports from different data sources (e.g., Dettmers et al., 2010, Saban, 2013) to create a more holistic picture of the study object. Thus, the current study collected reports from teachers and their students to assess two aspects of students' homework (i.e. behaviors and performance), as well as scores on homework assignments and grades on a standardized mathematics exam.

Hypothesis

Acknowledging the contributions of the models by Cooper (2001) and Trautwein and colleagues' (2006) as well as the suggestions for further research on this topic (Epstein & Van Voorhis, 2012; Rosário, Núñez, Vallejo, Cunha, Nunes, Mourão et al., 2015; Trautwein, Niggli et al., 2009), the current study aims to examine the mediating effects of students' perceived homework quality in the relationship between: four instructional homework purposes (i.e., practice, preparation, participation, and personal development, Epstein & Van Voorhis, 2001), students' homework behaviors (i.e. homework effort), homework performance (i.e. latent variable subsuming frequency of homework completed, completion rate, timeliness, accuracy and presentation of mathematical thinking), and mathematics achievement in the 6th grade.

This study, using a multilevel structural equation model (MSEM) approach, examined different sources for data collection: teachers' reports (i.e., homework purposes, frequency of homework completion), students' reports (i.e., perceived homework quality and homework effort), and students' outputs (i.e. homework performance and mathematics achievement on a standardized exam).

Grounded on extant research (e.g., the purposes of homework tasks assigned by teachers are related to students' academic achievement, Rosário, Núñez, Vallejo, Cunha, Nunes, Mourão et al., 2015; the homework purposes reported by teachers positively predicts students' homework behaviors, Trautwein, Niggli et al., 2009; homework quality perceived by students positively predicts homework behaviors and academic achievement, Dettmers et al., 2010; Trautwein & Lüdtke, 2007, 2009; Trautwein, Lüdtke, Schnyder, et al., 2006; communication of homework purposes contributes to students' perceptions of the quality of homework, Carr, 2013; Epstein & Van Voorhis, 2012; Hardré et al., 2007), a model was set with the following general hypothesis (see Figure 1):

Homework quality perceived by students mediates the relationship between *homework purposes*, students' homework variables (i.e. *homework effort* and *homework performance*), and *mathematics achievement*.

Insert Figure 1 about here

Methods

Participants

This study is part of a large project on homework in elementary school. The project, which required several data collections, is focused on assessing sixth grade students', teachers' and parents' variables related to (i) students' homework engagement, (ii) school engagement, and (iii) mathematics achievement. The Portuguese Ministry of Education authorized the present study, and afterwards, the research team randomly contacted and selected 84 elementary schools from various regions of Portugal. The majority of the schools contacted agreed to participate in the research (return rate of 78%), and 90% of the parents authorized the participation of their children in the study. Our data were collected from northern, central, and southern parts of the country as well as from the islands both in rural and urban contexts. A total of 4,265 (54.4 % male) 6th grade students from 199 classes in 66 elementary schools participated in this study. Classes enrolled included students from all ability levels. Seven classes were excluded because the teacher questionnaire was not fulfilled. The class size ranged between 15 and 31 students (*M* = 21; *SD* = 4.01). The participant students were aged between 10 and 13 years (*M* = 11.43; *SD* = 0.62) and attended three math classes per week (90 minutes per class). Note: 10 year old children (0,3 %) entry in the elementary school a few months earlier due to administrative reasons, while 13 years old children (6,5%) are those who failed one school year along their school path. On average, the families of the participating students were from working class backgrounds, evidenced by the high percentage of students receiving free or reduced-price lunch (25.7%), as reported in schools' office data.

One hundred and one mathematics teachers (72.9% female) enrolled in our study. Their teaching experience ranged between 5 and 39 years with an average of 19 years. At that time, participating teachers were working an average of 22 hours a week, and they taught from 1 to 5 different classes (3 classes on average). All teachers reported assigning math homework regularly, and 91% of them reported counting the students' homework completion in the final grade. Teachers reported using homework logs to check if homework is completed, and also that the final homework score (percentage of homework completed) count from 2 to 5% of the final mathematics grade. In Portugal, mathematics teachers are free to select exercises for homework, which usually require paper and pencil. These exercises are likely to be chosen from the students' textbooks, but teachers may decide to design their own (Nunes et al., submitted).

Instruments and measures

Teacher questionnaire and measures

Homework purposes (i.e. reasons or objectives underlying each task, Epstein & Van Voorhis, 2001). Prior controlled studies have shown a positive impact of homework purposes on students' achievement (Foyle et al., 1990; Rosário, Núñez, Vallejo, Cunha, Nunes, Mourão et al., 2015). However, in the current study, the main interest is to analyze naturally occurring homework associations by investigating what homework purposes teachers report to use in class and to learn its relationship to students' homework behaviors, homework performance and academic achievement (see Trautwein, Niggli, et al., 2009). Homework purposes were assessed by means of four subscales (i.e. practice, preparation, participation, and personal development) based on the description of the homework purposes by Epstein and Van Voorhis (2001). The first version of the questionnaire was analyzed by three experts on homework. These experts were asked to study in detail the homework purposes described by Epstein and Van Voorhis (2001) and analyze the questionnaire to evaluate whether the questions effectively captured the four homework purposes under investigation. The reviews were conducted independently, and their suggestions helped improve the final version of the questionnaire. The five items of the Practice Scale express teachers' intentions to use homework to practice skills taught in class, to increase speed, to demonstrate mastery, to retain skills, to review work, and to study for tests (e.g., "Overall, the main purpose of the homework tasks that I usually assign is to practice skills or content taught in class"). The Preparation Scale consists of three items that reflect the teachers' intentions to assign tasks aiming to prepare students for the next lesson (e.g., "Overall, the main purpose of the homework tasks that I usually assign is to prepare students for the next lessons that will be taught”). The Participation Scale is comprised of three items that are focused on the usage of homework to promote the student’s involvement in learning, applying specific skills and knowledge, and conducting projects (e.g., “Overall, the main purpose of the homework tasks that I usually assign is to apply specific skills and knowledge, for example, to conduct projects”). Finally, the fourth homework purpose subscale, Personal Development, is comprised of three items. This scale describes the potential of homework assignments to enhance students’ responsibility, motivation and self-regulation learning (e.g., “Overall, the main purpose of the homework tasks that I usually assign is to develop students’ skills to manage time; for example, the deadline to complete homework”). Homework purposes were assessed on a 5 point Likert-type scale (where 1 = completely disagree and 5 = completely agree). The internal consistency (Cronbach’s alpha) of these four scales were 0.80, 0.87, 0.81, and 0.78, respectively. Moreover, a confirmatory factor analysis was run. The model fits well to the data ($\chi^2_{(67,101)}$ = 95.41; p = .013; GFI = .88; CFI = .94; RMSEA = .065, 90% CI (.031, .093), which supports the construct validity. Moreover, we used two model evaluation criteria, the Akaike Information Criterion (AIC) - the extent to which parameter estimates from the original sample will cross-validate in future samples -, and the Expected Cross-Validation Index (ECVI) - the likelihood that the model cross-validates across similar-sized samples from the same population. Findings for AIC and ECVI suggest the cross-validation of the factorial model (i.e. AIC and ECVI of default model was less than the saturated and the independence models).

Students’ homework performance. This variable was assessed using teachers’ reports about the frequency of students’ homework completion, and the assessment of students’ homework.

The frequency of students' homework completion was tapped with a single item. Teachers were asked to keep a homework log with data for each student of the class in regard to the completion of each of the five homework assignments. In the end, data for each student was scored on a 5 point Likert-type item (where 1=never and 5=always).

The assessment of students' homework was as follows. Five homework assignments, collected by the class teacher, were graded by two mathematics teachers independently on 5 point Likert-type scale. The two mathematics teachers were members of the research team and were not enrolled in the study. They hold in average 12 years of teaching experience, and were trained in the assessment rubric for 14h. These teachers graded all homework assignments. A matrix homework assessment rubric with four categories was used (i.e. completion rate, timeliness, accuracy and presentation of mathematical thinking):

(i). Completion assesses how much of the homework assignment was completed. Students who did not deliver homework would earn a 1, and students who completed 100% of the homework would earn a 5;

(ii). Timeliness assesses whether the homework assignment was delivered by its deadline. Students who deliver the homework assignment on time would earn a 5. The students would earn lower scores as they turned in their homework assignments later; a 4 stands for an assignment delivered 1 day later, and a 1 for an assignment delivered more than a week later;

(iii). Accuracy assesses the level of correctness of homework. For example, see exercise 1 in the Appendix. Students who delivered their homework assignment completely correct would earn a 5 (e.g., (e.g.,

$A_{colorful} = 615{,}7536\ (A_{big\ circle}) - 39{,}27(A_{two\ small\ circles}) - 15(A_{triangle)} -$

$15\ (A_{rectangle)} = 546{,}4836\ cm^2)$), the students would receive a 4 if most of their homework assignment is correct (e.g., An incomplete answer. Mathematics computations are correct, but students forgot to compute the area of the big circle, thus it is not possible to compute the colorful area), and they would receive a 1 when none or only a very few of the answers are correct (e.g., compute the area of the small circles);

(iv). Presentation of mathematical thinking assesses students' mathematical reasoning based on the presentation of the steps for solving problems. Students would earn a 5 on their homework assignment when all the steps for solving the exercises are present (e.g., The base of triangle is equal to the diameter of the small circle, then b = 5 cm (2*2,5 radius of the small circle) and h = 6 cm. $A_{triangle} = \frac{b \times h}{2} = \frac{5 \times 6}{2} = \frac{30}{2} = 15\ cm^2$), they would earn a 4 if most of the steps are presented $A_{triangle} = \frac{b \times h}{2} = \frac{30}{2} = 15\ cm^2$), and they would receive a 1 when a few or none of the steps are presented (e.g., $A_{triangle} = 15\ cm^2$).

