Universidad de Oviedo

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The role of psychoemotional and educational variables in the mathematical performance of children and adolescents

Tesis Doctoral

Programa de Doctorado en Educación y Psicología

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José Carlos Núñez Pérez

Celestino Rodríguez Pérez

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RESUMEN (en español)

El rendimiento matemático es un área de interés clave en la investigación educativa debido a la importancia de las matemáticas en la vida diaria y académica. Su relevancia se relaciona con el bienestar, la satisfacción con la vida, la salud, la empleabilidad y la longevidad (Lipnevich et al., 2016; Jansen et al., 2013; Jain y Dowson, 2009). A pesar de los avances metodológicos en los centros educativos, los informes internacionales como PISA siguen mostrando desafíos en la competencia matemática.

Esta tesis doctoral plantea cuatro objetivos para analizar las variables influyentes en el rendimiento matemático del alumnado, considerando tanto variables internas (emocionales y motivacionales) como externas (implicación familiar durante los deberes). El primer objetivo busca conocer la fuerza predictiva de variables cognitivas, motivacionales y emocionales en el rendimiento matemático. El segundo objetivo analiza diferentes perfiles de creencia matemática y su relación con el rendimiento matemático. El tercer objetivo examina las metas académicas del alumnado para identificar perfiles motivacionales específicos. El cuarto objetivo investiga cómo la implicación familiar durante los deberes influye en el desarrollo y rendimiento de alumnado con necesidades educativas.

La primera fase de investigación abarca los tres primeros objetivos y se centra en las variables emocionales y motivacionales que influyen en el rendimiento matemático. Se utilizó una muestra de 2,365 estudiantes Educación Secundaria pertenecientes a centros educativos del Principado de Asturias.

Para el primer objetivo, se realizó un análisis de regresión jerárquica en tres modelos para predecir el rendimiento matemático. Los resultados indicaron que la capacidad intelectual predice dicho rendimiento, y que las variables motivacionales y emocionales también son relevantes. En concreto, la autoeficacia demostró tener el mayor poder predictivo, mientras que la ansiedad matemática y las atribuciones causales internas no funcionaron como predictores.

Para el segundo objetivo, se llevó a cabo un Análisis de Perfiles Latentes (LPA) para identificar perfiles según el nivel de autoeficacia y ansiedad matemáticas, complementado con un análisis de ecuaciones estructurales para entender su relación con el rendimiento matemático, y ANOVAs para analizar la interacción entre perfiles, género y curso académico. Los resultados indicaron seis perfiles de creencia matemática. Los perfiles de baja autoeficacia tendieron a obtener peores resultados en matemáticas, independientemente de su nivel de ansiedad. Por otro lado, los perfiles con alta autoeficacia se asociaron con mejor rendimiento matemático.

En cuanto al tercer objetivo, se llevó a cabo un Análisis de Perfiles Latentes para determinar perfiles motivacionales basados en tres metas académicas (dominio, aproximación al rendimiento y evitación del rendimiento) y su relación con el rendimiento matemático. Los estudiantes se agruparon en cuatro perfiles motivacionales, con el perfil de bajas metas en

todas las áreas siendo infrecuente y el perfil medio en todas las metas siendo el más común. Las metas de evitación del rendimiento fueron importantes a nivel motivacional y afectaron significativamente al rendimiento matemático según el perfil presentado.

La segunda fase de investigación, resultando en un cuarto estudio, buscó identificar variables individuales (necesidades educativas) y contextuales (implicación familiar durante los deberes) que influyen en el desarrollo y rendimiento del alumnado. Para este objetivo, se realizó una revisión sistemática bajo las directrices PRISMA, enfocándose en la implicación familiar y los trastornos del neurodesarrollo. Los resultados mostraron una investigación limitada, con solo 11 artículos publicados desde 2012 y en los que se observó que la implicación familiar positiva es crucial para estudiantes con trastornos del neurodesarrollo, quienes presentan más estrés relacionado con los deberes, lo que afecta a su vez a sus padres. Se concluyó la necesidad de poner en marcha programas específicos para el desarrollo de los deberes para este alumnado.

En definitiva, se observó una compleja interacción entre variables cognitivas, motivacionales, emocionales y contextuales. Los hallazgos de la presente Tesis Doctoral ofrecen una comprensión profunda de estos factores, desde la autoeficacia y la ansiedad matemática hasta las metas académicas y la implicación familiar, contribuyendo a la creación de estrategias educativas más efectivas centradas en las necesidades individuales de los estudiantes.

RESUMEN (en Inglés)

Mathematical achievement is a key area of interest in educational research due to the importance of mathematics in everyday and academic life. Its relevance is related to well-being, life satisfaction, health, employability and longevity (Lipnevich et al., 2016; Jansen et al., 2013; Jain and Dowson, 2009). Despite methodological advances in schools, international reports such as PISA still show challenges in mathematical competence.

This doctoral thesis has four objectives to analyze the variables that influence students' mathematical performance, considering both internal (emotional and motivational) and external (family involvement in homework) variables. The first objective is to examine the predictive power of cognitive, motivational and emotional variables on mathematical performance. The second objective is to analyze different mathematics self-belief profiles and their relationship with mathematical achievement. The third objective is to examine students' academic goals to identify specific motivational profiles. The fourth objective is to investigate the influence of family involvement during homework on the development and performance of students with educational needs.

The first phase of research encompasses the first three objectives and focuses on the emotional and motivational variables that influence mathematical achievement. A sample of 2,365 secondary education students from schools in the Principality of Asturias was used.

For the first objective, a hierarchical regression analysis was carried out on three models to predict mathematics achievement. The results indicated that intellectual ability predicted mathematical performance, and that motivational and emotional variables were also relevant. In particular, self-efficacy proved to have the highest predictive power, while mathematical anxiety and internal causal attributions did not function as predictors.

For the second objective, Latent Profile Analysis (LPA) was used to identify profiles according to levels of mathematical self-efficacy and anxiety, complemented by structural equation analysis to understand their relationship with mathematical performance, and ANOVAs to analyse the interaction between profiles, gender and academic year. The results revealed six profiles of mathematical beliefs. Low self-efficacy profiles tended to perform worse in mathematics, regardless of their level of anxiety. On the other hand, high self-efficacy profiles were associated with better mathematics performance.

Regarding the third objective, Latent Profile Analysis was conducted to determine motivational profiles based on three academic goals (mastery, performance and performance-avoidance) and their relationship with mathematics performance. Students were grouped into four

Universidad de Oviedo

motivational profiles, with the low goal profile being rare in all areas and the average profile being most common in all goals. Performance avoidance goals were important at the motivational level and significantly affected mathematics performance according to the profile presented.

The second phase of the research, which resulted in a fourth study, aimed to identify individual variables (educational needs) and contextual variables (family involvement in homework) that influence students' development and performance. To this end, a systematic review was conducted according to the PRISMA guidelines, focusing on family involvement and neurodevelopmental disorders. The results showed limited research, with only 11 articles published since 2012, which found that positive family involvement is crucial for students with neurodevelopmental disorders, who have more homework-related stress, which in turn affects their parents. It was concluded that there is a need for specific homework development programs for these students.

In short, a complex interaction between cognitive, motivational, emotional and contextual variables was observed. The findings of this theses provide a deeper understanding of these factors, from self-efficacy and mathematics anxiety to academic goals and family involvement and contribute to the development of more effective educational strategies that focus on the individual needs of students.

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Listado de trabajos

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Abín, A., Núñez, J. C., Rodríguez, C., Cueli, M., García, T., y Rosário, P. (2020). Predicting mathematics achievement in secondary education: the role of cognitive, motivational, and emotional variables. *Frontiers in Psychology, 11*:876. https://doi.org/10.3389/fpsyg.2020.00876

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Trabajos complementarios:

García, T., Núñez, J.C.; Abín, A., Van der Ven, S., Cueli, M., Valle, A., y Rodríguez, C. (under review). Motivational profiles and mathematical performance in students from 7th to 10th grade: a person-centered perspective. *International Journal of Educational Research.*

Índice

Resumen

El rendimiento matemático constituye un área de interés constante en la investigación dentro del contexto educativo, dada la relevancia de las matemáticas para la vida diaria y académica. En este sentido, se ha reconocido su valor y significatividad en relación con diversos aspectos que incluyen el bienestar, la satisfacción con la vida, la salud, la empleabilidad y la longevidad (Lipnevich et al., 2016; Jansen et al., 2013; Jain y Dowson, 2009). A pesar de los recientes avances en la materia que han permitido introducir cambios metodológicos en los centros educativos, los informes internacionales como PISA continúan evidenciando la persistencia en desafíos relacionados con la competencia matemática. Este hecho se ve subrayado por la constatación de que, en términos de rendimiento en esta disciplina, España ha registrado el peor resultado en competencia matemática desde que participan en informes de esta índole.

En la presente tesis doctoral se plantearon 4 objetivos, cuyo propósito final es aportar una aproximación a las diferentes variables influyentes en el rendimiento matemático del alumnado, teniendo en cuenta variables de carácter interno -variables emocionales y motivacionales- y variables de carácter externo -implicación familiar durante los deberes-. El primer objetivo trata de conocer la fuerza predictiva de las variables cognitivas, motivacionales y emocionales en el rendimiento matemático, determinando si esto puede variar en función del género y del curso académico. El segundo objetivo de investigación pretende determinar los diferentes perfiles de creencia matemática para analizar su relación con el rendimiento matemático. El tercer objetivo pretende comprobar las metas académicas que persigue el alumnado para identificar perfiles de motivación específicos. Finalmente, el cuarto objetivo trata de analizar cómo la implicación familiar durante los deberes escolares puede influir en el desarrollo y rendimiento del alumnado con necesidades educativas.

Los tres primeros objetivos, que han dado lugar a tres estudios, se engloban dentro de una **primera fase** investigadora en la que se pretende analizar las variables emocionales y motivacionales que influyen en el rendimiento matemático. Para ello, se utilizó una muestra de 2.365 estudiantes de los cuatro cursos de Educación Secundaria (12-16 años) pertenecientes a centros educativos del Principado de Asturias.

Para la consecución del primer objetivo, se realiza un análisis de regresión jerárquica en tres modelos utilizando el rendimiento matemático como variable dependiente: en el *primer modelo*, se introduce como variable predictora la capacidad cognitiva; en el *segundo modelo*, se añaden el género y el curso académico como variables predictoras; por último, en el *tercer modelo*, se introducen como predictores la competencia percibida o autoeficacia, la motivación intrínseca, la motivación para el éxito, las atribuciones causales y la ansiedad matemática. Los análisis en este estudio muestran los siguientes resultados generales: (1) la capacidad intelectual es una variable predictora del rendimiento matemático; (2) las variables motivacionales y emocionales tienen un peso relevante en la explicación del rendimiento matemático; (3) la autoeficacia es la variable con mayor poder predictivo del rendimiento matemático; (4) la ansiedad matemática o la atribución de éxito o fracaso a causas internas no muestran poder predictivo del rendimiento matemático; (5) el género y el curso también son predictores del rendimiento matemático.

Para lograr el segundo objetivo de investigación, se lleva a cabo un Análisis de Perfiles Latentes (LPA). El Análisis de Perfiles Latentes es una técnica estadística que permite un acercamiento multivariado basado en identificar grupos, perfiles o clases latentes a través de un conjunto de indicadores categóricos observables. Por tanto, el LPA permite agrupar a los participantes en clases en función de sus niveles de autoeficacia y ansiedad matemáticas. Este análisis, además, se complementa con un análisis de ecuaciones estructurales para conocer la relación entre dichos perfiles y el rendimiento matemático. Finalmente, se llevan a cabo dos

análisis de varianza (ANOVAs) para analizar la interacción entre los perfiles y el género, así como entre los perfiles y el curso académico. Los análisis realizados arrojan los siguientes resultados generales: (1) los estudiantes participantes se agrupan en 6 perfiles resultado de la combinación de sus niveles de autoeficacia matemática con los niveles de ansiedad matemática; (2) la autoeficacia matemática baja se combina en diferentes perfiles de estudiantes con ansiedad baja, media o alta; (3) la autoeficacia matemática alta se combina con niveles de ansiedad baja o media-baja; (4) los estudiantes con perfiles con baja autoeficacia matemática son quienes obtienen peores resultados en matemáticas, independientemente de los niveles de ansiedad matemática; (5) los perfiles con alta autoeficacia matemática obtienen un mejor rendimiento matemático; (6) el género y el curso también son variables importantes para determinar los tipos de perfiles de creencias matemáticas.

Para el cumplimiento del tercer objetivo, se lleva a cabo un Análisis de Perfiles Latentes con el fin de determinar los perfiles motivacionales en los participantes, basados en la combinación de tres metas académicas (metas de dominio, metas de aproximación al rendimiento y metas de evitación del rendimiento). A su vez, se pretende analizar la relación entre los perfiles y el rendimiento matemático. Los análisis efectuados revelan los siguientes resultados generales: (1) los estudiantes participantes se agrupan en 4 perfiles motivacionales resultado de la combinación de las metas académicas previamente comentadas; (2) nuestros resultados son similares a los encontrados por Wormington and Linnenbrink-García (2017) en cuanto a la frecuencia de aparición de los perfiles motivacionales; (3) el perfil caracterizado por un bajo nivel en todas las metas académicas (*Low All Goals Profile – LAGP*) es relativamente infrecuente; (4) el perfil motivacional más frecuente es aquel caracterizado por niveles medios en todas las metas académicas (*Average All Goals Profile – AAGP*); (5) las metas de evitación del rendimiento juegan un rol importante a nivel motivacional, dando lugar a diferencias significativas a nivel matemático en función del perfil presentado; (6) el género

y el curso también son variables importantes para determinar los tipos de perfiles de creencias matemáticas.

En una **segunda fase** de la investigación que da como resultado un cuarto estudio, se busca identificar otras variables de carácter individual (necesidades educativas del alumnado) y contextual (implicación familiar durante los deberes) que pudieran estar influyendo en el desarrollo integral y rendimiento del alumnado. En concreto, para la consecución del cuarto objetivo, se desarrolla una revisión sistemática bajo las directrices PRISMA que tiene como meta revisar los estudios publicados sobre los deberes y las necesidades educativas, poniendo el foco en el rol que juega la familia y en los trastornos del neurodesarrollo por su alta prevalencia a nivel educativo. La revisión realizada nos expone los siguientes resultados generales: (1) la investigación referente a la temática estudiada es escasa, encontrándonos solamente 11 artículos publicados desde 2012; (2) la muestra más utilizada comprende grupos de entre 31 y 100 estudiantes, con necesidades educativas relacionadas con problemas atencionales y dificultades de aprendizaje, y en la etapa de educación primaria (6-12 años); (3) la implicación familiar durante los deberes, cuando se caracteriza por un estilo parental positivo, es incluso más importante para los estudiantes con trastornos del neurodesarrollo; (4) el alumnado con trastornos del neurodesarrollo u otras necesidades educativas presenta niveles de estrés más altos en relación con los deberes en comparación con los estudiantes sin necesidades educativas; (5) la puesta en marcha de programas y estrategias específicas para el desarrollo de los deberes es de vital importancia para este alumnado.

En definitiva, se observa una compleja interacción entre variables cognitivas, motivacionales, emocionales y contextuales. Los hallazgos de la presente Tesis Doctoral ofrecen una comprensión más profunda de estos factores, desde la autoeficacia y la ansiedad matemática hasta las metas académicas y la implicación familiar, contribuyendo así a la formulación de estrategias educativas más efectivas y centradas en las necesidades y

características individuales de los estudiantes, especialmente aquellos con necesidades educativas específicas.

Summary

Mathematical achievement is a field of ongoing research interest in the educational context, given the relevance of mathematics to everyday and academic life. In this regard, its value and significance in relation to different aspects, including well-being, life satisfaction, health, employment and longevity, has been recognized (Lipnevich et al., 2016; Jansen et al., 2013; Jain & Dowson, 2009). Despite recent methodological advances in the field of mathematics education, international reports such as PISA continue demonstrating persistent challenges related to mathematical competence. This is evident in the finding that, in terms of performance in this discipline, Spain has recorded the worst result in mathematical competence since it has participated in reports of this nature.

The objective of this doctoral thesis is to provide an approximation to the different variables influencing the mathematical achievement of students. In order to achieve this, the thesis considers both internal variables, such as emotional and motivational factors, and external variables, including family involvement during homework. The first objective is to determine the predictive power of cognitive, motivational, and emotional variables on mathematical achievement, with a view to establishing whether this may vary according to gender and academic year. The second research objective is to identify the different mathematics self-belief profiles and analyze their relationship with mathematical achievement. The third objective is to test the academic goals pursued by students in order to identify specific motivation profiles. Finally, the fourth objective is to identify how family involvement during homework can influence the development and performance of students with educational needs.

The first phase of the research aims to analyze the emotional and motivational variables that influence mathematics achievement. A sample of 2.365 students from the four years of

secondary education (aged 12-16) from schools in the Principality of Asturias are used for this purpose.

In order to achieve the first objective, a hierarchical regression analysis is performed in three models using mathematical performance as the dependent variable. In the first model, cognitive ability is introduced as a predictor variable. In the second model, gender and academic year are added as predictor variables. Finally, in the third model, perceived competence or self-efficacy, intrinsic motivation, motivation for success, causal attributions and mathematical anxiety are introduced as predictors: The following general results emerge from the analyses carried out in this study: (1) intellectual ability is a significant predictor of mathematical performance; (2) motivational and emotional variables play an important role in explaining mathematical performance; (3) self-efficacy is the variable with the greatest predictive power for mathematical performance; (4) mathematical anxiety or the attribution of success or failure to internal causes does not predict mathematical performance; (5) gender and grade are also predictors of mathematical performance.

