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A multifactorial model of intrinsic / environmental motivators, personal traits and their combined influences on math performance in elementary school

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Abstract

Numerous studies have explored the important role of achievement goals, as well as factors such as interest and self-efficacy, for academic performance of students of various ages. Such studies usually focus on the influence of one or two of these factors that are known to be associated with performance. At the same time, achievement goals themselves are influenced by environmental factors such as the influence of "significant others" (parents, teachers) or the overall socio-cultural context. In the present study, we expand the framework of achievement goal theory by building a holistic multifactorial path analysis model of direct and indirect influences, where achievement goals and personality traits such as self-efficacy and interest exert a combined influence on performance, but also receive influence from environmental factors.

To achieve this goal, we collected data from 762 5th and 6th grade students, who attended 22 public primary schools in Cyprus. Data was collected with reliable and valid self-report scales such as the Achievement Goal Questionnaire (AGQ-R) and the Patterns of Adaptive Learning Scales (PALS), as well as a battery for Mathematical performance created by the researchers.

Our results indicate a robust model that effectively captures the complex grid of associations between these factors of interest. Among other findings, self-efficacy and interest were found to mediate the relation between students' mastery goals and performance. In sum, this research underscores the profound significance of mastery goals, self-efficacy and interest in Mathematical performance.

Keywords Goal Orientation · Achievement Goals · Interest · Mathematics · Modeling · Self-efficacy

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In the realm of educational psychology, extensive research underscores the role of student motivation in determining why some excel while others face challenges (Pintrich, 2003). This exploration encompasses intrinsic motivators like individual achievement goals and personal traits such as self-efficacy and interest, along with environmental motivators such as parental and classroom perceptions, shaping students' performance (Elliot & Hulleman, 2017; Kaplan & Maehr, 2007; Liem et al., 2008).

Motivation, especially in mathematics education, is vital for both learning and performance (Mouratidis et al., 2018; Panziara & Phillipou, 2015). However, multidirectional links between various motivational factors and traits in elementary school students require deeper exploration. Thus, this study delves into the relationships among intrinsic and environmental motivators, personal traits, and mathematical performance in fifth and sixth-grade students.

Achievement goal theory

One of the fundamental socio-cognitive theories, the Achievement Goal Theory (AGT; Elliot, 1999), posits that students' behavior is driven by goal pursuit, underpinning task engagement (Pintrich, 2003). Over the decades, the theory of achievement goals gradually progressed from a dichotomous model of two basic types (mastery and performance goals), to more complicated models (for a review of theory's evolution see Chazan et al., 2022, Hulleman et al., 2010, and Urdan & Kaplan, 2020). *Mastery goals* direct students towards activities that foster competence, as for example comprehension ability, skill development, knowledge acquisition, and self-improvement. On the other hand, *performance goals* center on demonstrating ability, recognizing one's own competence, preserving self-worth by comparing oneself to others, and striving to excel or outperform others (Elliot & Hulleman, 2017). Subsequent models introduced valence distinctions: approach goals focus on success, nurturing hope and enthusiasm, while avoidance goals center on fear, anxiety, and disappointment, hindering engagement (Elliot et al., 2011; Huang, 2011).

Recent models expanded competence references (task, self and others) but this more complicated model does not guarantee superiority to simpler models. Researchers select specific models based on alignment with the particular research questions at hand (Chazan et al., 2022; Elliot et al., 2011). However, subtle approach-avoidance distinctions pose challenges, especially with self-reporting, and notably in younger participants like elementary school children (Anderman & Patrick, 2012; Sideridis & Mouratidis, 2008).

Intrinsic motivators (achievement goals) and academic performance

High levels of mastery goals in students correlate with enhanced productivity, engagement, and effective cognitive strategies, leading to profound understanding and improved retention of knowledge and skills (Chazan et al., 2022; Mouratidis et al., 2018; Pantziara & Philippou, 2015). Mastery goals not only facilitate effective task completion, but also sustain interest, promoting positive emotions and reducing negative ones (Huang, 2011; Senko & Harackiewicz, 2005). The relationship between mastery-approach goals and academic performance, while indirect and mediated by beneficial affective and trait factors, is substantial, especially in elementary school students, diminishing in higher education levels (Linnenbrink-Garcia et al., 2008).

Although mastery-approach goals are generally considered more adaptive, performance-approach goals also appeal to many (students, teachers, and parents) due to their direct positive association with academic performance (Mouratidis et al., 2018; York et al., 2015). For challenging tasks like mathematics, mastery goals exhibit a stronger association with performance compared to performance-approach goals (Darnon et al., 2007; Linnenbrink-Garcia et al., 2008; Pekrun et al., 2009). However, contradictory findings arise, as revealed in meta-analyses (Baranik et al., 2010; Diseth & Kobbeltvedt, 2010; Van Yperen et al., 2014). These discrepancies may stem from varying attention to factors mediating the relationship between achievement goals and performance. Intrinsic motivation goals, goal characteristics (e.g. difficulty, specificity, interest), feedback types, self-efficacy, as well as environmental factors like parental and classroom goals, and students' social and cultural context, play pivotal roles. Our study delves into the mediating influence of personal traits, specifically interest and self-efficacy.

Personal trait influences: interest and self-efficacy

Achievement goals influence personal traits like self-efficacy and specialized interests in specific subjects (Kaplan & Maehr, 2007). Within education, *interest* denotes the joy and satisfaction experienced when engaging with particular topics, such as mathematics (Pantziara & Philippou, 2015; Zusho et al., 2005). *Self-efficacy* reflects students' belief in their ability to acquire new skills and knowledge in a specific academic domain (Bandura, 1997; Friedel et al., 2007). Research showcases a positive correlation between mastery goals and both self-efficacy and interest (Gonida & Cortina, 2014; Jiang et al., 2014; Lee et al., 2014; Martin & Elliot, 2016; Michaelides et al., 2019; Tosto et al., 2016; Yu & Martin, 2014). These personal traits interact bidirectionally with achievement goals, significantly influencing elementary school students' mathematical performance (Mouratidis et al., 2018; Pantziara & Philippou, 2015). Interestingly, performance-approach goals can also positively correlate with interest, especially in elementary students, heightening this association (Hulleman et al., 2010). Conversely, performance-avoidance goals exhibit a negative correlation with interest (Rawsthrne & Elliot, 1999). Studies focusing on students transitioning from elementary to high school have notably emphasized this interplay. Attempts to create predictive models expanded in two directions: either predict mastery goals based on self-efficacy (Pantziara & Philippou, 2015), or predict self-efficacy based on general mastery goals, or specifically mastery goals in the field of mathematics (Friedel et al., 2007, 2010). Mastery goals lead students towards learning-promoting activities, reinforcing their commitment to these goals. This mutual influence between achievement goals and motivators like interest forms a dynamic continuum (Pintrich, 2003).