The final score for each homework assignment was gathered by summing the total of points earned. Finally, the two teachers from the research team reviewed all the homework assignment scores and discussed the differences they each found so that they could reach a consensus. To ensure the reliability of findings, the Kappa value was calculated using the Coder Comparison Queries in the Navigation View of the NVivo software. The Kappa value was .87, which may be considered "almost perfect" according to Landis and Koch (1977, p. 165). The final scores for each homework were translated into a 5-point grade system (1 stands for scores between 4 and 7; 2 stands for scores between 7 and 9; 3 stands for scores between 10 and 13; 4 stands for scores between 14 and 16; and 5 stands for scores between 17 to 20). For this research, an average of the five scores was computed for each student.

Student questionnaire

Students' perceived homework quality. This variable was assessed using the subscale selection by Dettmers et al. (2010), which examines to what extent students perceived their homework assignments as: i) well chosen by their teacher; ii) interesting; iii) related to the class material taught; and iv) useful to understand the material covered in class. The four items were assessed in a 5 point Likert-type scale (where 1 = never and 5 = always). The internal consistency (Cronbach's alpha) of this scale was 0.74. A confirmatory factor analysis was run. The model fits the data well ($\chi^2_{(2, 4247)} = 25.67$; $p < .001$; GFI = .997; AGFI = .985; TLI = .982; CFI = .994; RMSEA = .053, 90% CI (.036, .072), which supports the construct validity.

Students' homework effort. This variable was assessed with the students' homework effort scale from Dettmers et al. (2010), which is comprised of four items (e.g., "I always try to do my mathematics homework"). The effort scale was assessed on a 5 point Likert-type scale (where 1=never and 5=always), and the internal consistency (Cronbach's alpha) of this scale was 0.76. With a validation purpose, a confirmatory factor analysis was run and the data indicate an acceptable fit ($\chi^2_{(2, 4247)} = 55.43$; $p < .001$; GFI = .994; AGFI = .969; TLI = .963; CFI = .988; RMSEA = .075, 90% CI (.062, .089).

School records

Students' mathematics achievement. Students' grades on the national standardized exam in mathematics (end of 6^{th} grade) were collected from the schools' secretary offices. Grades in this exam range from 1 to 5, where 1 and 2 means fail, 3 is pass, 4 is good, and 5 is excellent.

Covariates

Students' gender. Students reported their gender in the section of sociodemographic information of their questionnaires. This variable was coded as follows: 0 for girls and 1 for boys.

Students' prior achievement. The mathematics grades of the previous school year were collected from the schools' secretary offices. The grades in Portuguese compulsory education range from 1 to 5, where 1 and 2 is negative, 3 is passing, 4 is good, and 5 is excellent. Previous research has noted the need to control prior achievement because this variable can influence the results (e.g., Trautwein, Schnyder, et al., 2009).

The association of gender and prior student achievement have been statistically controlled because of their strong relationship to students' homework variables and academic achievement (Cooper et al., 2006; Núñez, Suárez, Cerezo, et al., 2015; Núñez, Suarez, Rosário, Vallejo, Valle, et al., 2015; Trautwein, 2007; Trautwein et al, 2009; Xu, 2010; Xu Yuan, Xu, & Xu, 2014). Specifically, there is a widespread consensus among researchers that in order to promote learning, teachers should help students utilize both new and previous knowledge (OECD, 2014). Recently, Rosário, Núñez, Vallejo, Cunha, Nunes, Mourão and colleagues (2015) found that mathematics achievement was positively affected by prior achievement. Regarding gender, the results of previous research indicates that girls, compared to boys: (i) tend to display more homework effort (Younger & Warrington, 1996), (ii) spend more time completing assignments (Núñez, Suarez, Cerezo et al, 2015; Trautwein, 2007; Wagner, Schober, & Spiel, 2007), (iii) use more strategies to complete homework (Xu, 2007), and (iv) control their negative homework emotions better (Xu, 2010).

Procedure

A research team that was comprised of the authors and ten research assistants distributed along the country (north, center and south) conducted this study. Before data collection began, all researchers and collaborators participated in a two-hour meeting to set the protocol for data collection.

Students' participation was voluntary and had to be approved by the students' parents. The participants (students and teachers) were informed by the research assistants about the aims of the study and were assured the confidentiality of data. In each class, the students' and teachers' instruments were delivered in the same day. The students' data was collected during regular lesson in the second term of the school year (February-March) by the research assistants and without the teachers' presence. Moreover, teachers answered the homework purposes self-report in a different room. The five homework assignments and the measure of frequency of homework completed were collected in a 3 weeks' time window. During this period, teachers selected homework freely, as they usually do. At the end of this time-frame, research assistants contacted each teacher to collect information (i.e. frequency of homework completed and students' assignments). Finally, at the end of the school year, the research team gathered the students' grades on the national standardized exam in mathematics from the schools' secretary's office.

Data analysis

To address the aims of this study, a multilevel structural equation model (MSEM) approach was conducted in M*plus*7 (Muthen & Muthen, 1998-2012). MSEM provides a suitable framework to estimate model parameters required to test indirect associations when the model includes multiple mediators and outcomes while accounting for the clustering effect of a two-level data hierarchy (i.e., students nested within classrooms). For testing the mediation hypotheses (see model detailed in Figure 1), a robust maximum likelihood (MLR) estimator that acknowledges missing data assumed to be missing at random was used. The robust ML estimator provides ML parameter estimates with standard errors that are sensitive to non-normality, and allow for the determination of whether there is any classroom clustering effect for the mediators measured at a lower level. When scores in the same group resemble each other, it may be necessary to use multilevel modelling.

To examine whether missing data were completely at random (MCAR), data for teachers and for students were analyzed separately. To test whether the missing data on homework purposes reported by teachers were MCAR, the Little's test (Little, 1988) was used. This test divides the sample into groups based on the patterns of data absence for the study outcome. The likelihood ratio test statistic yielded a χ^2 value of 3.238 on 4 *df* (p = 0.519) for items of the practice variable; a χ^2 value of 2.505 on 2 *df* (p = 0.286) for the participation variable; a χ^2 value of .619 on 2 *df* (p = 0.734) for the preparation variable, a χ^2 value of 1.022 on 2 *df* (p = 0.600), and a χ^2 value of 1.022 on 2 *df* (p = 0.600) for the personal development variable. All considered data suggest that the MCAR model provides an adequate fit to the data. The same Little's test was used on the students' data set. Findings indicate a similar missing data mechanism for homework quality perceived by students (χ^2 = 7.457, *df* = 9, p = 0.589), for homework variables reported by students and teachers (χ^2 = 19.151, *df* = 16, p = 0.261), and for mathematics achievement (χ^2 = 0.697, *df* = 2, p = 0.705). All considered, findings on the teachers and students' data sets indicate that missing values are MCAR (i.e. there's no relationship between whether a data point is missing and any values in the data set).

Insert Figure 1 about here

Current data are organized at more than one level, so data was initially analyzed at three levels (student, class, and school). Although the current study does not include any school-level variables in the model, class-level variables were aggregated to describe the set of 6th grade students in each school. However, results did not show differences between the class and the school level (see table in the supplementary material section [results for the Multilevel Structural Equation Model: students, class, and school] and their comparison with table 2 in the manuscript [MSEM at two levels: student and class]). This finding could be due to the fact that the model for school variables was built from the variables at class level (see table in supplementary material), not including specific variables from each school. In sum, these findings provide empirical support for using a simpler two-level analysis with students at level 1 and teachers at level 2, ignoring the school's effects.

Students' perceived homework quality (HW quality), students' homework effort (HW effort), students' homework performance (HW performance), and students' math achievement were assessed at the student level, whereas homework purposes (i.e. HW practice, HW preparation, HW participation, and HW personal development) were assessed at the classroom level. In addition, students' gender and prior achievement were included as covariates to control for their influence on the outcome variables.

Our aim was to examine the association of homework purposes (measured at Level 2) on three intervening (i.e. mediator) variables measured at Level 1 (HW quality, HW effort, HW performance) which in turn may affect students' academic achievement measured at Level 1. This model could be described as a «2→1→1» multilevel design (see, Krull & MacKinnon, 2001). The numbers of the mediational path (2,1,1) stand for the measurement levels of the independent, mediator, and outcome variables respectively.