Latent Profile Analysis (LPA) iss used to address the second research objective. Latent Profile Analysis is a statistical technique that allows a multivariate approach based on the identification of latent groups, profiles, or classes through a set of observable categorical indicators. Thus, LPA allows participants to be grouped into profiles according to their levels of mathematical self-efficacy and mathematical anxiety. This analysis is also complemented by a structural equation analysis, which is used to determine the relationship between the profiles and mathematical achievement. Finally, two analyses of variance (ANOVAs) are conducted to examine the interaction between the profiles and gender, as well as between the profiles and the academic year. The analysis demonstrate the following general results: (1) students are grouped into six profiles, resulting from the combination of their mathematical self-efficacy levels with their mathematical anxiety levels; (2) low mathematical self-efficacy

is combined into different profiles of students with low, medium or high anxiety; (3) high mathematical self-efficacy is combined with low or medium-low anxiety levels; (4) profiles with low mathematics self-efficacy profiles demonstrate poorer performance in mathematics, irrespective of their mathematics anxiety levels; (5) profiles with high mathematics self-efficacy exhibit superior performance in mathematics; (6) gender and grade are also significant variables in determining the types of mathematics self-belief profiles.

In order to achieve the third objective, an LPA is conducted to identify the motivational profiles of the participants, based on the combination of three academic goals (mastery goals, performance-approach goals, performance-avoidance goals). Additionally, the objective is to examine the relationship between the profiles and mathematical performance. The analysis demonstrate the following general results: (1) students are grouped into four motivational profiles resulting from the combination of the previously discussed academic goals; (2) our results are similar to those found by Wormington and Linnenbrink-García (2017) in terms of the frequency of occurrence of the motivational profiles; (3) the profile characterized by a low level in all academic goals (Low All Goals Profile – LAGP) is relatively infrequent; (4) the most frequent motivational profile is characterized by average levels in all academic goals (Average All Goals Profile -AAGP); (5) performance-avoidance goals play an important role at the motivational level, leading to significant differences at the mathematical achievement depending on the profile presented; (6) gender and grade are also important variables in determining the types of motivational profiles.

In a second phase of the research, which leads to a fourth study, the objective is to identify other individual (students' educational needs) and contextual (family involvement during homework) variables that might be influencing students' overall development and performance. To achieve the fourth objective, a systematic review is conducted in accordance with the PRISMA guidelines. The objective is to review the studies published on homework

and educational needs, with a particular focus on the role of the family and neurodevelopmental disorders, given their high prevalence at the educational level. The review yields the following general results: (1) the research on the subject under study is scarce, with only 11 articles published since 2012; (2) the most commonly used sample comprises groups of between 31 and 100 students, with educational needs related to attentional problems and learning difficulties, and in the primary education stage (6-12 years old); (3) family involvement during homework is of particular importance for students with neurodevelopmental disorders when characterized by a positive parenting style; (4) students with neurodevelopmental disorders and other educational needs experience higher levels of stress related to homework compared to students without educational needs; (5) the implementation of specific homework programs and strategies is of vital importance for these students.

In summary, a complex interaction between cognitive, motivational, emotional and contextual variables is observed. The findings of the present doctoral thesis offer a deeper understanding of these factors, from self-efficacy and mathematics anxiety to academic goals and family involvement. This contributes to the formulation of more effective educational strategies that are focused on the individual needs and characteristics of students, especially those with specific educational needs.

Introducción

Las matemáticas se han convertido en objeto de gran interés para el mundo investigador, y ya no solo por su relevancia a nivel académico, sino también porque se consideran una herramienta clave en nuestro día a día. Varios autores ya destacaron la importancia de las matemáticas en nuestra vida diaria, resaltando que la competencia matemática va unida al éxito personal y profesional, relacionándose también con el bienestar, la satisfacción con la vida, la salud, la empleabilidad y la longevidad (Lipnevich et al., 2016; Jansen et al., 2013; Jain y Dowson, 2009). A pesar de la reconocida utilidad y relevancia de la competencia matemática, es común encontrar alumnado al que no le resulta especialmente fácil aprender esta disciplina. Estos estudiantes pueden presentar dificultades en las habilidades matemáticas lógicas, en la resolución de problemas matemáticos, o incluso en relación con otras variables influyentes en el proceso de aprendizaje durante el período académico (Cipkova et al., 2019; García et al., 2016).

Informes internacionales como *the Program for International Student Assessments* (en adelante, PISA), tratan de evaluar el nivel de conocimiento o de habilidad del alumnado en diferentes áreas de rendimiento, entre las que se incluyen las matemáticas. Su última versión, realizada en 2022, analiza específicamente el nivel de competencia matemática a nivel internacional. En este informe de evaluación participaron un total de 81 países y economías con el objetivo de contribuir al entendimiento del rendimiento matemático y así poder ofrecer una visión general y nacional de los resultados al respecto.

En el informe PISA 2022, la evaluación de la competencia matemática viene dada por 8 niveles de dominio, que van desde el *nivel 1c* al *nivel 6* de competencia. El *nivel 2* se categorizó como la línea de dominio base en la que los estudiantes son capaces de demostrar

su habilidad e iniciativa para usar las matemáticas en situaciones simples de la vida cotidiana. Así, todo aquel que no logre alcanzar el *nivel 2* es etiquetado como estudiante de "bajo rendimiento", lo que correlaciona una menor probabilidad de completar estudios superiores y de asegurar empleos más remunerativos y de renombre en el futuro, según lo evidenciado por informes de la Organización para la Cooperación y Desarrollo Económicos (en adelante, OCDE) en 2016 y 2018 (OCDE, 2017; OCDE, 2019). En términos generales, se ha observado que el 31% de los estudiantes participantes de países pertenecientes a la OECD obtuvieron resultados inferiores al *nivel 2* en matemáticas. Por otro lado, aquellos estudiantes situados en los niveles *5* o *6*, son etiquetados como estudiantes de "alto rendimiento" por tener un alto nivel de competencia matemática. En este contexto, únicamente 8 de los 81 países evaluados registraron una proporción de estudiantes en esta categoría superior al 10%.

Si utilizamos una evaluación longitudinal como referencia, podemos identificar cambios en el rendimiento matemático entre 2018 (o 2017 en algunos países) y 2022. De manera general, se percibe una caída global de los resultados durante la última década, especialmente en el tramo entre 2018 y 2022. Esto podría explicarse por la pandemia de COVID-19, aunque parece ser que esta situación excepcional ha sido un factor intensificador de una trayectoria que ya venía siendo ligeramente negativa en los últimos años.

A nivel nacional, y ya poniendo el foco en el alumnado español, se ha encontrado el peor resultado en competencia matemática desde que participan en informes de esta índole, aunque se sitúan ligeramente por encima de la media marcada por la OCDE en esta disciplina. Es decir, el rendimiento matemático medio de España no presenta diferencias estadísticamente significativas ni con el promedio OCDE ni con el total de la Unión Europea. A nivel autonómico, se observa que es Castilla y León la comunidad que obtiene el mejor rendimiento medio estimado, seguida de Asturias y Cantabria.

Adicionalmente, en el informe PISA se incorporó una variable de notable relevancia: la ansiedad ante las matemáticas. Tras la evaluación correspondiente, se evidenció que los estudiantes españoles experimentan ansiedad ante las matemáticas en una medida considerablemente mayor que el promedio de la OCDE. Asimismo, se observó que son las chicas quienes reportan un índice de ansiedad ante las matemáticas significativamente superior en comparación con los estudiantes masculinos. De forma específica, se ha determinado que un incremento de 1 punto en el índice de ansiedad matemática se traduce en una disminución de 20 puntos en el rendimiento en matemáticas, tanto en España como en el promedio de la OCDE (PISA, 2022).

En resumen, el análisis PISA señala una preocupante disminución del rendimiento matemático a nivel global, destacando la necesidad de abordar los desafíos educativos y la ansiedad asociada.

Cabe entonces plantearse las siguientes cuestiones: ¿A qué se deben estas bajas puntuaciones en la competencia matemática? ¿Qué variables pueden estar influyendo en este rendimiento matemático? Independientemente de la discusión sobre la metodología de las evaluaciones o la forma en que se enseña esta materia durante las horas lectivas, resulta evidente que el rendimiento matemático se ve afectado por una serie de variables, tanto internas como externas, que inciden en los estudiantes. En general, cabe esperar que el origen de las diferencias en el rendimiento matemático pueda atribuirse a factores individuales e internos, como la capacidad intelectual, que tiende a mantenerse constante a lo largo de la escolaridad del alumnado. Esta capacidad cognitiva ha sido identificada como una de las variables más influyentes y predictivas del rendimiento en numerosas investigaciones llevadas a cabo en los últimos años. A pesar de esto, otros estudios sugieren que existen otras variables internas (de naturaleza motivacional y emocional) y variables de carácter externo o contextual que también contribuyen significativamente a la explicación de este rendimiento (Miñano y Castejón, 2011;

Zimmerman, 2008). Partiendo de esta premisa, la presente tesis doctoral se centra en el estudio del rendimiento matemático teniendo en cuenta el papel que juegan las variables de carácter emocional, motivacional y educativo en alumnado de Educación Secundaria Obligatoria del Principado de Asturias.

La relevancia dada a este nivel educativo se debe en parte a que se trata de una etapa en la que las demandas educativas comienzan a ser mayores tanto a nivel de volumen de tarea como a nivel de complejidad a la hora de procesar la información. La Educación Secundaria coincide además con un momento en el que los estudiantes empiezan a presentar actitudes, creencias y motivaciones más claras en relación con el aprendizaje de las matemáticas. En este contexto, los estudiantes en esta etapa pueden expresar su preferencia por la materia, percibir las matemáticas como una disciplina útil y relevante en su vida cotidiana, y considerarlas una habilidad valiosa que influye en su desempeño académico. También podrían expresar su confianza en su capacidad para cumplir con éxito las tareas prescritas por el profesorado y si experimentan emociones negativas que afectan su rendimiento matemático diario (Adelson y McCoach, 2011; Miñano y Castejón, 2011).

En conclusión, el entendimiento del rendimiento matemático del alumnado de Educación Secundaria implica un análisis integral de diversas variables influyentes, tanto internas como externas. Además, esta etapa se caracteriza por un aumento de la dificultad y complejidad de las tareas académicas, lo que puede influir en la percepción de utilidad de las matemáticas, en las creencias y motivaciones, en el nivel de compromiso y, en definitiva, en el rendimiento del alumnado. Se expone a continuación una justificación teórica de la importancia del estudio de las variables internas y externas por su influencia en el rendimiento matemático.

1. Importancia de las variables internas en el rendimiento matemático

1.1 Modelos y perspectivas teóricas sobre la motivación en el contexto educativo

Aunque existen varios factores influyentes en el aprendizaje de las matemáticas, la motivación ha sido una de las variables más estudiadas no solo por su importancia de manera independiente, sino también por su relación con otras variables motivacionales (Chen y Lin, 2020; Mercader-Rubio et al., 2022; Rojo-Robas et al., 2020). La motivación se define como un constructo que explica el inicio, la dirección y la perseverancia para llegar a un objetivo preestablecido (Deci y Ryan, 1985; Atit et al., 2020; García et al., 2016; Pintrich, 2000a, 2000b) y ha sido explicada en diferentes modelos teóricos de gran importancia, tales como: Teoría de la Atribución, Teoría de la Autodeterminación, Teoría de la Expectativa-Valor y Teoría de los Objetivos Académicos.

La *Teoría de la Atribución* (Weiner, 1986, 2010) defiende que la interpretación que las personas hacen sobre sus acciones y las de los demás influyen en la forma en la que se implican o ejecutan ciertas tareas o conductas. En este caso, Weiner propone tres aspectos clave para entender la causalidad: la *internalidad* (interna vs externa) referida a si la causa está dentro o fuera del sujeto; la *estabilidad* (estabilidad invariante vs estabilidad variante) relacionada con la persistencia y modificabilidad de la causa; y la *controlabilidad* (control intencional vs ausencia de control) definida como el grado de control del sujeto para modificar esas consecuencias o efectos. Esto ayuda a relacionar la motivación con las atribuciones causales y, por tanto, los estudiantes podrían mostrar diferentes perfiles motivacionales en función de las interpretaciones y valoraciones de sus éxitos y fracasos (Weiner, 1986, 2004).

La *Teoría de la Autodeterminación* (Deci y Ryan 1985), por otro lado, es una teoría de corte empírico-humanista cuyo objetivo es la defensa de la cualidad de la motivación, más que la existencia de motivación en sí. En concreto, se defiende una estructura jerárquica en tres

niveles de generalización de la motivación (Vallerand, 1997). El primer nivel hace referencia a la dirección general que toma la persona -*nivel global*- siendo de carácter estable y acorde a su personalidad. En el *nivel contextual* entran en juego ciertas esferas de la vida diaria, por lo que la motivación parece coexistir con otros factores sociales y contextuales. Por último, ya en el *nivel situacional*, la motivación se relaciona con momentos particulares de la vida de la persona. En cualquiera de los niveles, la motivación puede tener diferentes características, encontrándonos con la motivación intrínseca, la motivación extrínseca o la amotivación. La *motivación intrínseca* hace referencia a la realización de las actividades por el mero placer y satisfacción de hacerlas, no siendo necesarias recompensas o premios externos, lo cual se define como *motivación extrínseca*. La *amotivación*, por otro lado, hace referencia a conductas que no pueden ser controladas por los individuos.

La *Teoría de la Expectativa-Valor* (Wigfield y Eccles, 2000) se centra en otra dimensión de la motivación relacionada con el valor dado a una tarea y su coste, así como los sentimientos de competencia personal para realizar dicha tarea, o lo que es lo mismo, la expectativa (Wigfield y Eccles, 2000; Jiang et al., 2018). En concreto, las expectativas de éxito que se tienen sobre las tareas académicas, así como el valor que se les da, potencian la motivación para realizarlas (Eccles et al., 1983; Eccles y Wigfield, 2020; Wigfield y Eccles, 2000; Wigfield y Eccles, 2020). Esta teoría suele ser el fundamento teórico utilizado en estudios que tienen un enfoque individual o personal con el objetivo de descubrir diferentes perfiles motivacionales. En los últimos años, estos estudios se han centrado particularmente en el ámbito de las matemáticas (Lazarides et al., 2020; Musu-Gillette et al., 2015). En resumen, esta teoría se divide en dos tipos de creencias motivacionales. Por un lado, *las expectativas* se definen como las creencias que el alumnado tiene sobre su rendimiento futuro en ciertas tareas. Estas expectativas se han venido relacionando con otros constructos como el autoconcepto académico y la autoeficacia académica (Shavelson et al., 1976; Bandura, 1997). Por otro lado,

el valor, entendido como el conjunto de creencias referentes al grado en que el alumnado valora las tareas que realiza. Es aquí, al referirnos al valor de la tarea, donde entra en juego una vez más, el valor intrínseco o motivación intrínseca (Anderman, 2020; Ryan y Deci, 2020).

Por último, la *Teoría de las Metas Académicas* (Ames, 1992, Dweck y Leggett, 1988) ha servido como marco teórico para entender la motivación de logro, una variable especialmente importante en aquellos estudios con un enfoque centrado en la persona. En este marco teórico, existen dos principales orientaciones, la orientación a metas de dominio y la orientación a metas de rendimiento (Elliot y Dweck, 1998). La orientación a metas de dominio (*mastery-goal orientation)* se da cuando el estudiante tiene como objetivo aprender y mejorar sus habilidades, o lo que es lo mismo, busca el desarrollo de la propia competencia. En cambio, la orientación a metas de rendimiento (*performance-goal orientation)* se refiere a aquel estudiante que tiene como objetivo demostrar competencia (Wormington y Linnenbrink-García, 2017). A su vez, las metas de rendimiento pueden dividirse en dos clases: metas de aproximación al rendimiento (*performance-approach goals*), referentes a la demostración de competencia ante los demás, y objetivos de evitación del rendimiento (*performance-avoidance goals*), referentes a la evitación de juicios negativos por parte de los demás (Elliot y McGregor, 2001).

Considerando todo lo expuesto, existen dos teorías que se sitúan como las más pertinentes para contextualizar los conceptos abordados en la presente Tesis Doctoral. Estas son la *Teoría de la Expectativa-Valor* y la *Teoría de los Objetivos Académicos.* Estas teorías se distinguen por su enfoque centrado en la persona y su capacidad para identificar diferentes tipos de creencias motivacionales y metas de rendimiento, así como por su énfasis en la introducción del valor o utilidad percibida de las diferentes tareas existentes. A pesar de esto, es fundamental considerar la viabilidad y relevancia de otros modelos y perspectivas teóricas sobre la motivación ya que todas son especialmente útiles para ofrecer un marco sólido que

sirva, a su vez, para comprender cómo las metas académicas, las creencias matemáticas, las atribuciones causales y otras variables afectan al rendimiento y al proceso de aprendizaje en general. Por esta razón, es preciso conocer cómo las variables emocionales y motivacionales interactúan y afectan el rendimiento académico, proporcionando una visión más completa y holística de este proceso en el contexto educativo.

1.2 Las variables emocionales y motivacionales en el contexto educativo

Tras conocer los fundamentos teóricos que han surgido en relación con la motivación, es importante resaltar no solo el impacto de esta variable en el proceso de enseñanza-aprendizaje, sino también la influencia de otras variables emocionales y motivacionales en el entorno educativo. A lo largo de este apartado se exponen los hallazgos de varios estudios científicos que abordan diferentes variables motivacionales, como la propia motivación, la autoeficacia, la utilidad percibida o las atribuciones causales. Asimismo, se analizan variables emocionales como la ansiedad ante las matemáticas.