Similarly, performance goals interact with self-efficacy. Students with high self-efficacy, driven by achievement-oriented goals, pursue comparison with others, while those with low self-efficacy avoid such evaluations (Elliot, 1999). Performance-approach goals exhibit a positive correlation with self-efficacy (Gonida & Cortina, 2014; Jiang et al., 2014; Martin & Elliot, 2016; Pantziara & Philippou, 2015; Yu & Martin, 2014). Other studies fail to report such correlation (Clayton et al., 2010; Friedel et al., 2010; Sakiz, 2011). In contrast, performance-avoidance goals negatively correlate with self-efficacy (Long et al., 2007). Finally, a direct positive correlation exists between self-efficacy and academic performance, especially notable among junior high-school students in the context of mathematics

(Kitsantas et al., 2010; Lee et al., 2014). This complex web of interactions underscores the pivotal role of personal traits in students' academic pursuits.

Environmental motivators: parental and classroom achievement goals

Environmental influences on achievement goals

The learning environment, encompassing both immediate contexts like classrooms and schools, and broader societal and cultural spheres, profoundly shapes students' thoughts and actions (Jiang et al., 2014; Meissel & Rubie-Davies, 2015). These environments, influenced by perceived expectations, pressures, and support from parents, teachers, and peers, influence students' sense of capability, their goal orientations, and their perceptions of the meaningfulness of learning activities (Bong, 2008). Achievement goals, in turn, are associated with these environmental factors, making them important determinants of students' academic pursuits (Elliot, 1999; Schunk et al., 2010).

Classroom influences

Within classrooms, the goals set by teachers significantly impact students' orientations. Perceived classroom mastery goals, where the emphasis is on learning and understanding, positively correlate with students' self-efficacy and classroom involvement (Gonida et al., 2007; Murayama & Elliot, 2009; Wolters, 2004). In contrast, perceived classroom performance goals, emphasizing outperforming others, exhibit negative correlations with students' mastery goals,interest and self-efficacy, but positive correlations with their performance goals (Anderman & Patrick, 2012; Friedel et al., 2007; Murayama & Elliot, 2009). Moreover, perceived classroom achievement goals, both mastery and performance, are positively interrelated (Bong, 2008; Sideridis, 2007), allowing predictions of one from the other (Gonida et al., 2009; Sideridis, 2007).

Parental influences

Similarly, parental influences significantly shape students' goals. Perceived parental mastery goals align with individual mastery goals, fostering a positive learning environment. Conversely, perceived parental performance goals correspond with individual performance goals. Notably, parental goals exert a stronger influence on individual goals compared to classroom goals, emphasizing the familial impact on students' academic pursuits (Friedel et al., 2007; Gonida & Cortina, 2014; Gonida et al., 2007, 2009).

Broader sociocultural context

Beyond classrooms and families, the sociocultural context, reflecting diverse cultural standards and values, profoundly influences achievement goals (Kim, 2015; Meissel & Rubie-Davies, 2015; Zusho & Clayton, 2011). However, external influences are challenging to dissect. These factors can be studied by collecting data from the relevant important others (e.g. parents, teachers) or through students' subjective perceptions. In our study, students' perceived parental and classroom achievement goals are an important component to model.

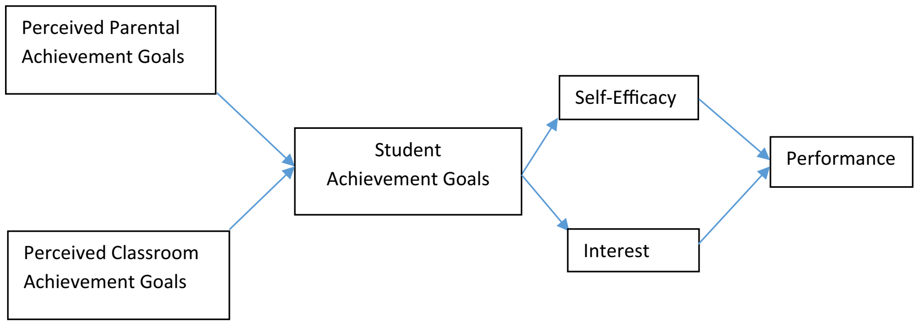

Fig. 1 An initial model for the potential effects of intrinsic and environmental motivators, as well as personal traits, on math performance

Combined influences

These multifactorial interactions between environment and achievement goals underscore the complexity of students' motivation and highlight the need for a holistic understanding of the factors shaping their educational experiences. Perceived classroom and parental mastery goals have a positive association to self-efficacy and students' involvement in the classroom (Murayama & Elliot, 2009). In general, students' mastery goals seem to be positively correlated to classroom mastery goals and negatively correlated to classroom performance goals, whereas the opposite is true for students' performance goals (Wolters, 2004). Perceived classroom achievement goals (mastery and performance) are also positively correlated to one another. This might explain why sometimes we can predict classroom mastery goals based on classroom performance goals, and vice versa. Similarly, perceived parental mastery goals are associated with individual mastery goals and perceived performance goals are associated with individual performance goals (Bong, 2008; Friedel et al., 2007; Gonida et al., 2009; Sideridis, 2007).

The present study

In this study, we scrutinize key factors influencing elementary school children's mathematics performance. Employing a multiple mediator model (Fig. 1), we examine the interactions among our variables of interest. Our study particularly addresses the following important issues:

Variable mediation

Personal achievement goals are treated as mediators on the effects of intrinsic and environmental factors on academic performance (Jiang et al., 2014; Pantziara & Philippou, 2015). Such an analysis was also done by Gonida and her colleagues (2009), who reported that perceived classroom mastery goals, but not performance goals, significantly mediated the association between individual mastery goals and student participation in the classroom.

Classroom dynamics

Individual mastery goals significantly mediate the link between perceived classroom mastery goals and student participation; classroom performance goals negatively affect interest and self-efficacy (Anderman & Patrick, 2012; Gonida et al., 2009; Murayama & Elliot, 2009).