For the purposes of the present study, a parsimonious MSEM approach with random intercepts and fixed slopes was chosen (see, Preacher, Zphur, & Zhang, 2010). Random effects represent between-classroom variation in intercepts while fixed slopes refer to the fact that within-classroom regression coefficients (or structural coefficients) are assumed to be constant across classrooms. In other words, the association of the three intervening variables (i.e. HW quality, HW effort, HW performance) on academic achievement was not allowed to vary across classrooms. Reasons to follow this procedure are twofold: to facilitate model convergence and to analyze the between-classroom effects of the mediators on the outcome variable controlling for the effects of homework purposes.

A cluster-mean centering approach, with the cluster means reintroduced into the Level-2 intercept model, was run. This strategy is likely to offer a clear view of the mediation mechanism at each level of analysis because the indirect association on within-classroom and between-classroom levels is mutually orthogonal (Tofighi & Thoemmes, 2014). Still, due to a poor convergence, an alternative method had to be found. In the end, the mediation effects at different levels were estimated without changing the scale of the mediator variables measured at a lower level.

Finally, the identified model is expected to provide a good fit to the data. A large set of fit indices is available for models without random slopes (Muthén & Muthén, 1998–2007), which include the comparative fit index (*CFI*), Tucker-Lewis index (*TLI*), the root mean square error of approximation (*RMSEA*), the standardized root mean square residuals for the between ($SRMR_B$), and the within ($SRMR_W$) models. The model shows a good fit to the data when *CFI* and *TLI* > 0.95, and *RMSEA* and *SRMR* ≤ 0.05.

Results

Preliminary analysis

Table 1 provides the descriptive statistics of the variables included in the Multilevel Structural Equation Homework Model. According to Finney and DiStefano (2006), all variables follow a normal distribution.

Insert Table 1 about here

Multilevel analysis: Testing the role of students' perceived homework quality as a mediating variable

The intra-class correlation estimates for the variables that may potentially show both between- and within-level variation (see Figure 1). It was examined to decide whether fitting a two-level MSEM was appropriate.

The estimates ranged from 0.046 to 0.060 (*HW quality*), from 0.044 to 0.056 (*HW effort*), from 0.132 to 0.226 (*HW performance*), and from 0.191 to 0.192 (*Math achievement*). These estimates suggested that the within-level variability was generally far larger than the between-level variability (see Table 3). Therefore, the estimates indicated the need to run a two-level assessment, especially considering that these estimates are generally attenuated (downwardly biased) due to measurement error. The MSEM approach provides fit indices for the mediation model (not shown in the Table 2), indicating a good model fit (CFI = 0.97; TLI = 0.96; $RMSEA$ = 0.05; $SRMR_B$ = 0.09; $SRMR_W$ = 0.03; and $\chi^2(405)$ = 1372.42, χ^2/df = 3.38).

Insert Table 2 about here

Data (see Table 2) showed that in the *within-classroom part* of the model the direct associations of HW quality on HW effort (.686) and on HW performance (0.124) were significant at 95% CI [0.651, 0.722; 0.073, 0.175]. Moreover, the direct association of HW effort on HW performance (0.250) at 95% CI [0.073, 0.178] and the direct association of HW performance on Math achievement (0.614) at 95% CI [0.561, 0.670] were also positive.

It was also found that gender had direct associations on HW quality (-0.244), HW effort (-0.049), HW performance (-0.179), and Math achievement (0.113). Finally, prior achievement showed direct associations on HW quality (0.442), on HW effort (0.152), on HW performance (0.623) and on Math achievement (0.336). All the direct associations found were significant at 95% CI. The remaining direct associations were not statistically significantly.

Analysis regarding the *between-classroom part* of the model showed the direct associations of HW quality on HW effort (.726) and HW performance (0.112) which were all significant at 95% CI [0.604, 0.848; 0.060, 0.164]. Moreover, a direct association of HW effort on HW performance (0.106), significant at 95% CI [0.054, 0.158], and a direct association of HW performance on Math achievement (0.458), also significant at 95% CI [0.380, 0.537], were also found.

The following associations were also found as significantly different at 95% CI: gender on Math achievement (-0.327), prior achievement on HW quality (0.825), prior achievement on HW performance (0.765) and prior achievement on Math achievement (0.462). The remaining direct associations were not significant.

Besides, *specific indirect* associations were found as follows: HW practice with Math achievement (i) via HW quality and HW performance (0.012) and (ii) via HW quality, HW effort, and HW performance (0.008); HW participation with Math achievement (i) via HW quality and HW performance (-0.007) and (ii) via HW quality, HW effort, and HW performance (-0.005); and HW personal development with Math achievement (i) via HW quality and HW performance (-0.014) and (ii) via HW quality, HW effort, and HW performance (-0.009). All of these specific indirect associations were significant at 90% CI. The remaining specific indirect associations were not significantly different. In sum, Figure 2 presents a summary of the main associations at the *between level* (classrooms), and Figure 3 presents a summary of the main associations at the *within level* (students).

Insert Figures 2 and 3 about here

Finally, Table 3 presents the R-square coefficients for each latent variable as well as the between- and within-classroom variance residual. The within-classroom residual variance captures the variation of each student's score from their latent classroom mean score. The between-classroom variance quantifies variation in the latent classroom mean scores. When combined, these results show that the strategy of data analysis at two levels (within and between) has proven to be successful.

Insert Table 3 about here

Discussion

Using a multilevel structural equation model approach, the current study aimed to examine the mediating role of the students' perceived homework quality in the relationship between four homework purposes reported by teachers (i.e., practice, preparation, participation, and personal development), homework effort, homework performance, and mathematics achievement. The findings are discussed attending to both direct and indirect associations.

Direct associations

At the between level, the homework purposes and students' perceived homework quality were only partially related ($p < 0.05$ for homework practice and homework personal development; $p < 0.1$ for homework participation. No relationship was found for homework preparation) (see figure 2). Moreover, the direction of the relationship between some types of homework purposes and the perceived homework quality differs. For example, the relationships between practice and preparation homework and perceived homework quality are positive, whereas the relationship between participation and personal development homework and perceived homework quality is negative. These findings highlight the importance of students' perspective about homework delivered in class. These findings seem to suggest that homework assignments with purposes that students can relate with the work done in class (practice exercises similar to those worked in class or exercises aiming at preparing students to the exam) are likely to be perceived as homework with quality (i.e. well chosen by their teacher, interesting, related to the class material taught, and useful to understand the material covered in class). In contrast, when homework assignments have purposes less likely to be related to the class content by students (i.e. participation and personal development purposes), students are prone to perceive them as showing low quality and to make less effort while doing the homework.

This finding suggests that elementary school students may have conceived homework quality in relation to the value it serves. Our data stresses that the more the students associated homework assignments with their practice (e.g., review class contents, test preparation exercises) the higher their perceived instrumental value. Moreover, the relationship is negative regarding homework with purposes of personal development. This data is important to homework literature, and should be further investigated; future research could consider the possibility that elementary students asked about homework quality may be responding to homework value, stressing the instrumentality of homework for their progress on learning. Researchers could consider further investigate students from different grade levels to understand how they conceive homework quality.

Homework purposes and students' homework effort are not directly related. However, the findings of Trautwein, Niggli et al. (2009) indicated that 8th graders who were learning French as their second language, in classes that were assigned, more tasks addressing drill and practice reported less homework effort than counterparts in classes who were assigned more tasks to promote motivation. In the current study, homework purposes are only indirectly related to homework effort through the students' homework perceived quality. This suggests that the purposes for homework set by teachers do not seem to be influencing students' homework behaviors (e.g., effort on homework) (see figure 2). In fact, findings indicate that students are likely to complete their homework when it is perceived as quality; the higher the perceived quality of the homework, the greater the perceived effort in carrying out the assignments. Therefore, our data indicate that homework perceived quality plays a key mediating role between the purposes for homework (prescribed by the teacher) and the level of students' involvement while doing homework.

At within and between levels the results indicated that the higher the homework quality perceived by elementary school students, the greater the effort put forth, the greater the homework performance, and the higher the math achievement. These latter findings are consistent with those of Dettmers et al. (2010, 2011) and of Trautwein and Lüdtke (2007) in the upper grade levels (8th to 10th) focusing on mathematics. These authors found that the middle and high school students who perceived their homework assignments as well-selected or well-prepared by their teachers reported higher motivation and effort at student and at class level (Dettmers et al., 2010; Trautwein & Lüdtke, 2007). As Trautwein, Lüdtke, Schnyder et al. (2006) stated in their theoretical homework model, the perceptions of homework quality influence homework expectancy and value which predicts homework effort. In sum, one major finding of the current study stresses that for elementary students, what seems to be explaining the mathematical achievement is the quality of homework perceived by students (i.e., assignments well chosen by their teacher, interesting, related with the class material taught, and useful to understand the material covered in class), more than the type of purposes set for homework. This variable has shown to be strongly related with students' homework behaviors (i.e. homework effort and homework performance).