La motivación es definida como un motor potenciador de la implicación del estudiante en las tareas académicas (Gottfried et al., 2013; Suárez-Álvarez et al., 2014), además de ser una variable que ayuda a estimular y mantener el comportamiento individual durante el aprendizaje para satisfacer los deseos del sujeto a nivel académico (Schraw y Sinatra, 2004). Es una variable dinámica, multifacética y que conlleva el entendimiento de varios aspectos como los objetivos, las metas y el valor de la tarea (Linnenbrick y Pintrich, 2002). Tomando como referencia el rendimiento matemático, diferentes estudios realizados tanto en Educación Primaria (Liu et al., 2022; Mercader et al., 2017; Núñez et al., 2015; De Sixte et al., 2020) como en Educación Secundaria (Hossein-Mohand y Hossein-Mohand, 2023; Moenikia y Zahed-Babelan, 2010; Widlund et al., 2024) informaron que aquellos estudiantes con un mayor nivel de motivación estaban más comprometidos con el aprendizaje y, además, obtenían

mejores resultados en matemáticas (Hammoudi et al., 2019, Rojo-Robas et al., 2020; Trujillo-Torres et al., 2020). Pero, a pesar de esta clara influencia, debe tenerse en cuenta la cualidad de la motivación, tal y como defiende la *Teoría de la Autodeterminación* (Deci y Ryan, 1985, 2000). De esta manera, se ha visto que es la motivación intrínseca la que se relaciona con un mayor disfrute de las matemáticas, un mayor esfuerzo invertido (García et al., 2016a) y tasas de éxito más altas, incluso cuando el nivel de dificultad es elevado (Cheng, 2019).

Desde una perspectiva centrada en la persona y con el propósito de comprender el papel de la motivación en el aprendizaje y desempeño de cada estudiante de manera individual, es preciso resaltar la teoría comentada previamente bajo el nombre de *Teoría de las Metas Académicas* (AGT, Elliot y Dweck, 1998) que aborda diferentes facetas de las metas u objetivos académicos. Este enfoque explica que la motivación del estudiante para implicarse de una u otra manera en las tareas viene dada por las orientaciones hacia la meta que muestre, encontrándose dos tipos diferentes de orientación: a metas de dominio -*mastery goals*- o a metas de rendimiento -*performance goals*-. Las metas de rendimiento se dividen, a su vez, en dos clases previamente expuestas: metas de aproximación al rendimiento -*performance-approach goals*- y de evitación del rendimiento -*performance-avoidance goals*-. La evidencia científica ha subrayado el valor de las metas de dominio y de las metas de aproximación al rendimiento debido a su correlación positiva con el éxito académico (Guo et al., 2022; Luo et al., 2011). De manera específica, centrándonos en la perspectiva matemática, Skaalvik (2018) evidenció que las metas de dominio se relacionan con el uso de mecanismos de afrontamiento centrados en el problema, la reducción de los niveles de ansiedad matemática y un menor uso de estrategias de afrontamiento con carácter desadaptativo. Además, si el alumno o alumna presenta una alta orientación a metas de dominio y presenta bajas metas de evitación del rendimiento, es probable que obtenga un mejor rendimiento en asignaturas relacionadas con el

lenguaje y las matemáticas (Horstra et al., 2017; Wormington y Linnenbrick-García, 2017; Skaalvik, 2018).

Otra variable de tipo motivacional relevante es la denominada *autoeficacia*, también conocida como competencia percibida, definida como la percepción que el estudiante tiene sobre sí mismo y sobre su capacidad para enfrentarse con éxito a las tareas matemáticas (García et al., 2016b). La evidencia científica de los últimos años muestra que los estudiantes con mayor autoeficacia tienen más confianza, son más propensos a fijarse objetivos de aprendizaje más ambiciosos y muestran mejores habilidades de resolución de problemas. Todo ello, por tanto, favorece el rendimiento académico (Du et al., 2021; Hwang et al., 2015; Lee et al., 2014). Bien es cierto que la relación entre la autoeficacia y el rendimiento es de carácter bidireccional (Du et al., 2021; Talsma et al., 2018). Específicamente en el área de matemáticas, se ha visto que los estudiantes obtienen mejor rendimiento matemático cuanto mayor es la autoeficacia o competencia percibida. Es decir, si se ven capaces de tener éxito en la tarea asignada, es más probable que rindan mejor en esa materia (Tosto et al., 2016; Hammoudi, 2019). Pero, además, el hecho de rendir adecuadamente en matemáticas hace que aumente su autoeficacia o competencia percibida (Du et al., 2021; Talsma et al., 2018). En esta relación entre la autoeficacia y el rendimiento matemático, hay autores que han afirmado que la mayor influencia sobre el rendimiento proviene del hecho de considerar o percibir que se tienen mejores habilidades o capacidades para la realización de una tarea determinada y no el hecho de poseerlas realmente (Erturan y Jansen, 2015; Pérez-Fuentes et al., 2020).

A pesar de la importancia de la variable anterior como predictora del rendimiento matemático, es cierto que sentirse capaz de ser exitoso en la asignatura o tarea no es suficiente para explicar el compromiso académico personal. Por ende, existe otra variable de carácter motivacional que hace referencia a la percepción que el estudiante tiene sobre la aplicabilidad, significatividad y beneficios de aprender una asignatura concreta por su extensión a la vida

futura y cotidiana, relacionándose esto con la *Teoría de la Expectativa Valor* (Eccles, 1983). Tal y como se ha comentado, una parte de esta teoría defiende el papel del valor subjetivo dado por el estudiante a la tarea a la que se tienen que enfrentar. En este sentido, existen varias dimensiones en relación al valor de la tarea (Eccles y Wigfield, 2020; Hidi y Renninger, 2006): a) valor intrínseco -*intrinsic value*-, referente al placer durante la realización de una tarea y relacionado con la motivación intrínseca; b) valor de logro -*attainment value*-, referente a la importancia de realizar una tarea para mantener nuestra identidad en comparación con los demás; c) valor de utilidad -*utility value*-, referente a la significatividad de esa tarea para poder hacer frente a otras tareas posteriormente; y d) coste percibido -*perceived cost*-, referente al tiempo y esfuerzo que hay que invertir para realizar una tarea, así como las consecuencias emocionales y psicológicas de hacerlo. La variable relacionada con lo anterior recibe el nombre de *utilidad percibida* y se relaciona con la comprensión por parte del estudiante de la aplicabilidad y beneficios del aprendizaje de esa asignatura (en este caso, las matemáticas) para la vida diaria (Adelson y McCoach, 2011).

Por último, nos encontramos con las *atribuciones causales*, ya expuestas en la *Teoría de la Atribución* (Weiner, 2004) y que se refieren a la reacción o interpretación que el estudiante hace de sus éxitos y fracasos. Diversas investigaciones han indicado que estas atribuciones causales se relacionan con el rendimiento académico del alumnado (Cerda y Vera-Sagredo, 2019; Cerda et al., 2022; Clem et al., 2018). De manera específica, aquellos estudiantes que atribuyen su rendimiento a causa internas, estables y controlables, tendrán más éxito académico que aquellos estudiantes cuya atribución es de carácter externo, inestable e incontrolable (Spencer et al., 2021; Rodríguez-Rodríguez y Guzmán-Rosquete, 2019).

El rendimiento matemático, además de verse afectado por las variables motivacionales comentadas, también puede verse influenciado por los pensamientos y emociones (Du et al., 2021; Pitsia et al., 2017). Es en este momento donde entra en juego la *ansiedad matemática*,

entendida como la emoción caracterizada por sentimientos negativos hacia las matemáticas que conducen a la evitación de esta asignatura y a un peor rendimiento (Buckley et al., 2016; Pizzie y Kraemer, 2017). La investigación ha mostrado que cuanto mayor es el nivel de ansiedad matemática, menor es su nivel de autoeficacia matemática y menor su motivación por aprender lo que repercute negativamente en el rendimiento matemático (Cueli, 2014; García et al., 2016; Henschel y Roick, 2017).

Teniendo en cuenta lo anterior, algunas de las variables presentadas han sido agrupadas en un constructo mayor como es el de las *creencias matemáticas* que abarcarían diferentes aspectos como el autoconcepto, la autoeficacia, la ansiedad o la confianza matemáticas (Stankov y Lee, 2017). Las creencias matemáticas pueden afectar sustancialmente al nivel de rendimiento matemático ya que sus dimensiones pueden interactuar entre sí para explicar los diferentes niveles de rendimiento (Stankov y Lee, 2017; Yildirim y Yildirim, 2019). Por tanto, es probable encontrarse con diferentes perfiles de creencia matemática fruto de la combinación de las variables o dimensiones comentadas. Esto explicaría por qué existen alumnos con el mismo nivel de autoeficacia, pero con diferentes niveles de rendimiento matemático. En esta relación estarían actuando otras variables como la ansiedad o el autoconcepto matemáticos, resultando entonces en perfiles con un carácter más individual (Canedo et al., 2022; Fan et al., 2019; Howard y Hoffman, 2018). Por tanto, algunas investigaciones han sugerido que el comportamiento humano es el resultado de la combinación de diferentes variables, lo que ha resultado en metodologías de investigación con una perspectiva centrada en la persona en lugar de utilizando una perspectiva centrada en la variable (Canedo et al., 2022; Fan et al., 2019).

Dada la abundancia de conocimientos científicos y teóricos en torno a las variables motivacionales, identificadas como potentes indicadores del rendimiento matemático, se les ha atribuido un considerable poder predictivo, llegando incluso a superar a las variables intelectuales del estudiante (García et al., 2016b; Lipnevich et al., 2016; Gilar-Corbi et al.,

2019). A pesar de que en los últimos años la evidencia ha aumentado, aún sigue siendo escasa al menos en el sentido de estudiar la influencia de las emociones y motivaciones de los estudiantes en el rendimiento matemático desde una perspectiva centrada en la persona. Contar con esta evidencia puede ser especialmente importante para conocer los diferentes perfiles de creencia matemática y de motivación que se pueden encontrar en el sistema educativo, teniendo en cuenta la influencia de otras variables psicoemocionales y educativas. En base a ello, la presente Tesis Doctoral no sólo se centra en la influencia de estas variables en el rendimiento matemático, sino en intentar potenciar la evidencia y las implicaciones educativas de los resultados obtenidos dentro del mundo de la motivación académica.

2. Importancia de las variables externas en el contexto educativo

El entorno primordial para el desarrollo del alumnado es el ambiente familiar, lo que hace que la implicación de la familia sea una variable de gran influencia en su desarrollo social, personal y académico. En este sentido, el papel de la familia en la educación ha sido objeto de amplia investigación en las últimas décadas, con diversas perspectivas y modelos teóricos que intentan explicar esta variable crucial en el ámbito académico. Entre estos modelos, destaca el *Modelo de Esferas Superpuestas de Influencia* (Epstein, 1990).

Este modelo postula que el estudiante es el eje central sobre el que deben interactuar el resto de las esferas o contextos para fomentar su desarrollo integral. Además, enfatiza la importancia de la colaboración y relaciones de cooperación entre la institución educativa, la familia y otras entidades comunitarias para alcanzar el objetivo previamente comentado (Álvarez, 2019; Suárez y Vélez, 2018). Epstein (1987), establece seis áreas y prácticas de colaboración (Tabla 1) que tratan de explicar las maneras en las cuales la familia puede implicarse para y con el centro educativo y sus agentes.

Tabla 1. Áreas de cooperación y descripción según el Modelo de Esferas Superpuestas de Influencia (Epstein, 1990; Álvarez, 2019).

Área de cooperación	Descripción
Área 1: Ayuda por parte de los centros hacia los padres (*Parenting*)	Los centros educativos ofrecen su ayuda a las familias tanto para mejorar los estilos parentales de crianza, como para aportar información que les permita entender el nivel de desarrollo de sus hijos e hijas.
Área 2: Comunicación bidireccional (*Communication*)	Esta comunicación bidireccional se genera entre todos los miembros de la comunidad educativa (madres, padres, tutores/as, profesorado, etc.). Se trata de comunicar información referente al diseño curricular, desarrollo del alumnado, funcionamiento del alumnado a nivel académico, necesidades educativas o características familiares, etc.
Área 3: Voluntariado de las familias en el centro educativo (*Volunteering*)	El voluntariado hace referencia a la participación activa de las familias en actividades organizadas por el centro educativo o por otras entidades que forman parte de la comunidad educativa. Estas actividades tienen como objetivo potenciar el desarrollo integral del alumnado.
Área 4: Apoyo al aprendizaje desde casa (*Learning at home*)	La implicación familiar desde casa ha sido un tema ampliamente estudiado en los últimos años ya que se relaciona con el apoyo o ayuda que las familias dan a sus hijos/as durante el desarrollo de los deberes escolares, su desarrollo académico, su organización en el centro educativo, etc.
Área 5: Participación activa de la familia en las decisiones del centro (*Decision making*)	Implicación activa por parte de la familia para tomar decisiones en colaboración y cooperación con el centro educativo, participando en órganos de decisión y gestión del centro, como por ejemplo el Consejo Escolar o las Asociaciones de Madres y Padres.
Área 6: Colaboración con entidades comunitarias (*Collaboration with the community*)	La cooperación y la colaboración no se da solamente entre el centro educativo y la familia, sino que existen entidades de la comunidad y de la sociedad que permiten un trabajo conjunto triangulado.

La implicación familiar es, por tanto, un constructo multidimensional que puede dividirse en dos tipos de implicación: implicación en casa -*home-based involvement*- e implicación en el centro -*school-based involvement*-. Ambas se apoyan en un punto importante

que es la comunicación efectiva entre la familia y la escuela -*effective family-school communication*-.

La *implicación en casa* se refiere a aquellos comportamientos y conductas que buscan apoyar el aprendizaje desde el hogar, así como apoyar y guiar el aprendizaje y la realización de deberes escolares, proporcionando un espacio cómodo y familiar para el desarrollo de estas tareas. *La implicación en el centro* educativo, por otro lado, se refiere a la participación activa de las familias en el centro, incluyendo actividades de voluntariado, participación en Asociaciones de Madres y Padres, asistencia a reuniones o cursos diseñados por el centro, etc. Finalmente, el punto de encuentro de estos dos tipos de implicación se denomina *comunicación efectiva entre la familia y la escuela*, y se relaciona directamente con la comunicación bidireccional entre ambos entornos para conseguir ayudar al alumnado en su progreso académico y personal, incluso cuando existen ciertas necesidades educativas (Yotyodying y Wild, 2019; Poncelet et al., 2023).

En los últimos años se ha investigado extensamente la implicación de la familia, encontrándose una vinculación de esta con el éxito académico de los niños y niñas, de manera que una implicación familiar de calidad puede favorecer el rendimiento académico (Kang et al., 2024; Yang et al., 2023). Se ha demostrado que, aunque la participación familiar no sea tan evidente en niveles educativos superiores como Educación Secundaria o la etapa universitaria, esta implicación, junto con otras variables familiares como el nivel socioeconómico y los hábitos de estudio de los padres, pueden disminuir el riesgo de abandono escolar del alumnado (Ross, 2016; Tuero et al., 2020).

En resumen, la implicación de los padres, teniendo en cuenta que esta debe ser de calidad, puede tener consecuencias positivas para la motivación de sus hijos (De Sixte et al., 2020; Kowalski y Froiland, 2020), para su rendimiento académico, y para el desarrollo de

habilidades específicas como las matemáticas o la lectura (Liu y Leighton, 2021). Conocer los tipos de implicación familiar y la manera de comunicarse con los profesionales de la educación puede ayudar a conocer los diferentes estilos parentales, así como la percepción que los padres tienen del entorno educativo, de sus funciones compartidas y de su guía y orientación durante la realización de tareas escolares en casa.

2.1 *La familia y su implicación en el hogar a través de los deberes escolares*

Los deberes escolares, definidos por Cooper (2001) como aquellas actividades que el profesorado asigna para realizarlas en horas no lectivas, han generado gran cantidad de debates en los últimos años. Existe una corriente que defiende que una gran cantidad de deberes puede provocar estrés, reducir el tiempo para realizar otras actividades más agradables (Galloway et al., 2013; Pressman et al., 2015) y dar lugar a malas relaciones e interacciones entre el alumnado y la familia, e incluso con el profesorado (Maloney et al., 2015). Es cierto que la investigación ha demostrado los beneficios de hacer los deberes escolares, ya que su realización se ha asociado a una mejora del rendimiento. Sin embargo, esto no se debe a la cantidad de tareas o deberes realizados, sino a su relevancia y al aprovechamiento del tiempo de trabajo por parte del alumnado (Valle et al., 2015; Valle et al., 2017). De hecho, una investigación llevada a cabo por Dolean y Lervag (2021) mostró que una visión centrada en la no prescripción de deberes puede incluso tener un impacto negativo en el rendimiento académico del alumnado. Teniendo en cuenta el beneficio que la realización de los deberes bien prescritos puede tener sobre el rendimiento académico, es preciso señalar también que su realización puede potenciar el interés por las tareas académicas (Pan et al., 2013; Valle et al., 2015) y puede ayudar al repaso y asentamiento de los contenidos dados previamente en el aula (Kukliansky et al., 2016).

Como se mencionó previamente, la implicación familiar en el hogar se asocia con el respaldo, el apoyo y la orientación durante la realización de las tareas escolares, entre otras

cuestiones. Cuando el papel de la familia se centra en brindar ese apoyo y orientación académica, es probable que esto resulte en beneficios para la realización de los deberes y se consiga una mejora del rendimiento académico del estudiante (Núñez et al., 2015; Silinskas y Kika, 2019; Womack et al., 2021). Es aquí donde entran en juego diferentes variables importantes, como la motivación del estudiante para enfrentarse a las tareas, su compromiso académico, la utilidad percibida de los deberes por parte de la familia, la calidad de la implicación o la comunicación bidireccional e implicación en el centro educativo. Estas variables pueden condicionar la manera de implicarse por parte de los padres y, por tanto, también puede influir en el desempeño del estudiante durante los deberes y en su rendimiento académico posterior.