Hierarchical models

Different hierarchical models explore the role of environmental mediators (Gonida et al., 2009; Jiang et al., 2014) and personal traits like interest and self-efficacy (Elliot & Murayama, 2008; Friedel et al., 2007; Pantziara & Philippou, 2015; Zusho et al., 2005) on performance. Such studies though usually study a limited number of variables each time.

Elementary school focus

Our study emphasizes elementary school students, with a specific focus on mathematics (Athanasiou, 2010; Gonida et al., 2014; Middleton et al., 2004; Pantziara & Philippou, 2015).

Model structure

The main objective of this research study was to build a full model including various interacting sources of influence, and investigate motivational and personal trait effects on mathematics performance in elementary school students. Our multiple mediator model encompasses 1. extrinsic motivators (perceived parental and classroom goals), 2. intrinsic motivators (mastery / achievement goals), and 3. personal trait mediators (self-efficacy and interest). 4. mathematics performance as the dependent variable of interest (Fig. 1). With such a model, we can concurrently examine both direct and indirect effects among the variables of interest, as well as mediation effects. Specifically, within this model we study the following associations:

Environmental Influence: how environmental factors shape students' achievement goals.
Goal Impact: Studying the influence of students' achievement goals and perceived parental/classroom goals on self-efficacy and interest in mathematics.
Performance Dynamics: Analyzing the interconnected effects of parental/classroom goals, students' goals, self-efficacy, and interest on mathematics performance.
Dual Mediation: Exploring dual mediation, where students' goals mediate first, followed by self-efficacy or interest, between perceived parental/classroom goals and student performance.

Overall, we hypothesize: a) a stronger influence of intrinsic and environmental mastery (compared to performance) achievement goals on personality traits (namely self-efficacy and interest), as well as on mathematics performance (Friedel et al., 2007; Gonida et al., 2009; Jiang et al., 2014; Mouratidis et al., 2018; Murayama & Elliot, 2009; Zusho et al., 2005), b) self-efficacy being a more important mediator than interest (Kitsantas et al., 2010; Lee & Chen, 2019; Michaelides et al., 2019; Tosto et al., 2016), c) interrelatedness of the mastery and performance achievement goals (Bong, 2008; Friedel et al., 2007; Gonida et al., 2009; Sideridis, 2007), influencing self-efficacy and mathematics performance in numerous ways (Gonida & Cortina, 2014; Jiang et al., 2014; Pantziara & Philippou, 2015).

Methodology

Participants

To recruit participants, we used a cluster sampling method. Out of roughly 40 elementary schools in the greater Pafos province in Cyprus, we excluded the smallest schools and created a pool of the remaining 25 schools. A letter was sent to the principals of these schools, summarizing the purpose and methodology of the research, and requesting their consent for the school's involvement in the study. 22 out of the 25 school principals granted consent. All 5th and 6th grade students within these schools (along with their teachers) were invited to participate, contingent upon parental consent. Roughly 50.5% of parents and all teachers provided affirmative responses. Verbal consent was also obtained from the children before the examination. Through this sampling procedure, we secured a representative sample of 762 students with a balanced distribution of age (49.1% 5th graders, approximately 10–11 years old, and 50.9% 6th graders, approximately 11–12 years old) and gender (48% boys, 51.2% girls, 0.8% missing). 50.8% of the participants attended schools located in the city of Paphos, 34.1% in Pafos' suburbs and 15.1% in the rural areas of greater Pafos.

Materials

Demographics

Basic demographic information (age, gender, academic grade) was collected for each participant. Additionally, we collected information about student's and parents' country of birth, duration of residence in Cyprus (pertinent to immigrants), languages spoken within their household, as well as the occupational status and educational level of parents.

Student questionnaire

The student questionnaire consisted of a mix of 46 statements originating from various normed scales. Namely, statements from the Achievement Goal Questionnaire (AGQ-R, Elliot & Murayama, 2008) (9), statements for perceived classroom goals (14), perceived parental goals (11), and self-efficacy (5) from the Patterns of Adaptive Learning Scales (PALS, Midgley et al., 2000), as well as statements on students' interest in mathematics (7) (Elliot & Church, 1997).

The statements, initially translated to Greek by the authors, were back translated to English by two independent and proficient Greek-English speakers. After comparing the two translations, slight adjustments were applied where discrepancies emerged. Moreover, the final statements were adjusted to match the comprehension ability and vocabulary of elementary school students. Any potential comprehension challenges were identified and rectified through a pilot study involving a subset of 22 children (15 fifth graders and 7 sixth graders).

The questionnaires were grouped into three sections, presented in the same order for all participants: a) students' achievement goals, self-efficacy, and interest in mathematics, b) perceived classroom goals, and c) perceived parental goals. Statements in each section were also arranged in random order. Participants rated their agreement or disagreement on a five-point Likert scale (from 1 = "Strongly Disagree" to 5 = "Strongly Agree"). A factor analysis verified the validity of the scale, and these factors were used in our analyses. After averaging all relevant statement scores, each factor ranged from 1 to 5.

Individual achievement goals of students

The Achievement Goal Questionnaire (AGQ-R), an up-to-date scale measuring achievement goals (Elliot & Murayama, 2008), encompasses four distinct goal types: mastery-approach goals, mastery-avoidance goals, performance-approach goals, and performance-avoidance goals. For the purposes of this study, statements related to mastery-avoidance goals were not used, as they are less common at this age (Anderman & Patrick, 2012; Lee & Bong, 2016). The questionnaire consisted of nine statements, with three statements assigned to each goal type. For mastery goals, statements such as "My goal is to learn everything I am taught in mathematics" were used. For performance-approach goals, statements such as "My goal is to do well in mathematics compared to other students" were used, and for performance-avoidance goals, statements such as "I try not to perform worse than others in mathematics" were used. In the relevant Elliot and Murayama (2008) study on university students, reliability was assessed at $\alpha = 0.84$, $\alpha = 0.92$, and $\alpha = 0.94$ for mastery-approach goals, performance-approach goals, and performance-avoidance goals, respectively. In this study, each type of goal is operationally defined as the average of participant's scores in the relevant statements for each category.