Prior research has stressed the role of gender and prior achievement on students' homework behaviors (e.g., Cooper et al., 2006; Núñez, Suárez, Cerezo, et al., 2015; Rosário et al., 2015; Trautwein, Schnyder, et al., 2009; Xu Yuan, Xu, & Xu, 2014). For this reason, in our study these variables were included as covariates to statistically control their predictive effect on the target variables of the model (see figure 1). As table 2 shows, gender and prior achievement are significantly associated with all the variables at student level (except for the association between gender and homework effort). In general, these findings are consistent with data from prior research indicating that girls complete more homework and with more quality than boys (Younger & Warrington, 1996; Wagner, Schober, & Spiel, 2007), but achieved lower grades in the national exam when compared with boys. This latter finding is also consistent with literature reporting mathematics performance gaps, and gender disparities in mathematical confidence, favoring boys in elementary school (Lubienski, Robinson, Crane, & Ganley, 2012). These disparities in diligence, achievement and confidence merits further attention of researchers, because this pattern is unique to gender and mathematics (Robinson & Lubienski, 2011). For example, researchers could consider further investigating students' conceptions of mathematics success, and students' biases about boys' and girls' mathematics abilities. Findings would help ground gender-focused educational interventions in elementary school. This pattern of associations was only found at within level (student level), not at between level (class level). Our data indicate that there are no class variables interacting with gender in the associations between gender and the homework variables analyzed. This finding is also consistent with data reporting that here is no consistent evidence that teachers' mathematics instructional practices predict later gender gaps in achievement (Lubienski et al., 2012).

Our data are consistent with previous research on prior knowledge (e.g., Rosário, Núñez, Vallejo, Cunha, Nunes, Mourão et al., 2015; Zuffianò, et al., 2012; Trautwein et al., 2002; Trautwein, Schnyder, et al., 2009). Findings show that prior knowledge is associated significantly with all variables included in the model at students and at class level. For both levels, students with higher prior achievement, when compared with those with lower prior achievement, show higher homework quality, display more effort on homework, complete more homework, and achieve higher grades on the national exam. These findings could help school administrators and teachers consider the need to acknowledge students level of prior achievement in their lesson plans. In general, these data are consistent with literature stressing that prior achievement influences the relationship between homework and academic achievement (Trautwein et al., 2002; Trautwein, Schnyder, et al., 2009), and plays important role on academic achievement (Rosário, Núñez, Vallejo, Cunha, Nunes, Suárez et al., 2015; Zuffianò, et al., 2012).

In sum, our data indicates that the students' mathematical achievement was explained (73% within level and 78% between level) by students' homework variables (i.e., perceived homework quality, homework effort, and homework performance). When students perceive their homework with higher quality, they are likely to put in more effort, complete homework more frequently, perform better on assignments, and achieve higher grades in mathematics. On the contrary, when students perceive the homework assigned with lower quality, their homework performance is likely to be poor and their achievement is lower which is consistent with previous research (Dettmers et al., 2010; Trautwein, Lüdtke, Schnyder et al., 2006). In sum, findings of the current study highlight the role played of students' perception of homework quality and are consistent with the work by Fan and colleagues (2017) in showing that homework benefits the elementary school students' achievement.

Specific indirect associations

At the between level, it was found that only three of the four homework purposes reported by teachers (i.e. homework practice, homework participation, and homework personal development) were barely related with math achievement (at 90% CI). The current study examined the naturally occurring associations of the homework purposes, and for that reason findings may help teachers and school administrators reflect on the importance of these processes (e.g., help students understand the homework quality) and improve achievement. For example, when teachers communicate the purposes of homework to students, it is likely that the students will understand its utility and benefit from them (see Carr, 2013; Hardré et al., 2007).

Strengths, limitations and future research

To the authors' knowledge, this was the first study that simultaneously examined the role of homework purposes reported by the teachers along with the quality of the homework assigned perceived by elementary school students. Besides, different data sources were used to collect data, and a multilevel structural equation model approach was used to test the mediational hypothesis of the students' perceived homework quality.

Still, despite the promising results and contributions of the current study, the implications derived should be taken cautiously due to the limitations of this study. First, due to the cross-sectional nature of this study, no causal inferences are allowed, even under a multilevel perspective. Future studies should adopt a repeated measures design and collect data multiple times to obtain information about causes and effects as well as the more-than-possible reciprocal relations between variables included in the model. This information could be useful to understand how the homework purposes may vary throughout the school year depending on the contents taught.

Despite having proposed a model with theoretically relevant variables for an explanation of the homework purposes, the model is not completely saturated as an important quantity of variance has not been explained. Still, there are other variables that may help to explain the results (e.g., the other role of teacher in the homework process - feedback; Rosário, Núñez, Vallejo, Cunha, Nunes, Suárez et al., 2015). For a deeper insight into the contribution of the homework purposes and students' perceived homework quality to homework behaviors and performance, researchers may consider conducting cross-sectional studies encompassing various school levels with subjects other than mathematics.

In addition, the majority of the variables in this study were assessed using self-reports which allowed for data collection among a large pool of students. However, self-reports did not capture real-time response demands of authentic learning environments (Rosário et al., 2010). These possible explanations reinforce the need to include event measures in the research design that capture the processual nature of the constructs in analysis. For example, future studies could use on-task measures (e.g., diaries) to increase the reliability of the findings. Moreover, and to further address the perceived homework quality, future studies could use qualitative data to help unveil its importance. For example, interviews could be conducted with students to learn their conceptions about how homework may help improve their learning. Also, the data could be complemented with a documental analysis of homework samples.

The majority of the participating teachers (91%) reported to count homework completion to the homework grade (2-5%). In fact, students in classes where teachers count, or not, homework to the final grade may consider homework differently. This fact was not considered in the current research, and may have had contributed to findings. Future studies may wish to consider analyzing this variable in relation to students' homework behaviors.

Lastly, the current study did not access the instructions given to students by their teachers nor the information provided in class about the purposes for the assignments. Future research could consider addressing these issues. Still, findings offer promising insights into the relevance of explaining to students the purposes of the homework assigned, and stress the importance of matching the homework purposes to students' learning needs. Future studies could further examine how students understand the features of homework quality as well as the impact of communicating the purposes of homework on the students' perception of homework purposes, homework quality, and homework performance.

Conclusions

The present study adds to literature by analyzing the mediating role of the elementary students' perception of the homework quality in the relationship between the homework purposes reported by teachers, the students' homework variables and academic achievement. Prior research had been limited to analyze homework behaviors of the upper levels. Current data also highlights the crucial role the students' perception of the quality of the homework assignments plays in elementary school. Participants are likely to have stressed the value of homework rather than the homework quality. In fact, data suggests that to promote the students' involvement on the homework completion process, the purposes for homework need to be understood by students as being instrumental for their progress (e.g., useful to understand the content taught in class). For example, it would be beneficial for students if teachers could explain how a particular homework task may accomplish the purpose set. This line of communication may help students clearly understand how the assigned homework intends to develop their work habits (e.g., distractors management), and autonomy (Epstein & Van Voorhis, 2001, 2012).

Data adds to literature by highlighting the importance of the first step of the homework process: design of the homework tasks. At that stage, teachers should not only address the purposes of their homework by aiming to fulfill the students' needs, but they should also allocate educational efforts to explain to students how the homework assigned (e.g., type of tasks, purposes) best matches their learning needs. The students' perception of how homework tasks might fit their purposes and help their learning progress has proved to play an important role. For example, homework with the purpose of practicing content learned in class may be motivating and may promote students' effort on homework when they want to automatize routines to solve mathematics exercises. This type of homework purpose, in certain moments of the learning process, may help students to increase their self-efficacy beliefs and motivation (e.g., Trautwein et al., 2009). In other moments, students may need homework with other purposes to reach the same outcomes. This match may be potentiated if teachers communicate the homework purpose to their students.

Regarding the homework-academic achievement relationships, as already discussed in the introduction section, a recent meta-analysis (Fan et al., 2017) on the relationships between homework and academic achievement in mathematics and science concluded that those relationships were stronger in elementary school. Findings of the present study also indicate a strong relationship between students' homework behaviors and mathematics achievement, stressing the relevance of students' homework performance. This may help teachers consider using instruments to capture a wide range of aspects of the homework completion process (i.e. effort, homework performance – frequency of homework completion, completion rate, timeliness, accuracy and presentation of mathematical thinking) and, hopefully, encourage the quality of homework. This important finding is expected to encourage school administrators and teachers to include homework on the educational agenda of the initial stage of formal learning.

All considered, the current study helps to simultaneously support the importance and the complexity of the discussion on the homework quality. In fact, on a daily basis, teachers face the challenge of matching the homework characteristics to their students' learning needs. Our data add complexity to this educational challenge and suggest that those efforts may fail to hit the target if the students do not understand the importance of the purposes for their learning progress.

References

Bas, G., Sentürk, C., & Cigerci, F. M. (2017). Homework and Academic Achievement: A Meta-Analytic Review of Research. *Issues in Educational Research, 27*(1), 31-50.

Buijs, M., & Admiraal, W. (2013). Homework assignments to enhance student engagement in secondary education. *European Journal of Psychology of Education, 28*, 767-779. doi:10.1007/s10212-012-0139-0.

Carr, N. S. (2013). Increasing the effectiveness of homework for all learners in the inclusive classroom. *School Community Journal, 23*(1), 169-182.