A pesar de que actualmente sigue existiendo un amplio debate sobre si los deberes son positivos o negativos para el alumnado, es cierto que la mayor parte de las investigaciones se han realizado en alumnado con un desarrollo normativo, viéndose esta evidencia reducida cuando se introducen las Necesidades Específicas de Apoyo Educativo (NEAE) en la ecuación. Es por esta razón que, durante el desarrollo de la presente Tesis Doctoral, se plantea un objetivo complementario que busca conocer el rol de la familia durante la realización de los deberes en alumnado con algún tipo de NEAE, específicamente trastornos del neurodesarrollo por la alta prevalencia existente de este tipo de necesidad.

Objetivos

La presente Tesis Doctoral tiene como objetivo general ofrecer un enfoque integral sobre las diversas variables que parecen influir en el rendimiento matemático del alumnado. Todo ello pretende contribuir a la formulación de estrategias educativas más efectivas y centradas en las necesidades y características individuales del alumnado. Este enfoque integral considera tanto variables de carácter interno, como las variables emocionales y motivacionales, como variables de carácter externo, como la implicación familiar durante los deberes escolares.

De acuerdo con la información expuesta anteriormente, y enfatizando la necesidad de aportar una aproximación a las diferentes variables influyentes en el rendimiento matemático del alumnado, teniendo en cuenta variables de carácter interno (como las variables emocionales y motivacionales) y variables de carácter externo (como la implicación familiar), se detallan los objetivos generales y específicos a desarrollar durante la presente Tesis Doctoral.

Todo ello se desarrolla en dos fases de investigación, incluyendo cada una de ellas determinados estudios con sus correspondientes objetivos y preguntas de investigación (Figura 1):

Primera fase: Análisis de las variables emocionales y motivacionales influyentes en el rendimiento matemático del alumnado de Educación Secundaria.

1. ¿En qué medida las variables cognitivas, motivacionales y emocionales predicen el rendimiento matemático? Estudio 1 – Publicación 1 (Abín et al., 2020).

   Objetivos específicos:

   - Analizar la fuerza predictiva de las variables cognitivas, emocionales y motivacionales en el rendimiento matemático.

- Determinar si la capacidad predictiva de estas variables cambia según el curso académico y el género.

Con ello se pretende analizar cómo las variables cognitivas, motivacionales y emocionales pueden influir en el desempeño en matemáticas, y examinar si estas influencias pueden ser distintas según el género y el curso académico. De esta manera, y utilizando un análisis de regresión jerárquica en tres modelos, se concluye de manera general que los estudiantes tienden a tener un mejor rendimiento matemático cuanto mejores son sus habilidades cognitivas, su competencia percibida, su motivación intrínseca y cuando perciben las matemáticas como una asignatura útil y valiosa. Además, se encuentran diferencias en función del género y del curso académico.

2. ¿Cómo se combinan las variables anteriores para formar perfiles de creencia matemática y qué relación tienen con el rendimiento matemático? Estudio 2 – Publicación 2 (Cueli et al., 2023).

   Objetivos específicos:

   - Identificar perfiles de creencia matemática derivados de las combinaciones de variables como la autoeficacia y la ansiedad matemática.
   - Analizar los perfiles de creencia matemática y su relación con el rendimiento matemático, teniendo en cuenta el género y el curso académico.

En este estudio se pretende identificar diversos perfiles de creencia matemática para explorar, a su vez, cómo se relacionan con el rendimiento matemático. De manera general, y tras llevarse a cabo un Análisis de Perfiles Latentes, se determina la existencia de 6 perfiles resultado de la combinación de los niveles de autoeficacia matemática con los niveles de ansiedad matemática, dando lugar a diferencias en cuanto al rendimiento matemático.

3. ¿Qué tipo de metas académicas persigue el alumnado y cómo se relacionan entre ellas y con el rendimiento matemático? Estudio 3 (enviado para publicación).

   Objetivos específicos:

   - Identificar perfiles motivacionales en función de las metas académicas y compararlos con los resultados del metaanálisis de Wormington y Linnenbrink-García (2017).
   - Determinar qué perfiles son los más adaptativos y, por tanto, mejor relacionados con el rendimiento matemático, considerando el rol del género y del curso académico cómo variables moderadoras.

Los objetivos de este tercer estudio, en el cual se lleva a cabo un Análisis de Perfiles Latentes, resultan en la identificación de 4 perfiles motivacionales, siendo el más frecuente aquel caracterizado por niveles medios de todas las metas académicas estudiadas (de dominio, de aproximación al rendimiento y de evitación del rendimiento), y el más adaptativo aquel caracterizado por una alta adhesión a las metas de dominio y de rendimiento y un bajo nivel de metas de evitación del rendimiento.

Segunda fase: Identificación de variables individuales y contextuales como elementos influyentes en el desarrollo integral y rendimiento del alumnado.

4. ¿Cómo es la relación existente entre las variables individuales (necesidades educativas del alumnado) y las variables contextuales (implicación familiar durante los deberes) y cómo esto influye en el desarrollo y rendimiento del alumnado? Estudio 4 – Publicación 3 (Abín et al., in press).

   Objetivos específicos:

- Analizar estudios previos que tengan como objetivo explicar las relaciones existentes entre los deberes escolares y las necesidades educativas, poniendo el foco en los trastornos del neurodesarrollo por su alta prevalencia.
- Determinar el rol que la familia desempeña en esta relación, así como el rol de otras variables individuales de carácter emocional y motivacional presentes en ambas esferas de desarrollo del alumnado.

Esta revisión empírica se desarrolla según la metodología PRISMA y permite concluir de manera general que el estado emocional es una prioridad en la vida académica del alumnado, especialmente para aquel con algún tipo de necesidad educativa como los trastornos del neurodesarrollo. Además, esta influencia emocional también interfiere en el tipo de implicación familiar durante los deberes escolares, pudiendo repercutir de determinadas maneras en el rendimiento académico y desarrollo integral del alumnado con trastornos del neurodesarrollo.

Figura 1.

Fases y preguntas de investigación durante el desarrollo de la Tesis Doctoral.

Publicaciones

Publicación 1 - Estudio 1

Abín, A., Núñez, J.C., Rodríguez, C., Cueli, M., García, T., y Rosário, P. (2020). Predicting mathematics achievement in secondary education: the role of cognitive, motivational, and emotional variables. *Frontiers in Psychology*, *11*:876. https://doi.org/10.3389/fpsyg.2020.00876

Publicación 2 - Estudio 2

Cueli, M., Núñez, J.C., García, T., Abín, A., y Rodríguez, C. (2023). A person-centered approach to the relationship between mathematics self-belief profiles and achievement. *The Journal of Experimental Education.* https://doi.org/10.1080/00220973.2023.2223539

Publicación 3 - Estudio 4

Abín, A., Pasarín-Lavín, T., Areces, D., Rodríguez, C., y Núñez, J.C. (in press). The emotional impact of family involvement during homework in children with neurodevelopmental disorders: a systematic review. *Children.*

Publicación 1

Primer estudio publicado en la revista *Frontiers in Psychology*.

Abín, A., Núñez, J.C., Rodríguez, C., Cueli, M., García, T., and Rosário, P. (2020). Predicting mathematics achievement in secondary education: the role of cognitive, motivational, and emotional variables. *Frontiers in Psychology*, *11*:876. https://doi.org/10.3389/fpsyg.2020.00876

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Predicting Mathematics Achievement in Secondary Education: The Role of Cognitive, Motivational, and Emotional Variables

Amanda Abín[1], José Carlos Núñez[1,2], Celestino Rodríguez[1], Marisol Cueli[1], Trinidad García[1] and Pedro Rosário[3]*

[1] Department of Psychology, Universidad de Oviedo, Oviedo, Spain, [2] Facultad de Ciencias Sociales y Humanidades, Universidad Politécnica y Artística de Paraguay, Asunción, Paraguay, [3] Department of Applied Psychology, Escola de Psicologia, Universidade do Minho, Campus de Gualtar, Braga, Portugal

Academic achievement in general, and in mathematics in particular, is positively associated not only with cognitive abilities, but also with emotional and motivational skills. The objective of this study was to analyze the prediction strength of cognitive, motivational, and emotional variables in mathematics achievement throughout high school, considering students' gender and age. A large sample of 2,365 Spanish students from the 4 years of high school (12–16 years old) participated in the study. Students provided information about their intellectual skills, perceived competence in mathematics, perceived utility of mathematics, intrinsic interest in learning, mathematics anxiety, and their causal attributions (for failure and for success), and of their achievement in mathematics. Data showed differences according to gender and the school grade level. The motivational and affective variables did not seem to play an important role in this relationship as predicted in the current study. The results of this study are discussed in light of previous research.

Keywords: intellectual abilities, perceived usefulness, perceived competence, anxiety, intrinsic motivation, achievement motivation, mathematics achievement

Abstract

Academic achievement in general, and in mathematics in particular, is positively associated not only with cognitive abilities, but also with emotional and motivational skills. The objective of this study was to analyze the prediction strength of cognitive, motivational, and emotional variables in mathematics achievement throughout high school, considering students' gender and age. A large sample of 2,365 Spanish students from the 4 years of high school (12–16 years old) participated in the study. Students provided information about their intellectual skills, perceived competence in mathematics, perceived utility of mathematics, intrinsic interest in learning, mathematics anxiety, and their causal attributions (for failure and for success), and of their achievement in mathematics. Data showed differences according to gender and the school grade level. The motivational and affective variables did not seem to play an important role in this relationship as predicted in the current study. The results of this study are discussed in light of previous research.

Keywords: intellectual abilities, perceived usefulness, perceived competence, anxiety, intrinsic motivation, achievement motivation, mathematics achievement.

Introduction

Researchers' growing interest in studying mathematical achievement is driven by the importance of mathematics in both formal education and people's daily lives (Jansen et al., 2013; Namkung et al., 2019). Jain and Dowson (2009), for example, underlined the fact that mathematical comprehension is crucial for personal and professional success. Furthermore, Lipnevich et al. (2016) noted that success in mathematics is related to well-being, satisfaction with life, health, income, employability, and longevity.

Extant research has analyzed the influence of cognitive variables on mathematics achievement, but researchers have paid little attention to the role of emotional or motivational variables (see Miñano and Castejón, 2011).

Specifically, these authors found that intelligence did not explain a higher proportion of academic achievement than that provided by variables of an emotional or motivational nature. More recently, García et al. (2016a) concluded that motivation and enjoyment of mathematics were powerful predictors of mathematics achievement. Similarly, Lipnevich et al. (2016) stated that although intelligence was a significant predictor of mathematics achievement, attitudes toward this subject were key to explanation students' higher achievement. In short, and consistent with Zimmerman (2008), findings indicated that students' skills and abilities did not offer complete explanations about the magnitude or nature of mathematics achievement. In sum, perceived competence, perceived utility, motivation, and academic achievement may be considered related constructs. For this reason, the present work is aimed to examine the prediction strength of cognitive, motivational, and emotional variables in mathematics achievement, considering students' gender and age.

Perceived competence, perceived utility, motivation, and emotions

Perceived competence in mathematics is defined as student perceptions about themselves as learners and of their capacity to successfully tackle mathematics tasks. This perception may fit reality to a greater or lesser extent, but in any case, it is a relevant source of students' motivation (García et al., 2016b). Literature reports a close association between students perceiving themselves as more capable in a particular subject and them being more willing to commit themselves to tasks related to that subject (for example, Pajares, 2008; Cabanach et al., 2009; Rosário et al., 2009). For example, Peixoto et al. (2017) have reported perceived competence to be strongly, significantly, and positively related to mathematics

achievement. Similar results have been found with Portuguese students from fifth to ninth grade (Rosário et al., 2012), with British adolescents (Tosto et al., 2016) and with ninth and tenth-grade students from the US (Stevens et al., 2004).

However, feeling oneself to be capable may not be sufficient to explain personal commitment with academic tasks. Furthermore, task commitment needs to be perceived as useful. Perceived utility of mathematics refers to students' understanding about the applicability and benefits of learning that subject to their lives (Adelson and McCoach, 2011). Findings on the association between the perception of the value of the subject and their ability to learn new concepts and achieve higher in mathematics are mixed, while some researchers found positive relationships (Guy et al., 2005; Jordan et al., 2010). Other studies, did not find a positive association between perceived utility and the use of self-regulated learning strategies to improve the quality of learning (e.g., Cerezo et al., 2019). According to these authors, this could be because students often do not perceive a meaningful relationship between the use of cognitive strategies, high-quality learning, and their academic achievement.

As already noted, students' involvement in deep learning need both actual and perceived cognitive abilities, but also a strong motivation on the task (Suarez-Alvarez et al., 2014). Motivation for learning may be defined as the initiation of a learning process, the direction set, and the perseverance in path chosen. The relationship between academic motivation and mathematics achievement has been well studied both in elementary (e.g., Mercader et al., 2017) and in high school (e.g., Moenikia and Zahed-Babelan, 2010). Recently, Hammoudi (2019) reported that students more motivated were more willing to find learning opportunities and achieved higher in mathematics than their counterparts. However, and regardless of the theoretical model considered, it is essential to distinguish between motivation for success, or the tendency to succeed in the realization of a task – achievement goals (Wigfield et al., 2015), and intrinsic motivation, or the will to improve mastery on the task –

mastery goals (Rodríguez et al., 2001; Murayama et al., 2013). In fact, although both types of motivation are positively related to perceived competence for mathematics (Hammoudi, 2019), intrinsic motivation is related to higher enjoyment of mathematics, higher effort displaced (García et al., 2016a), and higher success rates, even when the difficulty level is high. Recent literature defended the idea that students can pursue both intrinsic and achievement goals. The focus chosen is related to their personal characteristics, the nature of the task, and contextual variables (Wormington and Linnenbrink-Garcia, 2017). In addition, more than 30 years ago, Weiner (1986) found that the strength of students' motivation to learn was closely related to their reactions to academic successes and failures. Causal attributions may be defined as the explanations people ascribe to their successes and failures and play a determinant effect on students' motivation and academic achievement (González-Castro et al., 2014). In general, it has been shown that the more adaptive attributional patterns, the more the school achievement (i.e., success is attributed to internal and stable causes, and failure is attributed to changeable, but also internal causes) (Miñano and Castejón, 2011; Miranda et al., 2012).

Finally, learning in general and mathematics tasks in particular are experienced with certain amount of anxiety and a variety of emotional reactions (Rosário et al., 2008). Recently, Chang and Beilock (2016) related motivation with anxiety about mathematics. Math anxiety is the sensation of unease and worry felt when thinking about mathematics or while doing a mathematics task (Buckley et al., 2016). More specifically, math anxiety is characterized by negative feelings toward mathematics, which is likely to result in avoiding mathematics classes and show low math skills (Pizzie and Kraemer, 2017). In summary, many authors have emphasized the strong relationships between math anxiety, motivation, and mathematics achievement, noting that the lower the student's perceived competence in mathematics, the lower the motivation and the performance in mathematics (Lee and Stankov, 2013; Chang and Beilock, 2016; Passolunghi et al., 2016; Henschel and Roick, 2017).

Gender and age

The relationship between cognitive, motivational, and affective variables and achievement in mathematics is significantly influenced by students' gender and age. Achievement in mathematics seems to vary depending on students' gender. However, although some researchers have indicated that for 30 years the gender gap in mathematics achievement has been in favor of boys (García et al., 2007; Williams et al., 2016), others have reported that, mainly in countries with equal education for both sexes, boys and girls exhibit few or no differences in mathematical achievement (e.g., Spelke, 2005). As far as our knowledge, there are no data about gender differences regarding the predictive power of cognitive, motivational, or affective variables in relation to mathematics achievement.

When it comes to age, both transversal (e.g., Roskam and Nils, 2007) and longitudinal studies (e.g., Pintrich, 2000; Peetsma et al., 2005), have systematically reported that mathematics results diminish throughout schooling during adolescence. In addition, various studies have indicated that the motivational and emotional variables related to mathematics tend to change over time (Dowker et al., 2016), with perceived competence, perceived utility, intrinsic motivation, and even anxiety diminishing as students go through their schooling (Dowker, 2005; Mata et al., 2012). Nonetheless, as occurs with the gender variable, there is still little information about the interaction between student age and the predictive power of cognitive, motivational, or affective variables in mathematics achievement (Namkung et al., 2019).

The current study

Prior research has been analyzing the relationships between perceived competence, perceived utility, and math anxiety together with motivational variables and academic achievement (Miñano and Castejón, 2011; Lambic and Lipkovski, 2012; Chang and Beilock,

2016). As already noted, literature has reported recurrently positive relationships between mathematics achievement and cognitive competence, perceived competence, motivation (both intrinsic and for success), and adaptive attributional patterns. In addition, negative relationships with anxiety have been reported. However, there is little information about the predictive power of these variables in mathematics achievement when analyzed together. Furthermore, literature lacks information on the effects of the interaction of gender and age while estimating the effect size for each of these variables in mathematics achievement.

Consequently, in this study, we analyze the prediction strength of cognitive, motivational, and affective variables in mathematics achievement, considering students' gender and age. Grounded on data from previous research, the following hypotheses were set:

1. Cognitive variables (intellectual abilities), along with motivational variables (perceived competence, perceived utility, intrinsic and success motivation, and causal attributions for success and failure), and emotional variables (math anxiety) are good predictors of mathematics achievement.
2. The strength of the association between intellectual abilities and mathematics achievement is lower than that of the motivational or emotional variables.
3. The predictive power of the cognitive, motivational, and emotional variables in mathematics achievement varies depending on the students' age and gender.