Perceived classroom achievement goals

We measured students' perceptions of the achievement goals prioritized at the classroom level (mastery goals, performance-approach goals, and performance-avoidance goals) using the relevant section of the PALS questionnaire (Midgley et al., 2000), a scale originally developed and validated on elementary school students which includes six statements for the first two types of goals, and five for the last. Statements such as "In our class, it is important to try hard in mathematics" measured mastery goals ($\alpha = 0.76$), statements such as "In our class, the main goal is to get good grades in mathematics" measured performance-approach goals ($\alpha = 0.70$) and statements such as "In our class, it is very important to show others that you are not doing poorly in math assignments" measured performance-avoidance goals ($\alpha = 0.83$) (Midgley et al., 2000). In the present study, we calculated the mean scores for each type of classroom goals, so final scores ranged between 1 and 5.

Perceived parents' achievement goals

To measure perceived parental goals, the corresponding section of the PALS questionnaire (Midgley et al., 2000) was used, which included six statements for each of two types of parental goals: mastery and performance. Statements such as "My parents want me to spend time thinking about the math I am learning" measured mastery goals ($\alpha = 0.71$) and statements such as "My parents want me to show others that I am good at math assignments" measured performance goals ($\alpha = 0.71$) (Midgley et al., 2000). In the present study, we calculated mean participant scores in the statements for each category, so final scores ranged between 1 and 5.

Self-efficacy

Five statements from the corresponding section of PALS (Midgley et al., 2000), such as "I am confident that I can find a way to solve even the most difficult math problems", were used to measure self-efficacy ($\alpha = 0.78$). In the present study, the mean of participants' responses in these five statements created a score ranging from 1 to 5.

Interest

To measure interest in mathematics, we used seven statements ($\alpha = 0.92$) developed by Elliot and Church (1997), such as "I think mathematics class is interesting". The score is obtained by calculating the mean of responses to all statements and ranges from 1 to 5.

Mathematics test

In Cyprus elementary schools, there is no systematic numerical grading of students in any subject. Students only receive quantitative or qualitative feedback on diagnostic essays. At their own discretion, teachers who teach in the final grades of elementary school may grade numerically. Therefore, it was deemed necessary to create a valid assessment tool to quantify performance in this study. A mathematics skills test for each grade (5th / 6th) was created by the first author, a teacher with many years' experience in teaching mathematics in elementary school. Each test included 14 math problems that covered all five areas[1] of the centrally defined curriculum of each grade by the ministry of Education, and required only knowledge and skills of the topics covered until December, since data collection was scheduled for the months of January-March. These math problems were similar in format to the examples included in the mathematics Curriculum and the students' textbooks (Appendix).

Before data collection, a pilot study was conducted. Three teachers independently assessed the tests and 15 fifth graders and 7 sixth graders completed the tests while providing qualitative comments during administration to the researcher, e.g. point out problems that seemed too difficult or too easy. After minor modifications on the content and the wording of the math problems, the tests were finalized. All tests were graded by the researcher who created and normed them on a scale from 0 to 100. In addition to these tests, teachers were asked to grade each student in mathematics using a scale from 0–100. Based on this supplementary evaluation of performance, the face validity of the assessment tool created by the researcher was later examined.

[1] 1) Numbers and Operations, 2) Measurement, 3) Geometry, 4) Algebra, and 5) Statistics and Probability.

Experimental design

Within this research study, we collected a series of self-report data from students, including:

Perceived classroom and parental (mastery and performance) achievement goals, collectively described as environmental motivators. For ease of reference, we omit the word "perceived" when talking about classroom and parental goals in our text below, but it is implied.

Individual (mastery and performance) achievement goals, described as intrinsic motivators.

Self-efficacy and interest in mathematics, collectively described as personal traits.

Math performance scores, described as performance.

The data analysis plan included initial descriptive analyses of all data, including student demographics. Factor analysis was then performed on the participants' responses on the statements from each normed questionnaire to verify the validity of the data collected, with the extracted factors corresponding to the expected structure for each source questionnaire. Next, *t*-test comparisons and correlation analyses were conducted between the students' test scores and the grades given by the teachers, to examine the internal validity of the math test created for this study. Finally, the proposed path model (Fig. 1) was applied and improved, to identify the factors predicting achievement goals, interest, self-efficacy, and performance of the students and the associations among all factors.

Procedure

The study adhered to stringent ethical and methodological standards. Initial approval was obtained from the Center for Educational Research and Evaluation (C.E.R.E.). Subsequently, the Directorate of Primary Education, endorsed by the Ministry of Education and Culture, granted permission for school access. Ethical standards were affirmed by the National Bioethics Committee of Cyprus. Letters detailing the research's purpose and methodology were sent to school principals, requesting their consent. Upon principal agreement, teachers received the study details. Consent letters were distributed to students, explaining the study's purpose. Parents were informed through accompanying letters and were asked to provide their signed consent.

Data collection occurred in the second trimester (January-March) of the 2017–18 academic year. The researcher and 18 trained associate research coordinators (mainly teachers in the participating schools), overviewed the consent form collection process, allowing a period of five working days for the return of the signed consent forms, and conducted data collection. Training involved information about the data collection process and written instructions on the steps involved. Before in-classroom questionnaire completion, students were assured of anonymity. They had 40 min for the questionnaire and 60 min for a follow-up math test conducted within a two-week window. To correlate questionnaire responses with test results, class registration numbers were recorded on both by the researcher. Finally, teachers were asked to evaluate the overall performance of each student in mathematics on a scale from 0 to 100, and fill in the teachers' questionnaire. All data, including

Table 1 Means (M), Standard Deviations (SD) and reliability indicators (Cronbach's alpha) for the study's variables

Variable	M	SD	Cronbach's alpha
Mastery Goals	4.61	0.53	0.63
Performance Goals	4.02	0.80	0.79
Interest	4.37	0.70	0.86
Self-efficacy	4.24	0.69	0.74
Classroom Mastery Goals	4.51	0.50	0.60
Classroom Performance Goals	3.10	0.88	0.72
Parental Mastery Goals	4.14	0.62	0.69
Parental Performance Goals	3.50	0.92	0.67

Table 2 Correlation matrix of all variables of interest

	1	2	3	4	5	6	7	8	9
1.Mastery Goals	-								
2. Performance Goals	0.30**	-							
3. Interest	0.53**	0.20**	-						
4. Self-efficacy	0.46**	0.27**	0.53**	-					
5. Classroom Mastery Goals	0.45**	0.29**	0.37**	0.39**	-				
6. Classroom Performance Goals	0.02	0.39**	-0.02	0.01	0.14**	-			
7. Parental Mastery Goals	0.39**	0.31**	0.31**	0.37**	0.51**	0.15**	-		
8. Parental Performance Goals	0.07*	0.47**	0.01	0.01	0.16**	0.60**	0.30**	-	
9. Math Test Score	0.17**	0.03	0.23**	0.30**	0.11**	-0.16**	0.13**	-0.19**	-

** $p<0.001$ * $p<0.05$

student and teacher responses, math test scores, and teacher ratings, were meticulously recorded and entered into separate SPSS datafiles.