Cooper, H. (2001). *The battle over homework: Common ground for administrators, teachers, and parents* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Cooper, H., Robinson, J., & Patall, E. (2006). Does Homework Improve Academic Achievement? A Synthesis of Research, 1987-2003. *Review of Educational Research, 76*(1), 1-62. doi: 10.3102/00346543076001001.

Cooper, H., Steenbergen-Hu, S., & Dent, A. L. (2012). Homework. In K. R. Harris, S. Graham, & T. Urdan (Eds.), *APA educational psychology handbook, Vol. 3: Application to learning and teaching*. (pp. 475–495). Washington, DC: American Psychological Association. doi: http://dx.doi.org/10.1037/13275-019.

Corno, L. (1996). Homework is a complicated thing. *Educational Researcher, 25*(8), 27-30.

Corno, L. (2000). Looking at homework differently. *Elementary School Journal, 100*, 529–548.

Danielson, M., Strom, B., & Kramer, K. (2011). Real Homework Tasks: A Pilot Study of Types, Values, and Resource Requirements. *Educational Research Quartely*, *35*(1), 17-32.

Dettmers, S., Trautwein, U., Lüdtke, O., Goetz, T., Frenzel, A., & Pekrun, R. (2011). Students' emotions during homework in mathematics: Testing a theoretical model of antecedents and achievement outcomes. *Contemporary Educational Psychology*, *36*(1), 35-35. doi: 10.1016/j.cedpsych.2010.10.001.

Dettmers, S., Trautwein, U., Lüdtke, O., Kunter, M., & Baumert, J. (2010). Homework Works if Quality Is High: Using Multilevel Modeling to Predict the Development of Achievement in Mathematics. *Journal of Educational Psychology, 102*(2), 467-482. doi: 10.1037/a0018453.

Epstein, J. L., & Becker, H. J. (1982). Teachers' reported practices of parent involvement: Problems and possibilities. *The Elementary School Journal, 83*(2), 103-113.

Epstein, J., & Van Voorhis, F. (2012). The changing debate: From assigning homework to designing homework. In S. Suggate & E. Reese (Eds.), *Contemporary debates in child development and education* (pp. 263-273). London: Routledge.

Epstein. J. L., & Van Voorhis, F.L. (2001). More than minutes: Teachers' roles in designing homework. *Educational Psychologist, 36*(3), 181-193. doi: 10.1207/S15326985EP3603_4.

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. doi:10.1016/j.edurev.2016.11.003

Fernández-Alonso, R., Suárez-Álvarez, J., & Muñiz, J. (2015). Adolescents' Homework Performance in Mathematics and Science: Personal Factors and Teaching Practices. *Journal of Educational Psychology*. doi: http://dx.doi.org/10.1037/edu0000032.

Finney, S. J., & DiStefano, C. (2006). *Non-normal and categorical data in structural equation modelling*. In G. R. Hancock & R. O. Mueller (Eds.), Structural equation modelling: A second course (pp. 269–314). Greenwich, CT: Information Age.

Foyle, H., Lyman, L., Tompkins, L., Perne, S., & Foyle, D. (1990). *Homework and cooperative learning: A classroom field experiment.* Emporia, KS: Emporia State University, Faculty Research and Creativity Committee. (ERIC Document No. ED350285).

Hagger, M., Sultan, S., Hardcastle, S., & Chatzisarantis, N. (2015). Perceived autonomy support and autonomous motivation toward mathematics activities in educational and out-of-school contexts is related to mathematics homework behavior and attainment. *Contemporary Educational Psychology, 41*, 111-123. doi.org/10.1016/j.cedpsych.2014.12.002.

Hardré, P. L., Crowson, H. M., Debacker, T. K., & White, D. (2007). Predicting the academic motivation of rural high school students. *The Journal of Experimental Education, 75*(4), 247-269. doi: 10.3200/JEXE.75.4.247-269.

Krull, J. L., & MacKinnon, D. P. (2001). Multilevel modeling of individual and group level mediated effects. *Multivariate Behavioral Research, 36*, 249-277.

Kukliansky, I., Shosberger, I., & Eshach, H. (2016). Science teachers' voice on homework: beliefs, attitudes, and behaviors. *International Journal of Science and Mathematics Education.* doi: 10.1007/s10763-014-9555-8.

Landers, M. G. (2013). Towards a theory of mathematics homework as a social practice. *Educational Studies in Mathematics, 84*(3), 371-391. doi: 10.1007/s10649-013-9487-1.

Lee, J., & Pruitt, W. (1979). Homework assignments: Classroom games or teaching tools? *The Clearing House*, *53*(1), 31-35. doi: 10.1080/00098655.1979.9957112.

Lubienski, S., Robinson, J., Crane, C., & Ganley, C. (2013). Girls' and Boys' Mathematics Achievement, Affect, and Experiences: Findings from ECLS-K. *Journal for Research in Mathematics Education, 44,* 4, 634-645.

Muhlenbruck, L., Cooper, H., Nye, B., & Lindsay, J. (2000). Homework and achievement: Explaining the different strengths of relation at the elementary and secondary school levels. *Social Psychology of Education, 3*(4), 295-317. doi: 10.1023/A:1009680513901.

Muthén, L. K., & Muthén, B. O. (1998-2012). *Mplus user's guide* (7th ed.). Los Angeles, CA: Muthén & Muthén.

Nunes, T., Rosário, P., Núñez, J.C., Cunha, J., Moreira, T., & Fuentes, S. (submitted). "Homework should be…but we do not live in an ideal world": Teachers' perspectives of quality homework.

Núñez, J. C., Suárez, N., Cerezo, R., González-Pienda, J., Rosário, P., Mourão, R., & Valle, A. (2015). Homework and academic achievement across Spanish Compulsory Education. *Educational Psychology, 6*(35) 726-746. doi: 10.1080/01443410.2013.817537.

Núñez, J. C., Suárez, N., Rosário, P., Vallejo, G., Valle, A., & Epstein, J. L. (2015). Relationships between parental involvement in homework, student homework behaviors, and academic achievement: Differences among elementary, junior high, and high school students. *Metacognition and Learning, 10*, 375-406. doi: 10.1007/s11409-015-9135-5.

OECD (2013), *PISA 2012 Results: Ready to Learn – Students' Engagement, Drive and Self-Beliefs (Volume III), PISA,* OECD Publishing. doi: http://dx.doi.org/10.1787/9789264201170-en.

OECD (2014). *Education at a Glance 2014: OECD Indicators*, OECD Publishing. http://dx.doi.org/10.1787/eag-2014-en.

Patall, E. A., Cooper, H., & Wynn, S. R. (2010). The effectiveness and relative importance of choice in the classroom. *Journal of Educational Psychology,102*(4), 896. doi: 10.1037/a0019545.

Preacher, K. J., Zyphur, M. J., & Zhang, Z. (2010). A general multilevel SEM framework for assessing multilevel mediation. *Psychological Methods, 15,* 209–233.

Regueiro, B., Rodríguez, S., Piñeiro, I., Estévez, I., Ferradás, M., & Suárez, N. (2015). Differences in the perception of parental involvement in homework depending on the level of student motivation. *European Journal of Investigation in Health Psychology and Education, 5,* 313-323.

Robinson, J. P., & Lubienski, S. T. (2011). The development of gender achievement gaps in mathematics and reading during elementary and middle school: Examining direct cognitive assessments and teacher ratings. *American Educational Research Journal, 48* (2), 268–302. doi:10.3102/0002831210372249

Rønning, M. (2011). Who benefits from homework assignments? *Economics of Education Review, 30*(1), 55-64. doi:10.1016/j.econedurev.2010.07.001.

Rosário, P., González-Pienda, J. A., Cerezo, R., Pinto, R., Ferreira, P., Abilio, L., & Paiva, O. (2010). Eficacia del programa"(Des) venturas de Testas" para la promoción de un enfoque profundo de estudio. *Psicothema*, *22*(4), 828-834.

Rosário, P., Núñez, J. C., Vallejo, G., Cunha, J., Nunes, T., Mourão, R., & Pinto, R. (2015). Does homework design matter? The role of homework's purpose in student mathematics achievement. *Contemporary Educational Psychology, 43*, 10-24. doi:10.1016/j.cedpsych.2015.08.001.

Rosário, P., Núñez, J. C., Vallejo, G., Cunha, J., Nunes, T., Suárez, N., & Moreira, T. (2015). The effects of teachers' homework follow-up practices on students' EFL performance: a randomized-group design. *Frontiers in Psychology*, *6.* doi: 10.3389/fpsyg.2015.01528.

Saban, A. İ. (2013). A study of the validity and reliability study of the homework purpose scale: A psychometric evaluation. *Measurement*, *46*(10), 4306-4312. doi:10.1016/j.measurement.2013.08.027.

Tofighi, D., & Thoemmes F. (2014). Single-level and multilevel mediation analysis. *The Journal of Early Adolescence, 34,* 93-119.