Materials and methods

Participants

Participants in this study were 2,365 secondary school students from various schools in Asturias in the North of Spain. The total high school population (9th to 12th grade) in Asturias is 30,000. Data from the international PISA (2018) indicate that adolescents in Asturias scored slightly higher in mathematics than the Organization for Economic

Cooperation and Development (OECD) average (Asturias = 491; OECD = 489), but slightly lower than the European Union average (494). The PISA report also indicates that despite boys scored higher in mathematics achievement than girls, the differences were not statistically significant. It is estimated that in the Asturian population as a whole, 7% are immigrants. Data indicate that immigrant students score far below non-immigrants (about 15 points, which is equivalent to a school grade level gap). Concerning socioeconomic status, the PISA report presents Asturias on the OECD average level. There is no evidence of differences between the schools in Asturias (which may be interpreted as an index of educational equality).

The current sample selection procedure was not random; although schools were initially chosen at random, not all agreed to participate. In addition, within the schools, a small number of students declined to participate for various reasons (e.g., being absent in one or more of the evaluation sessions, lack of permission from the family).

The sample subgroups by gender were similar sizes [girls: n = 1180 (49.9%); boys: n = 1185 (50.1%); z = -0.145, p = 0.884], although there were significant differences with respect to school grade level [1st year: n = 465 (19.7%), 2nd year: n = 487 (20.6%), 3rd year: n = 731 (30.9%), 4th year: n = 682 (28.8%); $\chi^2(3) = 92.462$, $p < 0.001$]. The gender distribution in each school grade was balanced, with no statistically significant differences: 1st year (50.5% girls; z = 0.327, p = 0.743), 2nd year (47.8% girls; z = -1.345, p = 0.178), 3rd year (48.4% girls; z = -1.203, p = 0.229), and 4th year (52.5% girls; z = 1.843, p = 0.065). The study did not include students with special educational needs or learning difficulties.

Instruments

Intellectual abilities

To evaluate students' intellectual abilities, we used the Triarchic Intelligence Test (STAT). This is a test to measure intellectual abilities according to the Triarchic theory of

intelligence (Sternberg, 1993). Its structure is the result of combining the three types of thinking (analytical, creative, and practical) with the content (verbal, numerical, and figurative). Although it is possible to get a score for each subscale, in this study, we only used the total test score. The test has adequate validity and reliability (Sternberg et al., 2001).

Motivational and affective variables

We measured perceived competence, perceived utility, intrinsic and success motivation, causal attributions, and anxiety from the responses of the students to the Spanish adaptation of the Inventory of Attitudes Toward Mathematics from Fennema and Sherman (1978). In this adaptation, the dimensions used show satisfactory reliability (Cueli et al., 2014): perceived competence (six items, e.g., I believe I can do even the most difficult mathematics tasks; α = 0.85), perceived utility (eight items, e.g., Mathematics is a valuable and necessary subject; α = 0.85), intrinsic motivation (eight items, e.g., I find mathematics enjoyable and stimulating; α = 0.77), motivation for success (five items, e.g., I would like to be one of the best at mathematics; α = 0.86), math anxiety (six items, e.g., Normally, mathematics makes me nervous and uneasy; α = 0.78), attribution of success to internal causes (two items, e.g., I am convinced that to get good grades in mathematics you have to be intelligent; α = 0.71), and attribution of success to external causes (four items, e.g., To get good grades in mathematics, above all you have to be lucky; α = 0.78).

Mathematics achievement

Data about the students' achievement in mathematics were gathered from the final grades in the subject. The secretaries of the participating schools with the permission of the parents provided data.

Procedure

The study was conducted in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki), which reflects the ethical principles for research involving humans (Williams et al., 2016). The study had the approval of the pertinent Ethical Committee of the Principality of Asturias (reference: CPMP/ICH/135/95, code: TDAH-Oviedo), and all procedures were performed in compliance with relevant laws and institutional guidelines. Data related to the predictor variables (cognitive, motivational, and affective) were collected 3 months before the mathematics tests were taken. Three qualified educational psychologists of the research project visited the schools and collected the data. Parents were informed about the study by the school authorities, and once they were assured of data confidentiality policy, they were asked to sign the informed consent document.

Data analysis

Data were analyzed in two stages. Firstly, the descriptive data, correlation matrix, and distribution of means were examined, along with missing values (0.2%). Secondly, we performed various hierarchical regression analyses using SPSS 24. The strength of the associations and effect sizes were evaluated using R^2 (where $R^2 < 0.01$ = null; $R^2 > 0.01$ and < 0.09 = low/slight; $R^2 > 0.09$ and < 0.25 = medium/moderate; $R^2 > 0.25$ = high/strong) and Cohen's d (1988), where $d < 0.20$ indicates a minimal effect size, $0.20 < d < 0.50$ indicates a small effect size, $0.50 < d < 0.80$ indicates a moderate effect size, and $d > 0.80$ indicates a large effect size.

Results

Preliminary Analysis

Table 1 presents the descriptive statistics and the Pearson correlation matrix. The result of the KMO test indicated that the sampling was adequate (KMO = 0.733), and the Bartlett

Sphericity test suggested that the matrix was suitable for multivariate analysis (χ^2 = 16556.93, p <0.001). According to the values for asymmetry and kurtosis, and according to commonly accepted criteria, the variables in the study complied with the criteria for univariate normality (Gravetter and Wallnau, 2014).

Table 1

Descriptive statistics and Pearson correlation

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	-	.253**	-.101**	-.169**	.386**	.339**	.340**	.171**	-.225**	-.071**	-.218**
2		-	.043*	.226**	.108**	.111**	.073**	.068**	-.108**	.005	-.135**
3			-	-.017	.088*	-.033	.087**	-.007	-.142**	.144**	.165**
4				-	-.250**	-.215**	-.197**	-.157**	.146**	.004	.071**
5					-	.450**	.517**	.312**	-.476**	-.054**	-.176**
6						-	.467**	.388**	-.268**	-.149**	-.478**
7							-	.305**	-.378**	-.041*	-.188**
8								-	-.074**	.110**	-.177**
9									-	-.051*	-.203**
10										-	.318**
11											-
M	2.464	11.377	.50	2.69	3.496	3.582	3.071	3.639	2.843	2.845	2.326
SD	1.293	5.471	.500	1.087	.852	.857	.748	.980	.885	1.095	1.095
A	.514	-.029	-.004	-.276	-.355	-.078	.038	-.437	.040	.014	.511
K	-.875	.028	-2.002	-1.214	-.290	-.514	.203	-.327	-.201	-.682	-.686

Note. 1: Mathematics achievement; 2: Intellectual abilities; 3: Gender (0 = girls; 1 = boys); 4: School year; 5: Perceived competence; 6: Perceived utility of mathematics; 7: Intrinsic motivation; 8: Motivation for success; 9: Math anxiety; 10: Attribution to internal causes; 11: Attribution to external causes; A: Asymmetry; K: Kurtosis.

*p < .05; **p < .01.

Prediction of Mathematical Achievement: Overall Sample

The hierarchical regression analysis was performed in three phases: (a) firstly, only intellectual ability was included as the sole predictor (model 1); (b) secondly, gender and school grade level were added as predictors (model 2); and (c) thirdly, perceived competence, perceived utility, intrinsic motivation, motivation for success, attribution of success and failure

to internal or external causes, and math anxiety were added (model 3). The results are shown in **Table 2.**

Data show that intellectual abilities were strong, positive predictors of mathematics achievement (students with higher intellectual abilities tended to achieve higher results than students with lower intellectual abilities). Nonetheless, although the amount of explained variance was low (6.3%), the predictive capacity was similar in the two subsequent models, with a moderate effect size (d = 0.538). In fact, the predictive capability hardly suffered as a consequence of the inclusion of gender and school grade level (model 2) or the motivational and affective variables (model 3).

Gender and school grade level were also predictors of mathematics achievement, with a low percentage of explained variance (and both with small effect sizes: d = 0.307 and d = 0.257, respectively). This association was stable even after including the motivational and affective variables in the regression model (model 2 vs. model 3). Girls tended to show higher mathematics achievement than boys, $F_{(1,2365)} = 24.234$; $p < 0.001$; $\eta^2 = 0.010$, although the effect size for these differences was small (d = 0.20). As students progressed through the school years, their mathematics achievement tended to fall, $F_{(3,2381)} = 30.261$; $p < 0.001$; $\eta^2 = 0.037$, again with a small effect size (d = 0.39).

Data indicated that including the motivational and affective variables in the model was statistically significant, $F_{(2,2354)} = 63.341$; $p < 0.001$, with a moderate strength for the association: $R^2 = 0.14$. From the seven variables included in the third model, the only predictors of mathematics achievement were perceived competence (albeit with a small effect size; d = 0.39), the perceived utility of mathematics (with a very small effect size; d = 0.17), intrinsic motivation (again with a small effect size; d = 0.29), and the attributions of successes and failures to external causes for which, although statistically significant at $p < 0.05$, the size of the

coefficient of prediction was not significant (d = 0.08). Neither motivation for success, nor attribution to internal causes, nor anxiety were found to be predictors of mathematics achievement.

Finally, model 3 predicted a significant and relevant amount of the variability of mathematics achievement (with a large effect size: R^2 = 0.27). Nonetheless, it is important to note, as the data in **Table 2** shows, that while intellectual abilities explained a small amount of the variance in mathematics achievement (R^2 = 0.063), the motivational and affective variables explained a moderate amount of the variability in achievement (R^2 = 0.138).

Table 2

Results of the regression analysis for the overall sample (N = 2365)

	Model 1	Model 2	Model 3
Intellectual ability	.251***	.312***	.236***
Gender (0 girl, 1 boy)		-.118***	-.135***
School year (1st to 4th)		-.243***	-.119***
Perceived competence			.215***
Perceived utility			.099***
Intrinsic motivation			.153***
Motivation for success			-.025
Anxiety			.010
Internal causal attribution			-.005
External causal attribution			-.042*
R^2	.063	.131	.269
ΔR^2		.068	.138

*p < .05; ***p < .001.

Prediction of Mathematical Achievement by Gender

Table 3 presents the results of the regression analysis for the girls' and boys' samples. Data were similar for both subsamples and did not differ significantly from what has already been reported for the overall sample. Specifically, we learned that intellectual abilities, despite

the low amount of variance explained (R^2 = 0.050 girls; 0.080 boys), were good predictors of mathematics achievement in both samples, even after inclusion of the other variables. Likewise, the perceived capability for mathematics explained academic achievement to the same extent for boys and girls, with similar results for intrinsic motivation. However, perceived utility has not significantly predicted mathematics achievement for the girls' sample, which was not true for boys. Irrespective of the samples, for the other variables (i.e., motivation for success, attributional processes, and mathematics anxiety), data were not found to be significantly associated with mathematics achievement.

Finally, analyzing the coefficients of determination, we found that the three models explained a higher quantity of the variance in the boys than in the girls' sample, with the effect size being moderate for the girls (R^2 = 0.228) and large for the boys (R^2 = 0.306) sample. In both samples, the amount of variance explained by intellectual abilities was small, while the variance explained by the motivational and affective variables was moderate (R^2 = 0.124 girls; 0.164 boys).

Table 3

Results of hierarchical regression models for the variable gender

	Model 1	Model 2	Model 3
Girls (*n* = 1180)			
Intellectual ability	.230***	.280***	.204***
School year (1st to 4th)		-.232***	-.110***
Perceived competence			.203***
Perceived utility			.067
Intrinsic motivation			-.008
Motivation for success			.136***
Anxiety			.051
Internal causal attribution			-.034
External causal attribution			-.022
R^2	.053	.104	.228
ΔR^2		.051	.124
Boys (*n* = 1185)			
Intellectual ability	.283***	.346***	.270***

School year (1st to 4th)		-.257***	-.129***
Perceived competence			.239***
Perceived utility			.136***
Intrinsic motivation			-.047
Motivation for success			.167***
Anxiety			-.036
Internal causal attribution			-.048
External causal attribution			-.035
R^2	.080	.143	.306
ΔR^2		.062	.164

***$p < .001$.

Prediction of Mathematical Achievement by School Year

Table 4 presents the results of the predictions of mathematics achievement in the four school grade levels. The following are some of the most interesting results.

Firstly, as students' progress through the school years, up to the third year, there was a significant fall in the importance of intellectual abilities while explaining mathematics achievement. In first and second years, the amount of variance was moderate (R^2 = 0.162 in 1st year; 0.134 in 2nd year), but small in the third and fourth years (R^2 = 0.067 in 3rd year; 0.062 in 4th year). At the same time, perceived competence was a significant predictor of mathematics achievement in all four school years, and there was no decrease over time. Secondly, we found that intrinsic motivation was also a good predictor of achievement, except in the first year, in which this relationship was not statistically significant. The remaining motivational and affective variables were not clear, consistent predictors of mathematics achievement in the four school years. Taken together, and considered as a trend, the variance explained by motivational and affective variables decreased as students progressed from the 1st to 4th year high school grades. For the four school grade levels, the size of the association between the predictor variables and mathematics achievement was moderate or medium (17.5, 16.9, 14, and 13% of the variance explained, respectively). Thirdly, we also found that, in

general, the explained variance for mathematics achievement was higher for the first two school years (34.4 and 32.3% of the variance explained for mathematics achievement) than for the last two (22.3 and 20.6% of variance explained, respectively). For the first two school grade levels, the size of the association was large and moderate for the final two. Finally, regarding gender, with the exception of the first year, in which the association was not statistically significant, for the other three school grade levels, girls tended to be more likely in showing higher mathematics achievement than boys (although the effect size was small in all cases).

Table 4

Results of hierarchical regression models for the variable school year

	Model 1	Model 2	Model 3
1st year (*n* = 465)			
Intellectual ability	.403***	.408***	.305***
Gender (0 girl, 1 boy)		-.085***	-.058
Perceived competence			.222***
Perceived utility			.089
Intrinsic motivation			-.029
Motivation for success			.068
Anxiety			.019
Internal causal attribution			-.162***
External causal attribution			-.031
R^2	.162	.169	.344
ΔR^2		.070	.175
2nd year (*n* = 487)			
Intellectual ability	.367***	.372***	.260***
Gender (0 girl, 1 boy)		-.143***	-.183***
Perceived competence			.149***
Perceived utility			.078
Intrinsic motivation			-.013
Motivation for success			.162***
Anxiety			.130***
Internal causal attribution			-.119***
External causal attribution			.075
R^2	.134	.155	.323
ΔR^2		.021	.169
3rd year (*n* = 731)			
Intellectual ability	.259***	.257***	.204***

Gender (0 girl, 1 boy)		-.126***	-.154***
Perceived competence			.271***
Perceived utility			.106***
Intrinsic motivation			-.013
Motivation for success			.107***
Anxiety			-.010
Internal causal attribution			.052
External causal attribution			-.024
R^2	.067	.083	.223
ΔR^2		.016	.140
4th year (*n* = 682)			
Intellectual ability	.250***	.264***	.207***
Gender (0 girl, 1 boy)		-.117***	-.139***
Perceived competence			.184***
Perceived utility			.073
Intrinsic motivation			-.039
Motivation for success			.213***
Anxiety			-.056
Internal causal attribution			-.041
External causal attribution			.036
R^2	.062	.076	.206
ΔR^2		.014	.130

***$p < .001$.

Discussion

In this study, we aimed to assess the predictive capacity of a set of variables: cognitive variables (intellectual ability), motivational variables (perceived competence, perceived utility, intrinsic motivation, motivation for success, and attribution of causality for success and failure), and emotional variables (math anxiety) in determining students' achievement in mathematic. Our goal was focused on determining not only their explanatory power but also to further understand their interactions with the variables gender and school grade level. Although vast research has examined the predictive capacity of one or more of these variables, there are not much data analyzing them together, nor addressing whether the resulting predictive models would vary depending on variables such as gender and school grade level.

We formulated various hypotheses based on previous research. Firstly, we hypothesized that cognitive variables, motivational variables, and affective variables are good predictors of mathematics achievement. We also hypothesized that the size of the association between intellectual abilities and mathematics achievement is smaller than the size of the association between the motivational and emotional variables. Current data partially supported this general hypothesis.

In general terms, we found that students tended to be more likely to perform well in mathematics tasks when they had better intellectual abilities, higher perceived competence for mathematics, higher intrinsic motivation (i.e., interest in understanding mathematics and becoming more expert), and when they perceived mathematics to be useful. In line with previous research (e.g., Stevens et al., 2004; Miñano and Castejón, 2011; Lambic and Lipkovski, 2012; Miñano et al., 2012; Rosário et al., 2012; Tosto et al., 2016; Hammoudi, 2019), data showed the relationship of intellectual abilities and motivational variables (particularly perceived competence and intrinsic motivation, and perceived utility to a lesser extent). In addition, similarly to other studies (e.g., Miñano and Castejón, 2011; Miñano et al., 2012; García et al., 2016b; Lipnevich et al., 2016; Gilar-Corbi et al., 2019), we also concluded that the motivational variables were stronger predictors of mathematics achievement than the students' intellectual abilities.

In this regard, there are some aspects worth noting. Firstly, the fact that when it comes to explain student's achievement, their perceived capabilities are as important as their actual abilities (see also, Erturan and Jansen, 2015). This is interesting because perceived competence is a personal construction, and therefore can be modified according to student's experiences with mathematics. For this reason, teachers could consider helping students on their work, which offers the chance of successfully constructing confidence to tackle challenges and improve learning in mathematics. Secondly, it seems that at these ages, students still trust that

what they learn in mathematics class will be useful; on the contrary, findings from Cerezo et al. (2019) indicate that college students fail to see the utility of what they are learning as a significant variable to organize their learning behaviors. For this reason, teachers and school administrators may wish to consider teaching learning strategies to help students link what they are learning with the near future (Cabanach et al., 2009; Rosário et al., 2015). Thirdly, as expected (e.g., Miñano and Castejón, 2011; García et al., 2016a; Lipnevich et al., 2016), the interest in learning a subject, such as mathematics, was associated with positive results. However, this did not happen, as our data showed, when learning mathematics was understood as an opportunity to outshine others or to gain some kind of reward. For this reason, the design of appropriate instructional strategies should include not only tasks focused on increasing students' self-confidence, and likely to be perceived as useful, but also tasks likely to increase students' interest and encourage them to deep their learning and compete with themselves rather than with their peers (Rosário et al., 2013).