Results

Questionnaire reliability

After filtering out statements with low correlations in their group ($r<0.02$), we calculated a value that corresponded to the mean of the grouped statements for each factor (Field, 2013; Neill, 2008), and assessed the reliability of the scores of all our variables of interest (see Table 1 for a summary of mean scores and reliability indicators for all factors). Some of these subscales (such as individual and classroom performance goals) had slightly lower reliability than the one reported in the original scales and dropped slightly below the widely used criterion of $\alpha>0.70$, but they were still adequate (>0.60). It is worth noting that other studies have reported similar Cronbach alphas for the same mastery approach subscales of the original AGQ-R (Muis & Winne, 2012) and its adaptation to other languages (Ratsameemonthon, 2015). This might be due to the adaptation of the original scale in another language or due to cultural differences from Anglosaxonic countries where a vast majority of such studies has been conducted. This argument was interestingly also proposed by Ratsameemonthon (2015), with regards to the relevance of mastery goals to the Thai/Asian context.

Correlations

The correlations among all variables of interest for this study are presented in Table 2. Most measures show small to medium, statistically significant correlations.

Math test validity

We also assessed the validity of student math test performance measurements using *t*-tests and Pearson correlations. When comparing the grades themselves, the mean grade given by teachers ($M_1 = 78.55$, $SD_1 = 16.72$) was significantly higher than the mean grade of the test ($M_2 = 62.39$, $SD_2 = 19.82$) (t (684) = -32.30, $p < 0.001$). Nevertheless, the scores from the math tests were significantly and strongly correlated to the teacher's subjective grades (r = 0.78). The same pattern applies to the similar comparison within each academic grade, with a statistically significant difference between the test grade and the mean teacher grade for both 5th ($M_1 = 77.45$, $SD_1 = 17.64$, $M_2 = 65.16$, $SD_2 = 20.68$; t (342) = -18.06, $p < 0.001$) and 6th graders ($M_1 = 79.60$, $SD_1 = 15.76$, $M_2 = 59.62$, $SD_2 = 18.53$; t (341) = -29.8, $p < 0.001$), but also strong positive correlations between the two types of grade, for both the 5th (r = 0.81) and the 6th graders (r = 0.76).

For the goal of this study, it doesn't really matter which grade is the more accurate representation of the student's competence in mathematics. Their high correlation demonstrates that both measures give comparable results, therefore supporting convergent validity. For the mediation model, we used the math test scores as a more objective measure of students' performance.

Mediation model

We used path analysis to explore the complex network of direct and indirect effects of all variables of interest on performance, as well as among themselves. Before conducting path analyses, we estimated the missing values using regression-based imputation. At the first step, we attempted to fit a basic full mediation model, following the initially hypothesized mediation structure presented in Fig. 1. This model (Fig. 2) demonstrated poor fit to our data: χ^2 (24, 762) = 908.53, $p < 0.001$, CFI = 0.53, RFI = 0.11, NFI = 0.53, PCLOSE < 0.001, RMSEA = 0.22, and CMIN/DF = 37.86.

Then, we attempted to fit our data to a model including all possible direct and indirect effects between the variables in the model. We also correlated the residual errors of individual mastery goals and performance goals, as well as the residual errors of variables at the same level of analysis, i.e. self-efficacy and interest, based on the recommended modification indices to improve the model. Additionally, before running the model, we performed bootstrapping with 2000 samples to bias-correct it (MacKinnon et al., 2004; Preacher & Hayes, 2004). This model did not fit the data very well, so we proceeded with a progressive simplification by removing paths between variables that did not appear to be related to each other. The resulting model, presented in Fig. 3, demonstrated excellent fit indices: χ^2 (8, 762) = 30.77, $p < 0.001$, CFI = 0.99, RFI = 0.93, NFI = 0.99, PCLOSE = 0.19, RMSEA = 0.06, and CMIN/DF = 3.85.

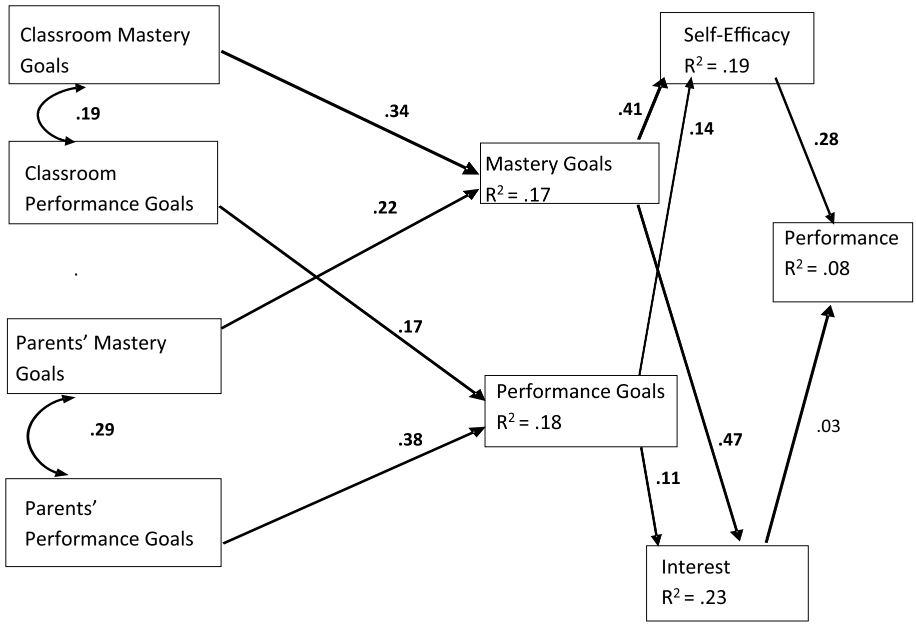

Fig. 2 Initial full mediation model of multifactorial influences on students' mathematical performance. In this diagram, standardized b values (β) are presented. Coefficients for statistically significant effects ($p<0.05$) are displayed in bold