Trautwein, U. (2007). The homework-achievement relation reconsidered: Differentiating homework time, homework frequency, and homework effort. *Learning and Instruction, 17,* 372-388. doi:10.1016/j.learninstruc.2007.02.009

Trautwein, U., & Köller, O. (2003). The Relationship Between Homework and Achievement—Still Much of a Mystery. *Educational Psychology Review, 15*(2), 115-145. doi: 10.1023/A:1023460414243.

Trautwein, U., & Lüdtke, O. (2007). Students` Self-Reported Effort and Time on Homework in Six School Subjects: Between-Students Differences and Within-Student Variation.

Journal of Educational Psychology, 99(2), 432-444. doi: 10.1037/0022-0663.99.2.432.

Trautwein, U., & Lüdtke, O. (2009). Predicting homework motivation and homework effort in six school subjects: The role of person and family characteristics, classroom factors, and school track. *Learning and Instruction, 19*(3), 243-258. doi:10.1016/j.learninstruc.2008.05.001.

Trautwein, U., Köller, O., Schmitz, B., & Baumert, J. (2002). Do Homework Assignments Enhance Achievement? A Multilevel Analysis in 7th-Grade Mathematics. *Contemporary Educational Psychology, 27*(1), 26-50. doi:10.1006/ceps.2001.1084.

Trautwein, U., Lüdtke, O. Kastens, C., & Köller, O. (2006). Effort on homework in grades 5 through 9: Development, motivational antecedents, and the association with effort on class-work. *Child Development, 77*(4), 1094-1111. doi:10.1111/j.1467-8624.2006.00921.x.

Trautwein, U., Lüdtke, O., Schnyder, I., & Niggli, A. (2006). Predicting homework effort: Support for a domain-specific, multilevel homework model. *Journal of Educational Psychology, 98*(2), 438-456. doi: 10.1037/0022-0663.98.2.438.

Trautwein, U., Niggli, A., Schnyder, I., & Lüdke, O. (2009). Between-teacher differences in homework assignments and the development of students´ homework effort, homework emotions, and achievement. *Journal of Educational Psychology, 101*(1), 176-189. doi: 10.1037/0022-0663.101.1.176.

Trautwein, U., Schnyder, I., Niggli, A., Neumann, M., & Lüdtke, O. (2009). Chameleon effects in homework research: the homework-achievement association depends on the measures and the level of analysis chosen. *Contemporary Educational Psychology, 34*(1), 77-88. doi:10.1016/j.cedpsych.2008.09.001.

Valle, A., Regueiro, B., Estévez, I., Piñeiro, I., Rodríguez, S., & Freire, C. (2015). Homework involvement and motivation in elementary school students according to academic achievement and grade. *European Journal of Investigation in Health Psychology and Education, 5,* 345-355.

Valle, A., Regueiro, B., Núñez, J. C., Rodríguez, S., Piñeiro, I., & Rosário, P. (2016). Academic goals, student homework engagement, and academic achievement in elementary school. *Frontiers in Psychology, 7,* 1-10. doi:10.3389/fpsyg.2016.00463

Van Voorhis, F. (2004). Reflecting on the Homework Ritual: Assignments and Designs. *Theory into Practice, 43*(3), 205-212. doi:10.1207/s15430421tip4303_6

Wagner, P., Schober, B., & Spiel, C. (2007). Time students spend working at home for school. *Learning and Instruction, 18,* 309–320.

Walker, C. O. (2012). Student perceptions of classroom achievement goals as predictors of belonging and content instrumentality. *Social Psychology of Education, 15*(1), 97-107. doi:10.1007/s11218-011-9165-z

Warton, P. (2001). The Forgotten Voices in Homework: Views of Students. *Educational Psychologist, 36*(3), 155-165.

Xu, J. (2007). Middle-school homework management: More than just gender and family involvement. *Educational Psychology, 27,* 173-189.

Xu, J. (2010). Predicting homework time management at the secondary school level: A multilevel analysis. *Learning and Individual Differences, 20,* 34-39.

Xu, J. (2015). Investigating factors that influence conventional distraction and tech-related distraction in math homework. *Computers & Education, 81,* 304-314. doi:10.1016/j.compedu.2014.10.024.

Xu, J., & Yuan, (2003). Doing homework: Listening to students', parents', and teachers' voices in one urban middle school community. *School Community Journal,13*(2), 23-44.

Xu, J., Yuan, R., Xu, B., & Xu, M. (2014). Modeling students' time management in math homework. *Learning and Individual Differences, 34*, 33-42.

Younger, M., & Warrington, M. (1996). Differential achievement of girls and boys at GCSE: Some observations from the perspective of one school. *British Journal of Sociology of Education*, *17*, 299–313. doi:10.1080/0142569960170304

Zakharov, A., Carnoy, M., & Loyalka, P. (2014). Which teaching practices improve student performance on high stakes exams? Evidence from Russia. *International Journal of Educational Development*, *36*, 13-21. doi: 10.1016/j.ijedudev.2014.01.003.

Zuffianò, A., Alessandri G., Gerbino, M., Kanacri, B., Di Giunta, L., Milioni, M., & Caprara, G. (2012). Academic achievement: The unique contribution of self-efficacy beliefs in self-regulated learning beyond intelligence, personality traits, and self-esteem. *Learning and Individual Differences, 23,* 158-162. doi:10.1016/j.lindif.2012.07.010.

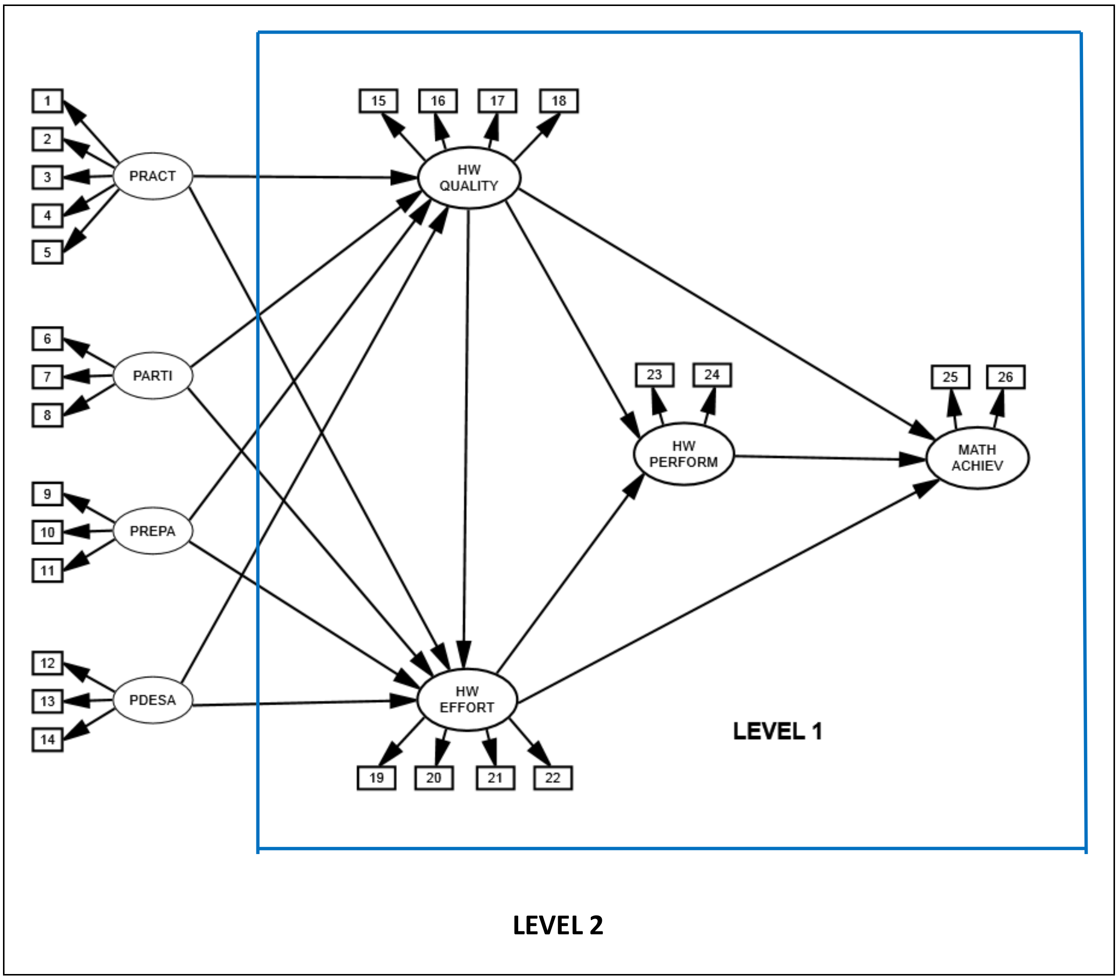


Figure 1. Multilevel Structural Equation Model of mediating role of students' perceived homework quality, homework effort and homework performance in the relationship between homework purposes and students' achievement.

Note: PRACT (Practice purpose), PARTI (Participation purpose), PREPA (Preparation purpose), PDESA (Personal development purpose), HW QUALITY (Students' perceived homework quality), HW EFFORT (Students' homework effort), HW PERFORM (Students' homework performance - frequency of homework completion and homework grades), MATH ACHIEV (Students' math achievement). Items 1 to 26 are observed measurements (see Table 1). LEVEL 1 (students), LEVEL 2 (classrooms).