Nonetheless, in contrast to some previous studies, the variables of a more emotional nature were not shown to be predictors of mathematics achievement (in either boys or girls samples), except in the second year of high school, in which anxiety and causal attribution processes significantly predicted mathematics achievement, thought. There may be various explanations for this.

When it comes to math anxiety, as mentioned in the beginning of this paper, prior data suggested a significant, strong, and negative relationship between anxiety and mathematics achievement (e.g., Rosário et al., 2008; Ashcraft and Moore, 2009; Miñano and Castejón, 2011; Maloney and Beilock, 2012; Miranda et al., 2012; Suárez-Pellicioni et al., 2015; Chang and Beilock, 2016; Passolunghi et al., 2016; Henschel and Roick, 2017). Firstly, and despite data from our study are not consistent with those results, they are in line with findings from Erturan and Jansen (2015), showing that when data are analyzed with regression equations, which

include studying anxiety together with other variables (e.g., perceived competence for mathematics as predictors of mathematics achievement), anxiety is no longer predictive of mathematics achievement. Secondly, the magnitude of the relationship between anxiety and mathematics achievement could be affected by which dimension of anxiety is examined (Mammarella et al., 2018). Specifically, Dowker et al. (2016), and Henschel and Roick (2017) noted that the cognitive and affective dimensions of anxiety could be differently related to mathematics achievement. Similarly, Goetz et al. (2013) and Bieg et al. (2015) observed high levels of trait anxiety about mathematics, girls scoring higher, but this did not happen with state anxiety. Our findings could be related to the fact that the items of the questionnaire used, although not referencing very specific situations, could be understood as more related to state anxiety than to trait anxiety. Thirdly, another possible explanation may be related to the role of anxiety in the association with mathematics achievement and other variables such as perceived competence for mathematics (Erturan and Jansen, 2015). In a recent study, Pérez-Fuentes et al. (2020) attempted to learn whether mathematics anxiety, rather than directly predicting mathematics achievement, functioned as a mediating or moderating variable for other variables involved. In that study, they attempted to learn whether the relationship between perceived math ability and math achievement was mediated, at least partially, by anxiety, and whether it may even differ (in intensity or direction) depending on anxiety levels. Their results indicated that anxiety partially mediated, and moderated, the relationship between perceived competence and achievement. In terms of the moderating role, Pérez-Fuentes et al. (2020) found that when mathematics anxiety was high, the effect size of perceived competence for mathematics was large, whereas with low levels of anxiety, the effect was small. Authors suggested that when students experience high levels of math anxiety, the importance of their confidence in themselves grows significantly as a determinant of mathematics achievement. In contrast, when

anxiety is low, students' self-confidence is a much less strong determinant of achievement. However, more research is needed to confirm these findings.

The third hypothesis raised the possibility of the influence of gender and age on the predictors of mathematics achievement and of the magnitudes of these relationships. The direction of the impacts could not be further specified due to the limited available knowledge. In fact, to the best of our knowledge, available data only relates gender differences to some of the variables analyzed in the current study. For example, mathematics achievement (Spelke, 2005; García et al., 2007; Reilly et al., 2015; Fahle, 2016; Williams et al., 2016), achievement depending on the school grade level (Fahle, 2016), mathematics anxiety (Hill et al., 2016; Henschel and Roick, 2017) and perceived competence for mathematics (Henschel and Roick, 2017).

Regarding gender, data from our study add literature as follows. Firstly, there were no relevant gender differences regarding the predictor variables for mathematical achievement (i.e., intellectual abilities, perceived competence, or intrinsic motivation), although for boys, unlike the girls, the perceived utility of mathematics has shown to be a significant and positive predictor of mathematics achievement. Secondly, the variability in mathematics achievement that could be explained by the predictors was substantially higher in boys (large effect size) than in the girls (moderate effect size) sample. Thirdly, we found that in both samples, the predictive capacity of the non-cognitive variables (mainly perceived competence for mathematics and intrinsic motivation) was substantially higher than that shown by cognitive abilities (intellectual abilities). Whereas the non- cognitive variables exhibited a moderate predictive capacity, a small association was found for the cognitive abilities. Finally, it is worth noting that, consistent with recent studies (e.g., Erturan and Jansen, 2015), we did not find gender differences related to the magnitude of the association between anxiety and mathematics achievement, although there were differences in the direction of the relationship

(positive for boys, negative for girls). As in the study by Erturan and Jansen (2015), in our research, perceived competence strongly and positively predicts performance in mathematics, for both boys and girls, but anxiety does not. So, we can conclude with Erturam and Jansen that "perceived math competence is more important in predicting performance than math anxiety" (p. 431).

With respect to the school grade level, this study adds literature by showing a decrease in the level of some of the variables taken as students' progress (e.g., a decrease in perceived competence, motivation, perceived utility of mathematics, and mathematics achievement; Peetsma et al., 2005; Roskam and Nils, 2007; Mata et al., 2012; Regueiro et al., 2015; Dowker et al., 2016). To be specific, we found that as students' progress throughout high school, the cognitive, motivational, and affective variables taken explain less of mathematics achievement. These findings indicate that mathematics achievement progressively depends less on the personal variables examined (e.g., intellectual abilities, perceived competence, motivation, anxiety, and attributional processes) and more on other variables: personal (e.g., personal engagement) and non-personal (e.g., school and family variables). In fact, despite the fact that it is reasonable to think that students' learning and achievement depend to a certain extent on family, school, and teaching variables, it is also expected that the main strong factors would be those personal to the students themselves (cognitive, motivational, and emotional). Thus, although the cognitive, motivational, and emotional variables considered in this study explain a significant proportion of the variability in mathematics achievement (with a large effect size), 70% of the variance remains to be explained. Although it may seem like a key strength of this study, it is clearly a shortcoming, since the remaining 70% have cleared educational and research implications. It does not seem feasible that 70% of adolescents' mathematics achievement can be explained by variables external to the student. It is reasonable to think that the different non-personal conditions (family, school, and teaching) may be important in

students' learning and development, but through their influence on student variables (e.g., mainly those that can be changed, such as perceived competence, motivation, attitudes toward mathematics, attributional processes, anxiety) rather than separately from them. Future research, perhaps through causal relationship models, preferably with longitudinal, or repeated measure designs, should examine this idea more deeply.

In sum, considering the results of the present work, there are some educational implications that is necessary to highlight. First, if teachers focus in the cognitive skills of students in order to analyze or predict their academic results, they would be omitting important factors as their motivational situation. In this sense, beyond other variables of emotional nature, working on the perceived competence, intrinsic motivation, and perceived utility of students could have a positive impact on their mathematics achievement, especially in the first years of high school. Also, teachers have to consider other variables in their professional practice (e.g., family environment, instructional processes or math, or practice implicit theories).

Finally, it is important to note that despite the fact data in this study collected data from a wide sample of students and were representative in terms of gender and school grade level, it should be taken with caution when generalizing to different educational communities or to societies with substantially different educational systems. Nonetheless, the fact that mathematics is important for all of the OECD countries might reduce the likelihood of bias in generalizing these results. It is also essential to bear in mind that data about motivational and affective variables were collected by self-reports, which may bring bias. However, most of the research reviewed also used self-reported data, which should facilitate comparison.

Data availability statement

The datasets generated for this study are available on request to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Committee of the Principality of Asturias.

Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Authors contributions

JN, AA, and CR contributed conception and design of the study. MC and TG organized the database. JN and PR performed the statistical analysis. CR, AA, and MC wrote the first draft of the manuscript. PR, TG, and JC wrote sections of the manuscript. All authors contributed to manuscript revision, read and approved the submitted version.

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A Person-Centered Approach to the Relationship between Mathematics Self-Belief Profiles and Achievement

Marisol Cueli, José Carlos Núñez, Trinidad García, Amanda Abín & Celestino Rodríguez

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Abstract

Students' self-beliefs about mathematics can interact with each other in the explanation of mathematics achievement. The present study aimed to identify self-belief profiles and their relationships with mathematics achievement in a sample of secondary-school students. The participants were 2,365 students who completed a self-report instrument for the assessment of mathematics self-efficacy and mathematics anxiety. A latent profile analysis was conducted to identify the participants' self-belief profiles. The relationship between the profiles, mathematics achievement, and gender was determined using a univariate analysis of variance. Six student profiles were identified based on the degree to which they combined mathematics self-efficacy and mathematics anxiety. Specifically, three patterns were found based on the combination of low, medium-low and high levels of mathematics self-efficacy and mathematics anxiety. The study provides insights into the importance of non-cognitive variables in the explanation of academic achievement.

Keywords: self-belief profiles; mathematics self-efficacy; mathematics anxiety; mathematics achievement; secondary school.

Introduction

During recent years, the study of constructs determining students' learning in subjects such as mathematics has been one of the key areas of research for educational psychologists, who have considered a range of variables to predict students' achievement in mathematics (Radisic et al., 2018; Zhao et al., 2022). Some research has focused on how academic achievement is affected by students' beliefs and perceptions (e.g., Du et al., 2021; Pitsia et al., 2017). For example, after reviewing findings from international surveys (such as the Program for International Student Assessment [PISA] and the Trends in International Mathematics and

Science Study [TIMSS]), Stankov and Lee (2017) showed that mathematics self-beliefs were among the most powerful predictors of mathematics achievement.

According to Pedrero and Manzi (2020), self-beliefs is an umbrella term covering a variety of different concepts, which has been widely studied in the educational area from the standpoint of self-concept and self-efficacy. Nevertheless, other studies have included variables such as anxiety in the construct of self-beliefs (e.g., Lee & Stankov, 2013; Sakellariou, 2020; Stankov & Lee, 2017; Zhu & Meyer, 2022). Stankov and Lee (2017) proposed that mathematics self-beliefs are made up of four dimensions: mathematics self-efficacy, mathematics self-concept, confidence, and mathematics anxiety. This set of variables can directly affect mathematics achievement, or they can inter- act with each other in the explanation of academic achievement (Yildirim & Yildirim, 2019). However, Stankov and Lee (2017) suggestion came out of task- (or variable-) centered studies, where the effect of each variable is considered individually. Studies from a person-centered perspective (e.g., Canedo et al., 2022; Fan et al., 2019; Howard & Hoffman, 2018) suggest that people's behavior is the result of the effect of a constellation of variables in an individual combination. Different people with the same level of self-efficacy may, for example, see very different effect sizes for this variable on academic achievement, depending on the levels of other relevant variables that interact with self-efficacy in the subject. There may therefore be several profiles of students with the same level of self-efficacy but different levels of other variables (e.g., anxiety, fear of failure, motivation) and consequently, different levels of academic achievement.

The interesting aspect of this study is to determine the profiles in which the effect of self-efficacy is stronger and those where it is weaker (or even null). The results of this research could therefore help us better understand the role self-efficacy plays in levels of academic achievement. For this reason, the present study aims to analyze the existence of different mathematics self- belief profiles (focusing on mathematics self-efficacy and

mathematics anxiety) and their relation- ship with mathematics achievement in a sample of secondary-school students while at the same time considering the role of gender and school year.

Mathematics self-efficacy and academic achievement

Mathematics self-efficacy is the self-belief or confidence that students have about successfully performing mathematics tasks and achieving good results (Bandura, 1997). It is typically measured with items that ask whether a person thinks that they can do a particular task, such as calculating the area of a room (Lee & Bong, 2023; Stankov & Lee, 2017). As Bandura (1997) pointed out, mathematics self-efficacy, in line with self-efficacy in other areas, is derived from a variety of information, from personal experiences (history of successes and failures), vicarious experiences (observation of others' performance), social persuasion (verbal and nonverbal messages from parents, teachers and peers), to physiological and affective states (internal information such as sweaty hands before performing a task).

Lee et al. (2022) highlighted that self-efficacy is the most powerful motivational resource that drives individuals to engage, persevere, and accomplish goals in various domains. In the case of mathematics, various studies have confirmed a positive relationship between mathematics self- efficacy and students' achievement in mathematics (e.g., Pitsia et al., 2017; Schunk & Pajares, 2009; Stankov & Lee, 2017), and self-efficacy has consistently been shown to be a strong predictor of mathematics achievement (e.g., Pérez-Fuentes et al., 2020; Skaalvik et al., 2015), with studies concluding that students with low levels of mathematics self-efficacy are at risk of failing this subject (e.g., Martin et al., 2012; Schunk & Pajares, 2009). For example, in a report about the results of TIMSS 2011, with the participation of 4th and 8th year students from 63 countries, Martin et al. (2012) showed that students who believed

in themselves performed much better in mathematics than students with poor or moderate levels of confidence.

In this vein, previous research has shown that this positive relationship between mathematics self-efficacy and mathematics achievement is stronger compared to other self-beliefs such as mathematics anxiety (Jiang et al., 2014; Karakolidis et al., 2016; Lee et al., 2022; Lee & Bong, 2023; Pitsia et al., 2017). Stankov and Lee (2017) highlighted that in PISA, mathematics self-efficacy correlated in the upper .40s (positively) with achievement, and mathematics anxiety correlated in the upper .30s (negatively). They also reported that in 2012 in participating PISA countries, 43% of students reported perceiving themselves as not good at mathematics, and around 30% reported feeling helpless when doing mathematics problems (Organization for Economic Co-operation and Development [OECD], 2013). Nonetheless, the relationship between mathematics self-efficacy and academic achievement can be affected by the level of mathematics anxiety (e.g., Pérez-Fuentes et al., 2020).

Mathematics anxiety and mathematics achievement

Mathematics anxiety is one of the most commonly-studied outcome emotions in mathematics and refers to the physio-emotional reactions that arise when a person thinks about or performs mathematics tasks (Dowker et al., 2016; Henschel & Roick, 2017; Pérez-Fuentes et al., 2020; Ramírez et al., 2016; Stankov & Lee, 2017). Rubinsten and Tannock (2010) showed that mathematics anxiety is distinguishable from other types of anxiety symptoms (i.e., mathematics anxiety can exist in the absence of more general anxiety traits) and has a direct, deleterious effect on the underlying cognitive processes as the individual performs mathematics tasks. Henschel and Roick (2017) stated that mathematics anxiety (as shown for general test anxiety) is assumed to be a multidimensional construct, including two psychological dimensions: The affective component (emotionality which includes feelings of

nervousness, tension, and unpleasant physiological reactions) and the cognitive component (conscious worry or concern which involves self-deprecatory thoughts about one's performance, negative expectations, and preoccupation) forming part of a person's self-beliefs. This is the dimension of mathematics anxiety studied in the present study.

Various studies have confirmed a negative relationship between mathematics anxiety and students' mathematics achievement (Chang & Beilock, 2016; Geary et al., 2019; Ma & Xu, 2004; Yi & Na, 2020). High mathematics anxiety is assumed to be both a cause and effect of low mathematics achievement (Henschel & Roick, 2017; Ma & Xu, 2004). This is even more significant considering that, according to Ashcraft and Moore (2009), around 17% of the population have high levels of anxiety about mathematics and according to Chinn (2009), mathematics anxiety is a very prevalent phenomenon which affects approximately 4% of high school students. In addition, the results from PISA 2012 indicated that 59% of the participants exhibited concern about possible difficulties during mathematics classes, while more than 30% of students said that they felt tense and nervous when they attempted a mathematics problem or while they were doing mathematics homework (OECD, 2015).

Wang et al. (2015) pointed out that the relationship between anxiety and academic achievement has been repeatedly shown to be curvilinear, namely an inverse-U, in line with the theory from Yerkes and Dodson (1908). Despite that, researchers generally assume linearity between mathematics anxiety and achievement (e.g., Ramírez et al., 2016), reporting that, as described above, low-achieving students tend to have higher levels of mathematics anxiety. However, high- achieving students can experience significant levels of mathematics anxiety in competitive educational settings (Foley et al., 2017; Tan & Yates, 2011). Results from comparative international studies such as PISA have shown that students in many high-performing East Asian countries are highly skilled in mathematics while at the same time

exhibiting unexpectedly high levels of mathematics anxiety (Dowker et al., 2016; Yi & Na, 2020).

The relationship between mathematics self-efficacy, mathematics anxiety, and mathematics achievement

Pérez-Fuentes et al. (2020) found that anxiety levels significantly affect the strength of the effect of self-efficacy on mathematical achievement. Specifically, their results indicated that the higher the mathematics anxiety, the stronger the relationship between mathematics self-efficacy and mathematics achievement (when mathematics anxiety was high, the effect of mathematics self- efficacy on mathematics achievement was large, and when mathematics anxiety was low, the effect of mathematics self-efficacy on mathematics achievement was small). In contrast to other studies (e.g., Wang et al., 2015), Pérez-Fuentes et al. (2020) did not find that moderate levels of mathematics anxiety were suitable for achieving adequate learning and achievement in mathematics.

Fan et al. (2019) carried out a study from a person-centered perspective with the aim of exploring profiles of mathematics anxiety in 15-year-old students. They used the PISA 2012 data for students from Finland, Korea and the United States. The results of the multi-group latent pro- file revealed three mathematics anxiety profiles in the three countries: low, medium and high pro- files. The high profile demonstrated significantly poorer mathematics achievement and lower mathematics interest, self-efficacy and self-concept than the medium or low mathematics anxiety profiles. The authors indicated that it would be necessary to consider other influences, such as cognitive and personal factors that may also play an important role in mathematics anxiety (Fan et al., 2019). In this regard, the exploration of factors that can interact with mathematics anxiety should be considered in the explanation of mathematics achievement (Yi & Na, 2020).