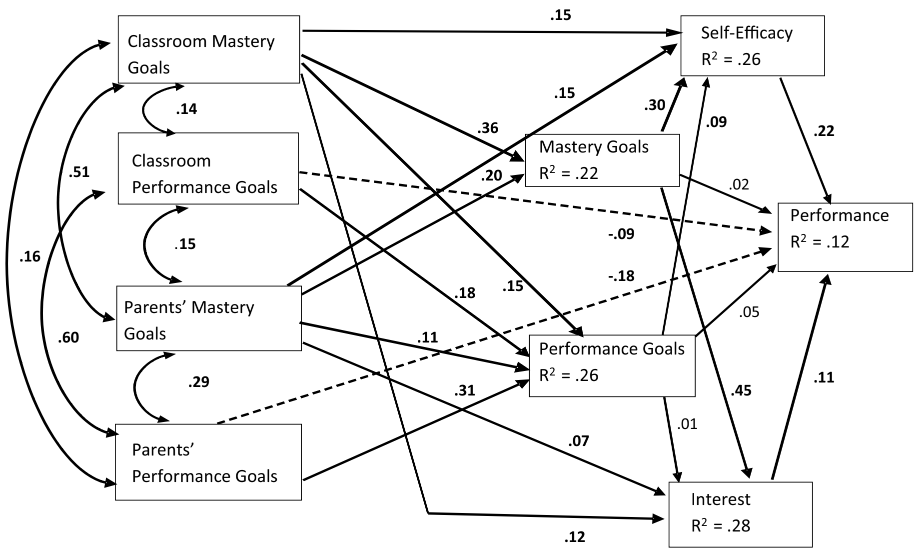

Fig. 3 Final model of direct and indirect multifactorial influences on students' mathematical performance. In this diagram, standardized b values (β) are presented. Coefficients for statistically significant effects ($p<0.05$) are displayed in bold. Continuous arrows represent positive influences; dashed arrows represent negative influences. To avoid an overly complicated graphical representation, additional indirect effects are mentioned in the main text

Among the extrinsic motivators in the first row, we found significant moderate to strong positive correlations between parental performance goals and classroom performance goals ($r = 0.60$, $p < 0.001$), as well as between parental and classroom mastery goals ($r = 0.51$, $p < 0.001$). There was also a moderate positive correlation between the mastery and performance goals of parents ($r = 0.29$, $p < 0.001$), as well as a weak positive correlation between the mastery and performance goals of the classroom ($r = 0.14$, $p < 0.001$). We also found weak but significant correlations between parental mastery goals and classroom performance goals ($r = 0.15$, $p < 0.001$), as well as between parental performance goals and classroom mastery goals ($r = 0.16$, $p < 0.001$).

Regarding extrinsic motivator effects (row 1) on intrinsic motivators (row 2), we see direct effects on individual mastery goals by classroom mastery goals ($\beta = 0.36$, $p < 0.001$) and parental mastery goals ($\beta = 0.20$, $p < 0.001$). Similarly, individual performance goals are directly affected by parental performance goals ($\beta = 0.31$, $p < 0.001$), classroom performance goals ($\beta = 0.18$, $p < 0.001$), and to a lesser extent, parental mastery goals ($\beta = 0.11$, $p = 0.003$) and classroom mastery goals ($\beta = 0.15$, $p < 0.001$).

Regarding personal traits (row 3), we discovered numerous direct effects on self-efficacy. Specifically, those involved, in descending order of magnitude, direct effects of mastery goals ($\beta = 0.30$, $p < 0.001$), parental ($\beta = 0.15$, $p < 0.001$) and classroom ($\beta = 0.15$, $p < 0.001$) mastery goals. To a lesser extent, there was also a direct effect of student performance goals ($\beta = 0.09$, $p = 0.01$). In addition to the direct effects on self-efficacy, there were also indirect effects of classroom ($\beta = 0.11$, $p = 0.001$) and parental ($\beta = 0.06$, $p = 0.001$) mastery goals that affected self-efficacy through the mediation of student mastery goals. Furthermore, there were indirect effects on self-efficacy by classroom ($\beta = 0.01$, $p = 0.004$) and parental ($\beta = 0.001$, $p = 0.01$) mastery goals, as well as by classroom ($\beta = 0.02$, $p = 0.005$) and parental ($\beta = 0.03$, $p = 0.006$) performance goals, through the mediation of individual performance goals. Overall, it appears that more than performance goals, mastery goals (of students, classroom, and parents) have both direct and indirect positive effects on students' self-efficacy.

Similarly, there were direct and indirect effects on interest. Specifically, direct effects were found, primarily by mastery goals ($\beta = 0.45$, $p < 001$), and at a lesser degree perceived classroom mastery goals ($\beta = 0.12$, $p = 0.001$) and perceived parental mastery goals ($\beta = 0.07$, $p = 0.041$). Additionally, there were indirect effects, through the mediation of individual mastery goals, of perceived classroom mastery goals ($\beta = 0.16$, $p = 0.001$) and parental mastery goals ($\beta = 0.09$, $p = 0.001$). Individual performance goals on the other hand did mediate the association of any of the above-named factors with students' interest. Overall, mastery goals (of students, classroom, and parents) appear to have a positive impact on students' interest, whereas a similar effect is not observed for the respective performance goals. When teachers and parents guide students towards mastery goals, they positively influence both the likelihood of high mastery goal orientation for the students, as well as cultivation of their interest in learning.

Regarding students' performance in mathematics (row 4), we also found numerous direct and indirect effects. Direct effects, in order of magnitude, were found from self-efficacy ($\beta = 0.22$, $p < 0.001$) and interest ($\beta = 0.11$, $p = 0.01$) which had a positive relation with performance, and perceived parental performance goals ($\beta = -0.18$, $p < 0.001$) and perceived classroom performance goals ($\beta = -0.09$, $p = 0.038$), which had a negative association with performance. Indirect effects included the relation between mastery goals and performance, that was mediated by self-efficacy ($\beta = 0.07$, $p = 0.001$), as well as interest ($\beta = 0.05$, $p = 0.003$). The relation between perceived classroom mastery goals ($\beta = 0.03$, $p = 0.001$) and perceived parental mastery goals ($\beta = 0.03$, $p = 0.001$) and performance was also mediated by self-efficacy. Similarly, interest mediated the effects of students' perceived classroom mastery goals ($\beta=0.01$, $p=0.004$) and perceived parental mastery goals ($\beta=.\ 001$, $p=0.05$) on performance. On the other hand, it is noteworthy to mention that our analysis did not reveal any significant direct effects on performance from individual (mastery or performance) achievement goals.