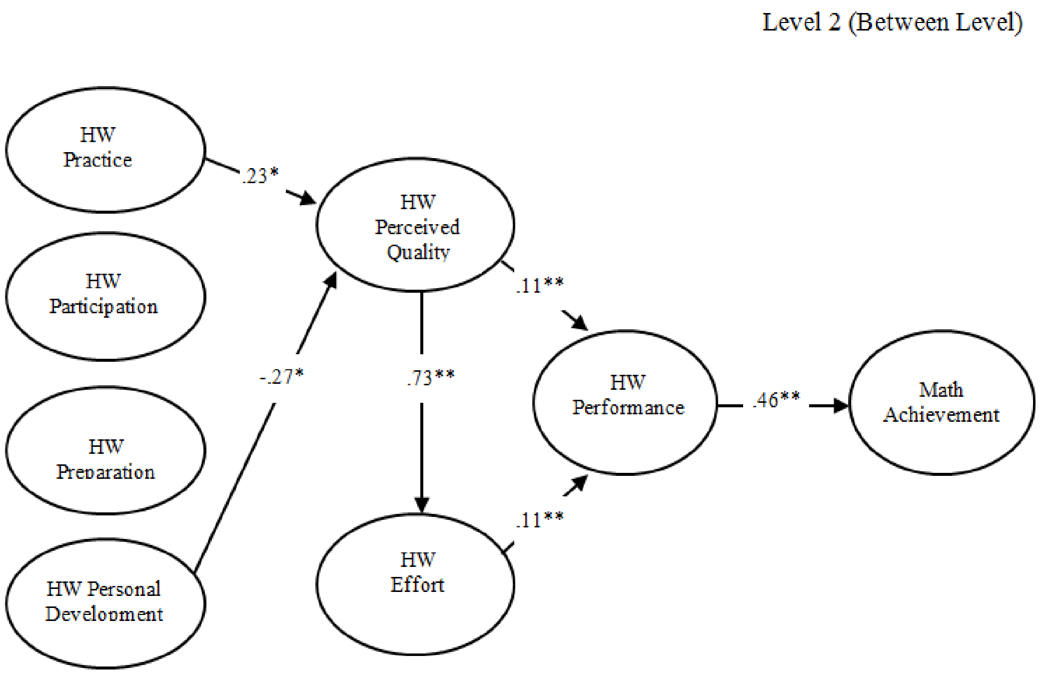


Figure 2. Main results corresponding to *between level* (classrooms) of the Multilevel Structural Equation Homework Model.

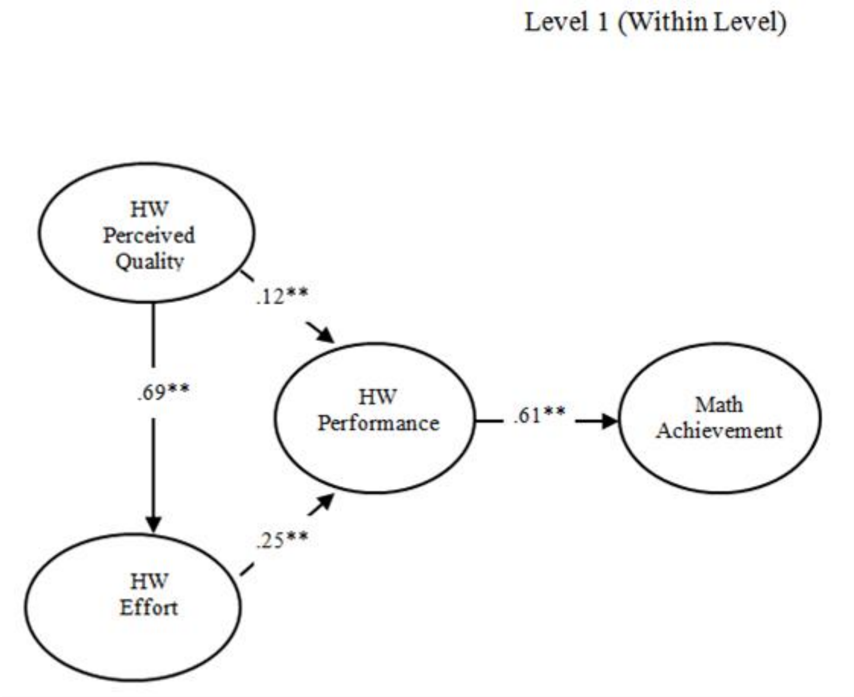


Figure 3. Main results corresponding to *within level* (students) of the Multilevel Structural Equation Homework Model.

Table 1

Descriptive statistics for the variables included in the measurement part of the Multilevel Structural Equation Homework Model.

	M	*SD*	*Asymmetry*	*Kurtosis*
Purposes Practice_1	4.35	.594	-.468	.295
Purposes Practice_2	4.12	.715	-.548	.250
Purposes Practice_3	4.41	.634	-.821	.652
Purposes Practice_4	4.26	.767	-.711	-.256
Purposes Practice_5	4.50	.621	-1.445	4.480
Purposes Participation_1	2.42	.787	.002	-.449
Purposes Participation_2	2.21	.799	.216	-.180
Purposes Participation_3	2.31	.724	.418	.079
Purposes Preparation_1	3.35	.956	-.201	-.279
Purposes Preparation_2	3.65	1.033	-.395	-.648
Purposes Preparation_3	3.03	.746	-.823	.999
Purposes Personal Devolpment_1	4.58	.582	-1.060	.121
Purposes Personal Devolpment_2	4.39	.626	-.626	.011
Purposes Personal Devolpment_3	4.53	.560	-.682	-.579
HW Quality perceived_1	2.83	.859	-.123	-.870
HW Quality perceived_2	3.56	.709	-1.493	1.423
HW Quality perceived_3	3.33	.763	-.824	-.220
HW Quality perceived_4	3.27	.830	-.778	-.444
HW Effort_1	3.26	.811	-.673	-.695
HW Effort_2	3.16	.839	-.609	-.581
HW Effort_3	3.30	.810	-.862	-.192
HW Effort_4	3.35	.818	-1.017	.104
Frequency of HW completed	4.04	1.012	-.871	-.036
HW Performance	2.81	.967	-.238	-1.011
Mathematics National exam	3.06	1.065	.079	-.762
Prior Achievement	3.41	.968	.128	-.922

Note. HW = Homework

Table 2

Standardised Results for the Multilevel Structural Equation Model

			95% CI		
	Estimate	*SE*	*LL*	*UL*	*p*
Direct Associations (Within Level)					
HW quality → HW effort	0.686	0.221	0.651	0.722	0.000
HW quality → HW performance	0.124	0.031	0.073	0.175	0.000
HW quality → Math achievement	0.000	0.021	-0.031	0.037	0.799
HW effort → HW performance	0.250	0.032	0.073	0.178	0.000
HW effort → Math achievement	0.030	0.023	-0.007	0.067	0.185
HW performance → Math achievement	0.614	0.016	0.561	0.670	0.000
Gender → HW quality	-0.244	0.034	-0.300	-0.188	0.000
Gender → HW effort	-0.049	0.031	-0.101	0.001	0.109
Gender → HW performance	-0.179	0.030	-0.228	-0.130	0.000
Gender → Math achievement	0.113	0.020	0.081	0.146	0.000
Prior achievement → HW quality	0.442	0.020	0.409	0.474	0.000
Prior achievement → HW effort	0.152	0.021	0.118	0.186	0.000
Prior achievement → HW performance	0.623	0.026	0.580	0.667	0.000
Prior achievement → Math achievement	0.336	0.032	0.284	0.388	0.000
Direct Associations (*Between Level*)					
HW practice → HW quality	0.230	0.116	0.040	0.421	0.047
HW participation → HW quality	-0.146	0.079	-0.276	0.015	0.067
HW preparation → HW quality	0.005	0.080	-0.127	0.137	0.951
HW personal development → HW quality	-0.265	0.126	-0.472	-0.058	0.035
HW practice → HW effort	0.121	0.089	-0.026	0.267	0.176
HW participation → HW effort	0.049	0.070	-0.066	0.164	0.485
HW preparation → HW effort	0.039	0.074	-0.084	0.161	0.604
HW personal development → HW effort	-0.001	0.092	-0.151	0.150	0.995
HW quality → HW effort	0.726	0.074	0.604	0.848	0.000
HW quality → HW performance	0.112	0.032	0.060	0.164	0.000
HW quality → Math achievement	0.002	0.014	-0.021	0.025	0.876
HW effort → HW performance	0.106	0.032	0.054	0.158	0.000
HW effort → Math achievement	0.019	0.015	-0.005	0.043	0.190
HW performance → Math achievement	0.458	0.048	0.380	0.537	0.000
Gender → HW quality	0.150	0.271	-0.293	0.549	0.578
Gender → HW effort	0.198	0.315	-0.320	0.716	0.529
Gender → HW performance	0.145	0.237	-0.245	0.505	0.541
Gender → Math achievement	-0.327	0.190	-0.640	-0.014	0.085
Prior achievement → HW quality	0.825	0.171	0.541	1.109	0.000
Prior achievement → HW effort	0.166	0.184	-0.137	0.479	0.367
Prior achievement → HW performance	0.765	0.116	0.574	0.956	0.000
Prior achievement → Math achievement	0.462	0.115	0.172	0.325	0.000
Specific Indirect Associations (*Between Level*)					
Practice → Quality →Performance →Math-Ach	0.012	0.007	0.001	0.023*	0.085
Participation → Quality →Performance →Math-Ach	-0.007	0.004	-0.015	-0.001*	0.093
Preparation→ Quality →Performance →Math-Ach	0.000	0.001	-0.006	0.007	0.995
P. Development → Quality →Performance →Math-Ach	-0.014	0.008	-0.026	-0.001*	0.068
Practice → Effort →Performance →Math-Ach	0.006	0.005	-0.003	0.015	0.213
Participation → Effort →Performance →Math-Ach	0.002	0.003	-0.004	0.009	0.500
Preparation→ Effort →Performance →Math-Ach	0.002	0.004	-0.005	0.009	0.620
P. Development → Effort →Performance →Math-Ach	0.000	0.004	-0.009	0.009	0.999
Practice → Quality → Effort →Performance →Math-Ach	0.008	0.005	0.001	0.018*	0.098
Participation → Quality→ Effort →Performance →Math-Ach	-0.005	0.003	-0.010	-0.001*	0.099
Preparation→ Quality → Effort →Performance→Math-Ach	0.000	0.003	-0.004	0.005	0.995
P.Development → Quality → Effort →Perform →Math-Ach	-0.009	0.005	-0.018	-0.001*	0.071