The role of gender and school year in mathematics self-beliefs and achievement

The relationship between variables such as mathematics self-efficacy, mathematics anxiety and academic achievement has been analyzed from a gender perspective (Pitsia et al., 2017) and the presence of gender-gaps in mathematics has historically been a focus of interest (see Pérez-Mejías et al., 2021). Although some studies have indicated that men and women in countries that pro- vide equality in education show little or no difference in mathematical performance (Dowker et al., 2016; Else-Quest et al., 2010; Sarouphim & Chartouny, 2017), other studies have provided evidence of gender differences (see Zhao et al., 2022).

The literature provides explanations for this gender-gap in mathematics in sociological and psychological theories. From a sociological viewpoint, gender-gaps in mathematics have been related to stereotypes ingrained in society and the socially accepted beliefs that women are not as good at mathematics as men (Forgasz et al., 2014; Zhu & Chiu, 2019). Other psychological factors that have been attributed to gender-gaps in mathematics achievement include mathematics self- efficacy, mathematics anxiety, attitude toward mathematics, and motivation (see Pérez-Mejías et al., 2021). In this context, Zhao et al. (2022) found that implicit theories of ability (beliefs about various personal traits such as intelligence/ability and personality) moderated gender differences in mathematics. Else-Quest et al. (2010) analyzed the data from the 2003 TIMMS and PISA studies with a total of 493,495 students aged between 14 and 16 years old. Their results showed that boys presented significantly lower levels of anxiety toward mathematics, along with higher levels of self-efficacy and self-concept, and intrinsic and extrinsic motivation. However, studying 777 eighth-school year students, Suren and Kandemir (2020) reported that male students' mathematics anxiety was higher than female students.

At the same time, some studies suggest that self-beliefs in mathematics tend to decrease with age (see Dowker et al., 2016). Unfortunately, the direction of this change seems negative, with worse results in anxiety or self-efficacy as schooling progresses (Abín et al., 2020; Dowker, 2005; Ma & Kishor, 1997; Mata et al., 2012). For example, Jacobs et al. (2002) analyzed changes in children's self-beliefs, specifically in a sample of 761 children across school year 1 to 12 in a longitudinal study. Their results indicated that self-beliefs declined as children got older.

In this context, the study of mathematics self-belief profiles and their relationship with mathematics achievement cannot ignore the effect of gender or age.

The current study

In summary, previous research suggests that variables such as mathematics self-efficacy and mathematics anxiety are important predictors of success in mathematics (e.g., Jiang et al., 2014 Karakolidis et al., 2016; Lee & Stankov, 2018; Pitsia et al., 2017), and that these variables are especially important considering the fact that mathematics self-beliefs influence course and even career choices (Erturan & Jansen, 2015). However, little is known about how these variables interact with each other in the explanation of academic achievement in mathematics. Pitsia et al. (2017) found that mathematics anxiety interacted with mathematics self-concept in terms of influence on mathematics achievement. More than 30 years ago, Cemen (1987) noted that personal characteristics such as self-esteem and task-related confidence can moderate individuals' levels of mathematics anxiety.

Timmerman et al. (2017) carried out a study with 108 students in secondary education (12 to 14 years old) aimed at analyzing the relationship between mathematics self-concept, mathematics anxiety, achievement motivation, and mathematics achievement. Contrary to expectations, their results indicated that mathematics anxiety was not a mediator in the

correlation between mathematics self-concept and mathematics achievement. One possible explanation is that anxiety, rather than being a mediator, behaves as a moderator of the effect of self-efficacy and mathematics achievement, as in the study described by Pérez-Fuentes et al. (2020).

In this context, the present study uses a person-centered perspective and is aimed at determining whether there are different mathematics self-belief profiles and their relationships with mathematics achievement in a sample of secondary-school students, considering the role of gender and school year. This person-centered perspective posits that there may be subgroups of individuals who have similar levels of one or more variables, and who can be differentiated from other sets of variables in this regard (Canedo et al., 2022). Spurk et al. (2020) highlighted that this per- son-centered perspective allows us to identify types, or groups, of people that have different con- figural profiles or combinations of personal and/or environmental attributes, as well as how these combinations are differentially related to predictors and outcomes. At the same time, as Howard and Hoffman (2018) emphasized, the person-centered approach provides a more precise, specific understanding of the relationships between each subpopulation (e.g., self-belief profiles) and other variables (e.g., mathematics achievement and gender in our case).

According to Spurk et al. (2020), to consider this person-centered perspective, it should be plausible that: (1) the research focus can be seen as mixture of distributions with similar characteristics, (2) the profile indicators that will be grouped together are indeed theoretically related, although distinct; (3) the profile indicators have the potential to form different types of latent profiles. As we noted above, mathematics self-efficacy and mathematics anxiety are two related constructs that have exhibited different levels in populations and different patterns of association. For example, in Pérez-Fuentes et al. (2020), perceived mathematics competence was a potent predictor of math achievement (the higher the perceived competence, the better

the performance in mathematics). However, the levels of mathematics anxiety also affected the strength of the association between perceived competence in mathematics and mathematical performance (i.e., at high levels of anxiety the size of the effect of the relationship between perceived competence and achievement was large, while at low levels of anxiety the effect was small). Thus, the mathematical performance of students with the same level of perceived competence (e.g., high) can vary significantly because they have different levels of anxiety toward mathematics. Therefore, it seems to be worth studying how the variables (mathematics self-efficacy and mathematics anxiety) can com- bine to give rise to different profiles and be significantly associated with different levels of mathematical performance.

Finally, according to Zhao et al. (2022) it is important to consider the role of gender in the analysis of these profiles and, given that some studies suggest that self-beliefs in mathematics tend to decrease with the age (e.g., Abín et al., 2020; Dowker et al., 2016; Mata et al., 2012), school year was also considered in the present study. Hence, we formulate the following hypotheses:

Hypothesis 1. Individual combination of self-efficacy and anxiety towards mathematics will give rise to various profiles of self-beliefs /or homogeneous groups of subjects that combine both variables in a similar way). We can expect to find profiles characterized by either low levels of mathematics-anxiety and mathematics self-efficacy or by medium and high levels in both variables. However, it also seems reasonable to think that we will be able to find profiles of low mathematics self-efficacy combined with high mathematics anxiety and vice versa.

Hypothesis 2. Although we do not know how mathematics self-efficacy will interact with mathematics anxiety, in general, profiles with low self-efficacy or high anxiety are more likely to be associated with lower achievement.

Finally, in terms of gender and school year, there is no basis in the literature about how gen- der or school year interact with mathematics self-belief profiles in the explanation of mathematics achievement. The interest here is focused on studying whether gender and school year might act as moderating variables in the relationship between mathematics self-belief profiles and mathematics achievement.

Methods

Participants

The participants in this study were 2,365 secondary-school students attending schools in Spain. Nine schools were initially invited to participate, randomly selected from the total of 66 schools in the central urban area in the Principality of Asturias (a region in the north of Spain), where the students are from families at a medium socio-economic level. Three of the nine selected schools decided not to participate, so the authors resorted to convenience and accessibility procedures to select three new schools. In addition, within the schools, a small number of students did not participate (e.g., absent from one or more of the evaluation sessions or lacking permission from their family). Students from a migrant background made up 9.2% of the sample (6.7% South American, 0.9% Asian, 0.4% African, 1.2% Romany).

The students were aged between 12 and 16 years old. All were in the four years of compulsory secondary school (corresponding to the 7th to 10th grades in other educational systems). The distribution by school year was as follows: 465 students were in 1st year (19.7%), 487 in 2nd year(20.6%), 731 in 3rd year (30.9%), and 682 in 4th year (28.8%). The sample subgroups by gender were similar sizes [girls: n = 1180 (49.9%); boys: n =1185 (50.1%); z = 0.011, p = .918]. The gender distribution by school year was also similar: 1st year (girls: n = 235, boys n = 230; z = 0.054, p = .817), 2nd year (girls n = 233, boys n = 254; z = 0.906, p =

.341), 3rd year (girls n = 354, boys n = 377; z = 0.724, p = .395), and 4th year (girls n = 358, boys n = 324; z = 1.695, p = .193).

Although all the students who gave their consent were evaluated, for this study, students with special educational needs were excluded from the initial total sample.

Instruments

Mathematics self-efficacy and mathematics anxiety

We measured mathematics self-efficacy, and mathematics anxiety from the students' responses to the Spanish adaptation of the Inventory of Attitudes Toward Mathematics from Fennema and Sherman (1978). The dimensions used in this study exhibited satisfactory reliability in previous studies (Cueli et al., 2014; Pérez-Fuentes et al., 2020). In the present study, the mathematics self-efficacy subscale (6 items, e.g., I believe I can do even the most difficult mathematics tasks) demonstrated good reliability (α = .85; ω = .85) and mathematics anxiety (6 items, e.g., Normally, mathematics makes me nervous and uneasy) exhibited acceptable reliability (α = .78; ω = .79). Items were scored using a 5-point Likert-type format, ranging from 1 (completely false) to 5 (completely true).

Mathematics achievement

Data about the students' achievement in mathematics were gathered from the results in mathematics tests carried out at the end of the academic year. This test was developed to assess the fundamental objectives established by the educational curriculum for the corresponding educational stage and included 20 standard activities, each of which was marked as 0 (incorrect) or 0.5 (correct). The maximum test score was 10 points, the minimum was 0 points.

Procedure

The study was conducted in accordance with The Code of Ethics from the World Medical Association (Declaration of Helsinki), which reflects the ethical principles for research involving humans (World Medical Association, 2013). The Ethical Committee of the Principality of Asturias approved the study (reference: CPMP/ICH/135/95) and all procedures were performed in compliance with relevant laws and institutional guidelines.

Once agreement and permission from school authorities was obtained, consent from the children's parents and/or legal guardians was sought. Parents were informed about the study by the school authorities. Informed consent was obtained from the principals, parents, and students, who were informed of the voluntary and anonymous nature of the study. Furthermore, participants could withdraw from the evaluation at any time.

Data related to the Inventory of Attitudes Toward Mathematics (mathematics self-efficacy and mathematics anxiety) were collected three months before the end of the academic year. Students completed the inventory in class (approximately 20 min), in the presence of their main teacher and a member of the research project. Three qualified educational psychologists from the research project visited the schools and collected the data.

Data analysis

Latent Profile Analysis (LPA; Lanza et al., 2003) was used to obtain the latent variables that help to group participants into classes based on their characteristics of mathematics self-efficacy and mathematics anxiety. The Mplus v.7 program (Muthén & Muthén, 2012) was used to determine which model best fit the data from a finite set of models, adding successive latent classes to the model. To determine the optimal number of classes, various models were evaluated using the Lo-Mendell-Rubin Adjusted Likelihood Ratio Test (LMRT; Lo et al., 2001), the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC) and

the BIC adjusted for the sample size (SSA-BIC), as well as the value of the entropy and the sample size of each subgroup. Lower values in AIC, BIC and SSA-BIC indicate more parsimonious models and better fit, while the p-value associated with the LMRT indicates whether the solution with more classes ($p < .05$) or less classes ($p > .05$) fits better (Nylund et al., 2007). It should be noted that small classes (those containing less than 5% of the sample) are typically considered spurious, a condition that is often associated with extracting too many profiles (Hipp & Bauer, 2006).

The relationship between the mathematics self-belief profiles (latent classes) and mathematics achievement was assessed using the 3-step method (Asparouhov & Muthén, 2014). Finally, we conducted two ANOVAs with the aim of analyzing the interaction of self-belief profiles and gen- der, and self-belief profiles and school year in the explanation of mathematics achievement. Effect sizes were assessed using partial eta squared: $\eta_p^2 < 0.01$ = small effect, $\eta_p^2 \geq 0.059$ moderate effect; and $\eta_p^2 \geq 0.138$ = large effect (Cohen, 1988).

Results

Descriptive statistics

Table 1 provides the descriptive statistics for the variables, as well as the Pearson correlation matrix. Skewness and kurtosis values for mathematics self-efficacy, mathematics anxiety and mathematics achievement were within the intervals indicating a normal distribution (between -2 and +2; George & Mallery, 2010).

The results showed that the students with the highest mathematical achievement had the highest mathematics self-efficacy and the least mathematics anxiety. Girls exhibited better mathematics achievement than boys (and reported greater anxiety about mathematics). In addition, mathematics achievement was negatively correlated with the school year and mathematics anxiety, and positively correlated with mathematics self-efficacy.

Table 1

Pearson correlations and descriptive statistics

	MA	MANX	MSE	Gender	School year
MA	—				
MANX	-.228*	—			
MSE	.391*	-.474*	—		
Gender	-.101*	-.142*	.089*	—	
School year	-.172*	.147*	-.252*	-.017	—
M	4.94	2.84	3.49	.50	2.69
SD	2.62	0.88	0.85	.50	1.08
Skewness	0.50	-0.04	-0.35	-0.00	-0.27
Kurtosis	-0.94	-0.18	-0.28	-2.00	-1.21

Note. MA (Mathematics Achievement); MANX (Mathematics Anxiety) MSE (Mathematics Self-efficacy).

* $p \leq .001$

Identification and description of self-belief profiles

To test the first hypothesis, we fit several models of latent profiles to the data (models of two to seven classes) to identify self-belief profiles. The indices of fit for the models are shown in **Table 2**. We stopped the process at seven clusters because: (a) the LMRT of the seven-class model was not statistically significant ($LMRT_{7C} = 24.894$, $p > .05$) indicating that the model did not fit better than the six-class model ($LMRT_{6C} = 34.599$, $p \leq .01$); (b) the six-class model gave lower values of AIC, BIC and SSA-BIC than the five-class model; (c) two groups of participants representing less than 5% of the total sample were obtained in the seven-class model, while only one group of participants with less than 5% were found in the six-class model (see Table 2); and lastly (d) the entropy values (classification power of the model) of the six-class model was greater than for five or seven classes. The classification accuracy of the six-class model was adequate, close to 85% for three of the classes (i.e., .87, .85, .84) and close to 80% for the remaining three classes (i.e., .80, .79, .78).

Table 3 provides the means for each latent class in the chosen model. In general, we found three patterns with respect to the profiles with different levels for the two variables. The profiles could be classified in function of low, medium, or high levels of mathematics self-efficacy. One pattern includes participants with low levels of mathematics self-efficacy that can be combined with different levels of mathematics anxiety as follows: (1) participants with low levels of mathematics self-efficacy and low levels of mathematics anxiety (LSELA, *n* = 22); (2) participants with low levels of mathematics self-efficacy and medium-high levels of mathematics anxiety (LSEMHA, *n* = 440); (3) participants with low levels of mathematics self-efficacy and high levels of mathematics anxiety (LSEHA, *n* = 117). The second pattern reflects medium levels in the two variables: (4) participants with medium-low levels of mathematics self-efficacy and medium-low levels of mathematics anxiety (MLSEMHA, *n* = 708). Finally, the third pattern shows students with high levels of mathematics self-efficacy combined with different levels of mathematics anxiety in two profiles: (5) participants with high levels of mathematics self-efficacy and low levels of mathematics anxiety (HSELA, *n* = 379); (6) participants with high levels of mathematics self-efficacy and medium-low levels of anxiety (HSEMLA, *n* = 699). **Figure 1** provides a graphical representation of each motivational profile.

Table 2

Statistics for identifying the cluster solution and examining the model's classification accuracy

	Models of self-belief profiles					
	Two-class model	Three-class model	Four-class model	Five-class model	Six-class model	Seven-class model
Akaike (AIC)	12888.158	12700.785	12601.668	12561.582	12285.304	12265.339
Bayesian (BIC)	12928.537	12758.470	12676.659	12653.879	12394.533	12391.814
SSA-BIC	12906.297	12726.698	12635.355	12603.044	12334.166	12321.916

LMRT	488.130***	185.417***	100.792***	44.189**	34.599*	24.894
Entropy	0.555	0.658	0.702	0.732	0.744	0.734
Number of groups with $n \leq 5\%$	0	0	0	1	1	2

Note. Mathematics self-efficacy and mathematics anxiety were the two variables used for the Latent Class Analyses.

*** $p \leq .001$; ** $p \leq .01$; *$p \leq .05$

Table 3

Descriptive statistics for each variable in the six latent classes.