Summarizing, it seems that self-efficacy significantly mediates the relation between student mastery and performance goals, as well as classroom and parental mastery goals, with performance. Interest also significantly mediates the effects of student mastery goals, classroom and parental mastery goals on performance. Our model also shows a few significant indirect effects, with the combined double mediation of students' goals as the first mediator and self-efficacy or interest as the second mediator. Mastery goals and self-efficacy mediated the effects of classroom ($\beta=0.02$, $p=0.001$) and parental ($\beta=0.01$, $p=0.001$) mastery goals on performance. Mastery goals and interest similarly mediated the effects of classroom ($\beta=0.02$, $p=0.003$) and parental ($\beta=0.01$, $p=0.05$) mastery goals on performance. Additionally, at a lesser extent, performance goals and self-efficacy mediated the effects of classroom ($\beta=0.003$, $p=0.001$) and parental ($\beta=0.002$, $p=0.009$) mastery goals, as well as classroom ($\beta=0.003$, $p=0.003$) and parental ($\beta=0.01$, $p=0.004$) performance goals on performance. The dual mediation of performance goals and interest did not lead to significant indirect effects. Overall, compared to interest, self-efficacy seems to play a stronger mediating role towards performance in mathematics.

Discussion

In the present study, we systematically examined the network of associations among different variables relevant to performance in mathematics (Gonida & Cortina, 2014; Jiang et al., 2014; Pantziara & Philippou, 2015) in elementary school students in Cyprus. Our study utilized a representative sample and built a complex model which combines different aspects of the relevant literature.

Our investigation began with the validation of the Greek translation of the scales employed in our study, ensuring their reliability and validity through confirmatory factor analysis (Pantziara, 2008; Sideridis & Mouratidis, 2008). Notably, similarly to previous studies, our elementary school participants faced challenges in discriminating performance goals based on approach-avoidance orientation, leading to the consolidation of these goals into a single performance goals factor (Anderman & Patrick, 2012; Chazan et al., 2022; Hulleman et al., 2010) in our study.

Our findings of high levels of mastery goals and self-efficacy agree with previous studies in Cypriot elementary school students. On the contrary, high performance achievement goal scores (student and parental) have not been reported in those studies (Athanasiou, 2010; Pantziara, 2008; Pantziara & Philippou, 2015). These high performance goals might be a result of our sampling method, the substantial percentage of students with immigration background in our sample and/or self-selection, where only students whose parents provided written consent were included in the study.

Environmental motivator influences on intrinsic motivators

Our results, in agreement with existing literature, confirm the predictive power of parental and classroom performance goals on the equivalent individual mastery goals (Bong, 2008; Gonida & Cortina, 2014; Jiang et al., 2014; Kim, 2015). Compared to parental goals, classroom goals exhibited a stronger impact on individual mastery goals, underscoring the significant role of classroom dynamics in shaping students' academic ambitions (Friedel et al., 2007). Conversely, parental influence took precedence when predicting individual performance goals (Gonida et al., 2009). Parental and classroom mastery goals also contribute to the prediction of individual performance goals, though at a lesser degree (Jiang et al., 2014; Kim, 2015). This might be partially explained by the positive correlation of perceived classroom learning and performance goals reported in other studies (Bong, 2008; Kim, 2015; Sideridis, 2007).

Factors influencing self-efficacy and interest

Both self-efficacy and interest were directly influenced by all types of mastery goals—individual, parental and classroom (Jiang et al., 2014; Martin & Elliot, 2016; Yu & Martin, 2014). Even without relevant data or mediation analyses, researchers often interpret the positive effect of mastery goals on performance with reference to their mediating effects on students' motivational and affective traits (Chazan et al., 2022; Mouratidis et al., 2018). In our study, we verify that student mastery goals were the primary mediators in the association of parental and classroom mastery goals with both self-efficacy and interest (Lee et al., 2014; Michaelides et al., 2019; Pantziara & Philippou, 2015; Tosto et al., 2016). Individual performance goals also had a weaker mediating effect in the association of both types of classroom and parental achievement goals (mastery and performance) with self-efficacy. On the contrary, our results indicate no direct or indirect influence on interest from individual or classroom performance goals, even though some studies report their negative correlation to interest (Anderman & Patrick, 2012; Murayama & Elliot, 2009).

Overall, our results corroborate the hypothesis that self-efficacy is more strongly associated with mastery goals than performance goals, but also highlight the degree of interrelatedness of the two types of achievement goals and their indirect effects on self-efficacy. At the same time, interest seems to be a positive "side-effect" of either intrinsic or environmental mastery goal influences.

Factors influencing mathematics performance

Self-efficacy and interest emerged as pivotal predictors of mathematics performance (Lee & Chen, 2019; Lee et al., 2014; Tosto et al., 2016). A positive attitude toward mathematics, coupled with the belief in one's abilities, significantly influenced students' academic outcomes (Michaelidis et al., 2019). At the same time, these factors significantly mediate the association between individual, classroom, and parental mastery goals with performance.