Note. CI=confidence interval; *LL*=lower limit, *UL*=upper limit; *SE*=standard error. HW = Homework *The distribution of the product of the coefficients 90% CI for the indirect effect that did not contain zero CI are significantly different from zero.

Table 3

R-square coefficients and between- and within-classroom variance residual for the Multilevel Structural Equation Model

	Estimate	*SE*	95% CI *LL*	*UL*	*p*
Latent variance residual (*Within Level*)					
C_Perceived HW quality	0.828	0.015	0.804	0.853	0.000
C_HW effort	0.432	0.023	0.394	0.469	0.000
C_HW performance	0.511	0.024	0.472	0.548	0.000
C_Math achievement	0.272	0.014	0.248	0.296	0.000
Latent variance residual (*Between Level*)					
C_Perceived HW quality	0.359	0.124	0.156	0.562	0.004
C_HW effort	0.313	0.128	0.103	0.523	0.015
C_HW performance	0.251	0.101	0.084	0.417	0.013
C_Math achievement	0.217	0.100	0.054	0.381	0.029
R-Square (*Within Level Latent Variable*)					
C_Perceived HW quality	0.172	0.015	not available		0.000
C_HW effort	0.568	0.023	not available		0.000
C_HW performance	0.489	0.023	not available		0.000
C_Math achievement	0.728	0.014	not available		0.000
R-Square (*Between Level Latent Variable*)					
C_Perceived HW quality	0.641	0.124	not available		0.000
C_HW effort	0.688	0.128	not available		0.000
C_HW performance	0.749	0.101	not available		0.000
C_Math achievement	0.783	0.100	not available		0.000

Note. See note from Table 2.

Appendix

Look at the figure.

Knowing that:

- The diameter of the circle is 28 cm;
- The small circles are geometrically similar with a radius of 2,5 cm;
- The basis of the triangle is equal to the diameter of the small circles;
- The height of the triangle is 6 cm;
- The area of the rectangle is equal to the area of the triangle

Please, find the colorful area of the figure.

Figure 1. Example of a homework exercise

Supplementary material

Table

Standardised Results for the Multilevel Structural Equation Model (three levels of analysis: students, class, school)

			95% CI*		
Direct Effects (*Within Level*)	*Estimate*	*SE*	*LL*	*UL*	*p*
HW quality → HW effort	0.688	0.016	0.657	0.719	0.000
HW quality → W performance	0.130	0.028	0.075	0.185	0.000
HW quality → Math achievement	0.003	0.020	-0.036	0.042	0.876
HW effort → HW performance	0.257	0.028	0.062	0.172	0.000
HW effort → Math achievement	0.030	0.020	-0.009	0.069	0.173
HW performance → Math achievement	0.612	0.016	0.580	0.643	0.000
Gender → HW quality	-0.245	0.033	-0.311	-0.180	0.000
Gender → HW effort	-0.048	0.030	-0.107	0.011	0.108
Gender → HW performance	-0.178	0.026	-0.230	-0.126	0.000
Gender → Math achievement	0.114	0.019	0.077	0.151	0.000
Prior achievement → HW quality	0.443	0.017	0.409	0.476	0.000
Prior achievement → HW effort	0.151	0.020	0.114	0.188	0.000
Prior achievement → HW performance	0.626	0.014	0.598	0.654	0.000
Prior achievement → Math achievement	0.337	0.016	0.306	0.369	0.000
Direct Effects (*Between Class Level*)					
HW practice → HW quality	0.095	0.204	-0.305	0.495	0.643
HW participation → HW quality	-0.215	0.157	-0.523	0.092	0.170
HW preparation → HW quality	0.056	0.168	-0.273	0.386	0.738
HW personal development → HW quality	-0.336	0.197	-0.722	-0.050	0.088
HW practice → HW effort	0.340	0.170	0.007	0.673	0.045

HW participation → HW effort	0.008	0.133	-0.252	0.286	0.951
HW preparation → HW effort	-0.037	0.139	-0.311	0.236	0.789
HW personal development → HW effort	-0.158	0.163	-0.477	0.160	0.330
HW quality → HW effort	0.634	0.090	0.458	0.810	0.000
HW quality → HW performance	0.200	0.094	0.015	0.384	0.034
HW quality → Math achievement	0.002	0.015	-0.028	0.033	0.876
HW effort → HW performance	0.194	0.091	0.017	0.371	0.032
HW effort → Math achievement	0.025	0.017	-0.008	0.058	0.141
HW performance → Math achievement	0.308	0.117	0.079	0.538	0.008
Gender → HW quality	0.069	0.170	-0.265	0.403	0.686
Gender → HW effort	-0.023	0.133	-0.284	0.238	0.863
Gender → HW performance	-0.896	0.642	-2.155	0.363	0.163
Gender → Math achievement	-0.353	0.205	-0.757	-0.047	0.084
Prior achievement → HW quality	0.650	0.123	0.408	0.891	0.000
Prior achievement → HW effort	0.121	0.118	-0.111	0.352	0.308
Prior achievement → HW performance	0.640	0.239	0.172	1.107	0.007
Prior achievement → Math achievement	0.403	0.083	0.240	0.567	0.000
Total Direct Effects (*Between School Level*)					
HW practice → HW quality	0.328	0.238	-0.140	0.795	0.169
HW participation → HW quality	0.047	0.171	-0.288	0.382	0.783
HW preparation → HW quality	-0.133	0.183	-0.491	0.225	0.466
HW personal development → HW quality	-0.082	0.242	-0.555	0.392	0.736
HW practice → HW effort	-0.341	0.264	-0.857	0.176	0.197
HW participation → HW effort	-0.032	0.178	-0.382	0.318	0.857
HW preparation → HW effort	0.160	0.195	-0.222	0.541	0.412
HW personal development → HW effort	0.320	0.245	-0.160	0.799	0.191
HW quality → HW effort	0.854	0.139	0.582	1.125	0.000
HW quality → HW performance	0.095	0.025	0.046	0.145	0.000
HW quality → Math achievement	0.002	0.012	-0.022	0.022	0.872

HW effort → HW performance	0.069	0.021	0.028	0.110	0.000
HW effort → Math achievement	0.015	0.010	-0.005	0.035	0.147
HW performance → Math achievement	0.522	0.065	0.394	0.650	0.000
Gender → HW quality	0.140	0.152	-0.159	0.439	0.359
Gender → HW effort	0.392	0.151	0.077	0.688	0.009
Gender → HW performance	0.485	0.163	0.166	0.804	0.003
Gender → Math achievement	-0.243	0.117	-0.472	-0.013	0.039
Prior achievement → HW quality	0.825	0.083	0.666	0.989	0.000
Prior achievement → HW effort	0.026	0.129	-0.226	0.278	0.839
Prior achievement → HW performance	0.736	0.071	0.596	0.876	0.000
Prior achievement → Math achievement	0.423	0.076	0.274	0.571	0.000

Note. CI=confidence interval; *LL*=lower limit, *UL*=upper limit; *SE*=standard error. *The distribution of the product of the coefficients 90% CI for the indirect effect that did not contain zero CI are significantly different from zero. HW = Homework

Highlights

- We aimed to gain a deeper understanding of homework purposes in relation with homework behaviors.
- A path analysis with two samples (calibration and validation) was run.
- Participants were 4265 6^{th} graders and their teachers
- The model showed a good fit explaining 70% of students' mathematics achievement
- teachers should relate the purposes of homework to students' educational needs