Interestingly, our model revealed no direct influence of individual mastery / performance goals on mathematics performance. In some studies, such influences have been reported, but only when performance goals are divided along the approach-avoidance dimension (Diseth & Kobbeltvedt, 2010; Jiang et al., 2014; Mouratidis et al., 2018; Pekrun et al., 2009; York et al., 2015). Instead, we found numerous indirect influences, with the effect of achievement goals on mathematics performance mediated by self-efficacy and interest for mastery goals, or only self-efficacy for performance goals (Jiang et al., 2014; Pantziara & Philippou, 2015). Positive correlations between performance goals and self-efficacy/interest reported in the literature (Gonida & Cortina, 2014; Murayama & Elliot, 2009; Pantziara & Philippou, 2006), might also indirectly affect mathematics performance. This mediation, along with the absence of a direct/unmediated impact of student achievement goals in our model, offers a crucial insight. It sheds light on the conflicting evidence in the literature, where mastery goals have been reported to influence academic performance both positively (Darnon et al., 2007; Linnenbrink-Garcia et al., 2008; Pekrun et al., 2009) and negatively (Baranik et al., 2010). Similarly, despite existing literature reporting a significant correlation of parental and classroom achievement goals with performance (positive for mastery goals, negative for performance: Gutman, 2006; Jiang et al., 2014), few such direct influences exist in our model. It is mostly the mediation of personality traits that determines their influence on performance (see also Pantziara & Philippou, 2015). Finally, our model reveals the double mediation of student mastery goals and self-efficacy, as well as student mastery goals and interest, on the association of classroom and parental goals with performance. A similar but less pronounced effect is also found through the double mediation of student performance goals and self-efficacy on the association between both types (learning and performance) of classroom and parental goals with performance.

Such mediation effects could lead to the likely conclusion that intrinsic and environmental influences on mastery and performance goals interact with students' traits, and may have different influences on performance for different students. It is also possible that such traits might influence the dominance of student's mastery goals, lead to the positive effect of environmental pressure towards mastery goals, or the negative effect of a real or perceived environmental pressure towards high performance (Metallidou & Vlachou, 2007), especially in the age range of our population of interest.

Limitations and future studies

The limitations of the present study include generic limitations of the methodology used and minor sampling issues. Given the possibility of bi-directionality in the associations of different types of achievement goals with one another, as well as with traits such as self-efficacy and interest (Pintrich, 2003), the variables in our model might influence each other in more complicated ways than a path analysis model implies. Hidden assumptions of causality are an integral part of a path analysis model, based on the researchers' decisions of where in the model each variable should be placed. Therefore, alternative models could also explain our dataset at a sufficient level. It is worth noting though that we also tested alternative models with different arrangements of the variables, resulting in inferior explanatory power from our proposed model, which appears to be a more valid implementation with optimal data fit. Regarding our sampling, we recruited students from one of the five major districts of Cyprus. Even though the sampling seems to be quite representative of the population of interest, it would be useful if future studies include samples from all districts. Furthermore, replication of our study in other countries would provide strong evidence for the validity of the proposed model, as long as the model is unaffected by cultural differences.

Future studies should also attempt to extend this model to other topics apart from mathematics, to explore its external validity. Also, using older students (e.g. junior high-school) would allow exploring potential similarities and differences among different ages. The meta-analysis of Linnenbrink-Garcia and her colleagues (2008) reveals higher numbers of studies reporting a significant correlation between performance goals and actual academic performance where pressures for performance are more intense (e.g. high school and university) compared to lower grades (junior high school and elementary school). Therefore, we might expect the influence of performance goals to be more pronounced in older ages.

Finally, given the plans of the Ministry of Education of Cyprus to incorporate grading of elementary school students from as early as the 1st grade in the near future, it would be interesting to replicate our study after the change, and explore the effects of such a change on the predictive value of our model.

Summary of main findings & educational implications

In summary, our study provided a deep insight into the multifaceted factors influencing mathematics performance in elementary school students, namely classroom, parental and individual achievement goals, as well as self-efficacy and interest. Unlike previous studies focusing on subsets of these variables, our study is the first, to our knowledge, to build a comprehensive model with all these variables of interest. Its novelty therefore lies in the capacity to study the combined influence of all these factors, reveal their complex interplay and successfully predict mathematical performance in elementary school students. This unique web of associations we uncovered emphasizes the need for a holistic approach in understanding student performance.

Our results reveal that both self-efficacy and interest seem to have particularly significant direct and indirect influences on performance. It is worth noting that self-efficacy and interest are correlated with one another (Lee et al., 2014; Pantziara & Philippou, 2015), so it might sometimes be difficult to study their effects on performance independently. Nevertheless, our model reveals that self-efficacy has a stronger influence on performance, compared to interest. Along with previous research findings on the positive influence of mastery goals on self-efficacy and interest (Anderman & Patrick, 2012; Murayama & Elliot, 2009), such results imply that promoting mastery, rather than achievement goals, can have a more pronounced positive influence on students' performance. Considering broader influences, our research underscores the importance of adopting a holistic perspective, acknowledging the interplay of classroom and parental factors (Gonida et al., 2009; Jiang et al., 2014). The study emphasizes the primacy of mastery goals, suggesting their promotion for enhanced student performance. These findings offer practical insights for educators, policymakers, and parents, informing interventions and strategies in real-world educational settings. Our findings can be applied in real-world settings and guide decisions on the most effective interventions to promote learning, motivation and academic achievement.

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Data Availability The data that support the findings of this study are available from the corresponding author, Dr. Konstantinos Tsagkaridis, upon reasonable request.

Declarations

Ethical standards This study was approved by the Centre of Educational Research and Evaluation (C.E.R.E.), the National Bio-Ethics Committee, and the Ministry of Education, Sport and Youth of Cyprus.

Conflict of interest Authors declare no financial or non-financial interests that were directly or indirectly related to the work submitted for publication.

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Dr. Malegiannaki. Current research interests focus on the assessment of cognitive development in school-aged children, with a particular emphasis on the intricate processes of attention, its mechanisms, and its relationship to meta-cognition and executive functioning.

Dr. Tsagkaridis. Has extensive research experience in the field of Cognitive Neuropsychology – Experimental Psychology. He also specializes in Research Methods and Statistics. His main research area concerns visual perception and action. Specifically, his research relates to semantic and action effects on object perception in healthy controls and patients with brain lesions. Other research interests include contextual effects on object perception, translational research in health and rehabilitation and developmental aspects of cognition. As an experienced statistician he has worked in various additional research areas with projects aimed at developing complex multivariate models of behaviors such as school performance, bullying, and addiction. Relevant Publications with such modeling include:.

Dr. Christodoulou. Is a recent Ph.D. graduate with no publications record. He is an experienced teacher working in primary school education. He now serves the Cyprus Ministry of Education, Sport and Youth as a primary school principal.

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Malegiannaki, A. C., Metallidou, P., & Kioseoglou, G. (2014). Psychometric properties of the Test of Everyday Attention for Children (TEA-Ch) in Greek-speaking school children. *European Journal of Developmental Psychology: Developmetrics*, *12*(2), 234-242. http://dx.doi.org/10.1080/17405629. 2014. 973842.

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