				Confidence Intervals	
	Raw Score M (SD)	*Z Score*	*SE*	Lower 5%	Upper 5%
LSELA (n = 21; 0.91%)					
MSE	1.25 (0.27)	-2.526	0.140	-2.887	-2.165
MANX	2.15 (0.73)	-0.598	0.310	-1.397	0.200
LSEMHA (n = 424; 18.28%)					
MSE	2.57 (0.22)	-1.008	0.085	-1.227	-0.789
MANX	3.19 (0.73)	0.447	0.051	0.315	0.578
LSEHA (n = 117; 5.05%)					
MSE	1.74 (0.26)	-2.001	0.077	-2.199	-1.803
MANX	3.89 (0.72)	1.128	0.150	0.742	1.513
MLSEMHA (n = 696; 30.01%)					
MSE	3.29 (0.21)	-0.224	0.099	-0.478	0.031
MANX	3.13 (0.70)	0.269	0.066	0.099	0.440
HSELA (n = 368; 15.87%)					

MSE	4.68 (0.21)	1.340	0.029	1.264	1.416
MANX	1.79 (0.63)	-1.114	0.079	-1.318	-0.909
HSEMLA (*n* = 693; 29.88%)					
MSE	4.00 (0.24)	0.585	0.075	0.393	0.778
MANX	2.72 (0.70)	-0.121	0.045	-0.237	-0.005

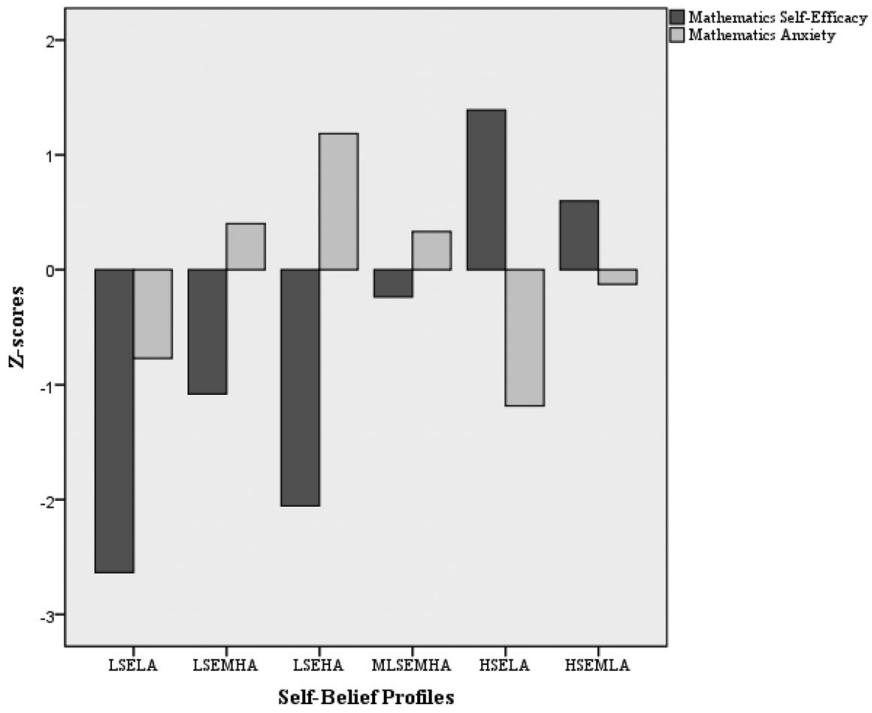
Note. MSE (mathematics self-efficacy); MANX (mathematics anxiety); LSELA: profile with low mathematics self-efficacy and low mathematics anxiety; LSEMHA: profile with low mathematics self-efficacy and medium-high mathematics anxiety; LSEHA: profile with low mathematics self-efficacy and high mathematics anxiety; MLSEMHA: profile with medium-low mathematics self-efficacy and medium-high mathematics anxiety; HSELA: profile with high mathematics self-efficacy and low mathematics anxiety; HSEMLA: profile with high mathematics self-efficacy and medium-low mathematics anxiety.

In general, we found three patterns with respect to the profiles with different levels for the two variables. The profiles could be classified in function of low, medium, or high levels of mathematics self-efficacy. One pattern includes three profiles characterized by low levels of mathematics self-efficacy that can be combined with different levels of mathematics anxiety as follows: (1) Profile of participants with low levels of mathematics self-efficacy and low levels of mathematics anxiety (LSELA, *n* = 22); (2) Profile of participants with low levels of mathematics self-efficacy and medium-high levels of mathematics anxiety (LSEMHA, *n* = 440); (3) Profile of participants with low levels of mathematics self-efficacy and high levels of mathematics anxiety (LSEHA, *n* = 117). The second pattern demonstrates medium levels in the two variables: (4) Profile of participants with medium-low levels of mathematics self-efficacy and medium-low levels of mathematics anxiety (MLSEMHA, *n* = 708). Finally, the third pattern includes two profiles characterized by high levels of mathematics self-efficacy combined with different levels of mathematics anxiety in two profiles: (5) Profile of

participants with high levels of mathematics self-efficacy and low levels of mathematics anxiety (HSELA, *n* = 379); (6) Profile of participants with high levels of mathematics self-efficacy and medium-low levels of anxiety (HSEMLA, *n* = 699). **Figure 1** provides a graphical representation of each motivational profile.

Figure 1

Graphical representation of self-belief profiles (z Scores)



Note. LSELA: profile with low mathematics self-efficacy and low mathematics anxiety; LSEMHA: profile with low mathematics self-efficacy and medium-high mathematics anxiety; LSEHA: profile with low mathematics self-efficacy and high mathematics anxiety; MLSEMHA: profile with medium-low mathematics self-efficacy and medium-high mathematics anxiety; HSELA: profile with high mathematics self-efficacy and low mathematics anxiety; HSEMLA: profile with high mathematics self-efficacy and medium-low mathematics anxiety.

Table 4 describes the mathematics self-belief profiles in terms of gender and school year. In relation to gender, we only found different representations of girls and boys in three profiles. Girls exhibited the LSEMHA profile (low mathematics self-efficacy and medium high mathematics anxiety) more than boys (57% girls vs. 43% boys; $z = 8.736$, $p < .01$). The same pattern occurred with the LSEHA profile (59% girls vs. 41% boys; $z = 8.736$, $p = .05$). However, boys were overrepresented in the HSELA profile (high mathematics self-efficacy and low mathematics anxiety) (41.2% girls vs. 58.8% boys; $z = 11.844$, $p < .001$). In terms of school year, profiles with low or medium low mathematics self-efficacy (LSELA, LSEMHA, LSEHA and MLSEMHA) were more common in the 3rd and 4th years, while the HSELA profile was overrepresented in the 1st year, and the HSEMLA profile in the 2nd and 3rd years.

Table 4

Profile composition in terms of gender and school year

	Mathematics self-belief profiles					
	LSELA	LSEMHA	LSEHA	MLSEMHA	HSELA	HSEMLA
Gender *n*						
Girls	9	251	69	360	156	365
Boys	10	189	48	348	223	364
School Year *n*						
1st year	3	46	15	113	127	161
2nd year	1	55	17	148	99	167
3rd year	11	152	42	217	94	215
4th year	7	187	43	230	59	156

Note. LSELA: profile with low mathematics self-efficacy and low mathematics anxiety; LSEMHA: profile with low mathematics self-efficacy and medium-high mathematics anxiety; LSEHA: profile with low mathematics self-efficacy and high mathematics anxiety; MLSEMHA: profile with medium-low mathematics self-efficacy and medium-high mathematics anxiety; HSELA: profile with high mathematics self-efficacy and low mathematics anxiety; HSEMLA: profile with high mathematics self-efficacy and medium-low mathematics anxiety.

Self-Belief Profiles and their Relationship with Mathematics Achievement, Gender, and School Year

To test the second hypothesis, we used the 3-step method. **Table 5** provides the descriptive statistics corresponding to mathematics achievement for the six mathematics self-belief profiles. The results indicate that participants' mathematics achievement was statistically significant different between the six mathematics self-belief profiles. All multiple comparisons were statistically significant, except for LSEMHA versus LSEHA. In other words, the combinations of low self-efficacy together with medium-high or high anxiety did not differ in terms of mathematics achievement. There were better academic results from profiles where mathematics self-efficacy was high or medium-low. However, when mathematics self-efficacy was low, mathematics achievement decreased regardless of a low level of mathematics anxiety (students with an LSELA profile had the worst mathematics achievement). This result indicates that some level of mathematics anxiety is needed for better results.

Table 5

Descriptive statistics of mathematics achievement and profiles comparison

Mathematics Achievement					
	M	*SE*		M	SE
Profile 1	2.623	0.325	Profile 4	4.514	0.104
Profile 2	3.897	0.110	Profile 5	6.772	0.148
Profile 3	3.574	0.206	Profile 6	5.258	0.111
Profiles Comparisons					
	Chi-Square	*p*		Chi-Square	*p*
Overall Test	188.327	< .001	Profile 1 vs. 2	15.159	< .001

Profile 1 vs. 3	6.326	.012	Profile 1 vs. 4	33.448	< .001
Profile 1 vs. 5	138.903	< .001	Profile 1 vs. 6	60.645	< .001
Profile 2 vs. 3	2.092	0.148	Profile 2 vs. 4	13.560	< .001
Profile 2 vs. 5	238.384	<. 001	Profile 2 vs. 6	76.344	< .001
Profile 3 vs. 4	16.719	< .001	Profile 3 vs. 5	156.884	< .001
Profile 3 vs. 6	49.829	< .001	Profile 4 vs. 5	154.665	< .001
Profile 4 vs. 6	20.173	< .001	Profile 5 vs. 6	61.928	< .001

Note. Profile 1: LSELA profile with low mathematics self-efficacy and low mathematics anxiety; Profile 2: LSEMHA profile with low mathematics self-efficacy and medium-high mathematics anxiety; Profile 3: LSEHA profile with low mathematics self-efficacy and high mathematics anxiety: Profile 4: MLSEMHA profile with medium-low mathematics self-efficacy and medium-high mathematics anxiety; Profile 5: HSELA profile with high mathematics self-efficacy and low mathematics anxiety; Profile 6: HSEMLA profile with high mathematics self-efficacy and medium-low mathematics anxiety. Mathematics achievement ranges from 1 to 5 (1 = lower, 5 = higher).

Role of gender and school year in the relationship between self-belief profiles and mathematics achievement

To examine the effect of the mathematics self-belief profiles more deeply, we considered not only the profile, but also the interaction between the self-belief profiles x gender

and self-belief profiles x school year. In both cases, the interaction between the type of profile and school year or gender was not statistically significant: Profile x Gender, F (5,2353) = 0.573, p = .721; Profile x School Year, F (15,2341) = 1.197, p = .266. Therefore, the association between self-belief profiles and mathematical performance is not affected either by a student's gender or by the school year they are in.

Discussion

The relationship between mathematics achievement and students' beliefs and perceptions has been the focus of multiple studies in the literature. More specifically, students' mathematics self-beliefs—including mathematics self-efficacy, mathematics self-concept and mathematics anxiety—has received considerable attention (Lee & Stankov, 2013; Sakellariou, 2020; Stankov & Lee, 2017; Zhu & Meyer, 2022). Considering that this set of variables can interact with each other in the explanation of mathematics achievement (Yildirim & Yildirim, 2019), the present study aimed to determine the existence of different mathematics self-belief profiles and their relationships with mathematics achievement, gender, and school year in a sample of secondary school students. To do this, we used an LPA approach to identify different mathematics self-belief profiles. We also examined the relationship between these mathematics self-belief profiles, mathematics achievement, gender, and school year.

Mathematics self-belief profiles

As we hypothesized, the interaction of mathematics self-beliefs such as mathematics self-efficacy and mathematics anxiety occurred in different ways. The LPA allowed us to identify six different mathematics self-belief profiles, which can be grouped according to how levels of mathematics self-efficacy are combined with levels of mathematics anxiety. Three profiles reflected low levels of mathematics self-efficacy (profiles with low mathematics self-efficacy and low, medium-high or high mathematics anxiety); one profile showed medium

levels of mathematics self-efficacy (profile with medium-low mathematics self-efficacy and medium-high mathematics anxiety) and two pro- files reflected high levels of mathematics self-efficacy (profiles with high mathematics self-efficacy and low or medium-low mathematics anxiety).

It is important to note that with low mathematics self-efficacy, there are profiles with both low and high mathematics anxiety. However, with high mathematics self-efficacy, we did not find any combination with high mathematics anxiety in the present sample (contrary to our hypothesis). Thus, a student having a profile characterized by good levels of mathematics self-efficacy could behave as a protective factor against mathematics anxiety. Nevertheless, in other cultural contexts, some authors have found higher levels of anxiety in high-achieving students (Foley et al., 2017; Tan & Yates, 2011; Yi & Na, 2020). At the same time, although these findings are in line with social cognitive theory (Bandura, 1992, 1997), which suggests that students with low mathematics self-efficacy often display high mathematics anxiety, we cannot ignore the fact that results of previous task- (or variable-) based research perspectives are inconsistent in explaining the relation- ship between mathematics self-efficacy and mathematics anxiety (see Hiller et al., 2022). This may be due to the fact that these variables can interact in different ways and produce different profiles in different students. In the present study, from a person-centered perspective, we were able to see that teachers can find a group of students in their classes with high mathematics self- efficacy and low or medium-low mathematics anxiety, students with low mathematics self-efficacy and low mathematics anxiety, but they can also see students with low mathematics self-efficacy and high mathematics anxiety. However, at this point we must wonder how many students' teachers would find in their classrooms with these profiles?

In the 2365 secondary students who participated in the present study, the most common pro- files were those characterized by medium-low mathematics self-efficacy and medium-

high mathematics anxiety (29.93% of the sample), or by high self-efficacy and medium-low mathematics anxiety (29.55% of the sample). In contrast, the least common profiles were low mathematics self-efficacy and low mathematics anxiety (0.93% of the sample) and low mathematics self-efficacy and high mathematics anxiety (4.94% of the sample). In the middle were the profiles with low mathematics self-efficacy and medium-high mathematics anxiety (18.60% of the sample) and high self-efficacy and low mathematics anxiety (16.02% of the sample).

Considering these percentages, 24.8% of the students demonstrate profiles with low mathematics self-efficacy. These students will need more individual support in relation to their mathematics self-beliefs. We cannot forget that verbal and non-verbal messages from parents and teachers are an important component in the development of self-beliefs and specifically self-efficacy (Bandura, 1997); hence the importance of providing a protective context for the development of a favorable levels of mathematics self-efficacy. Furthermore, considering and working on students' mathematics self-beliefs is even more important given the impact of those beliefs on mathematics achievement. The three profiles with high or medium high anxiety include 53.47% of the sample, indicating the need to work on these mathematics anxiety levels and remind teachers that students with better academic results have high mathematics self-efficacy and low anxiety.

Self-belief profiles and mathematics achievement

Our second hypothesis stated thar profiles with low mathematics self-efficacy or high mathematics anxiety would be more likely to be associated with lower mathematics achievement. The results showed statistically significant differences between the mathematics self-belief profiles in terms of mathematics achievement. Specifically, the results indicated that the differences between the six mathematics self-belief profiles were statistically significant,

with the exception of the two groups with low levels of mathematics self-efficacy and high, or medium-high, mathematics anxiety. The profiles with low mathematics self-efficacy had the worst results in mathematics achievement compared to the profiles with high or medium-low levels of mathematics self-efficacy.

Along these lines, Martin et al. (2012) showed that students who believed in themselves per- formed much better in mathematics than students with poor or medium levels of confidence. Furthermore, the important role of mathematics self-efficacy in the explanation of mathematics achievement has been highlighted in previous studies, in which the positive relationship between mathematics self-efficacy and mathematics achievement was stronger compared to other self- beliefs such as mathematics anxiety (Jiang et al., 2014; Karakolidis et al., 2016; Pitsia et al., 2017; Stankov & Lee, 2017). In our study, profiles with low mathematics self-efficacy demonstrated lower mathematics achievement regardless of low levels of mathematics anxiety. In contrast, the profiles with high mathematics self-efficacy had better mathematics achievement, with higher mathematics achievement from students with a profile of high mathematics self-efficacy and low mathematics anxiety.

Pérez-Fuentes et al. (2020), found that the relationship between mathematics self-efficacy and mathematics achievement was partially affected by anxiety levels. Considering our present results, we can add that profiles with medium-high or high mathematics anxiety exhibited lower mathematics achievement only when mathematics self-efficacy was low. In contrast, profiles with low mathematics self-efficacy had lower levels of mathematics achievement when mathematics anxiety was low and did not differ in terms of mathematics achievement when there were medium or high levels of mathematics anxiety.

In summary, our results lead us to believe that the role of mathematics anxiety in academic achievement should not be analyzed in isolation. Although learning anxiety and

mathematics anxiety have been negatively associated with worse academic achievement in multiple studies (Geary et al., 2019; Yi & Na, 2020), from a person-centered perspective we can see that mathematics self- beliefs do not appear alone in the student, but instead are combined in different profiles (Liu et al., 2020) as happens in educational reality. Considering this perspective, the effect of mathematics anxiety is minimized or weakened in explaining mathematics achievement. A student can feel a little confident or very confident about a task while at the same time feeling a little anxious or very anxious, however, what affects their achievement in mathematics is their mathematics self-efficacy. In fact, our findings indicate that the lower a student's mathematics self-efficacy, the worse their mathematics results. In contrast, higher levels of mathematics self-efficacy were related to better mathematics results, which were better when mathematics anxiety was low.

Self-belief profiles, gender, and school year

In addition, we must not ignore the role of gender and the school year in relation to the mathematics self-belief profiles. Our results showed that the interaction between these variables (gen- der and school year) and the mathematics self-belief profiles was not relevant to the explanation of mathematics achievement. Although there were differences in the distribution of boys and girls in some of the profiles, and in the presence of the profiles in each school year, these variables did not interfere with the effect that the mathematics self-belief profile had on mathematics achievement.

In terms of gender, we found differences in the distribution of girls and boys in three mathematics self-belief profiles. While girls were more likely to exhibit a profile characterized by low mathematics self-efficacy and medium high or high mathematics anxiety, boys were overrepresented in a profile of high mathematics self-efficacy and low mathematics anxiety. The differences in the profiles exhibited by girls and boys in the combination of mathematics

self-efficacy and mathematics anxiety can be explained—as was saw previously—in sociological and psychological theories (see Pérez-Mejías et al., 2021). Our results are in line with studies which found gender differences in mathematics self-efficacy and mathematics anxiety, and two self-belief profiles showed differences between girls and boys (e.g., Else-Quest et al., 2010). However, our results are, at the same time, in line with studies which did not find gender differences in these main variables. More specifically, in the profile with the worst academic results (low mathematics self-efficacy low mathematics anxiety) we saw no differences between boys and girls. In short, the result that the interaction of mathematics self-belief profiles and gender was not significant supports the idea that gender-based differences in mathematics achievement would be associated with mathematics self-belief regardless of gender.

In terms of the school year, we saw that profiles characterized by high mathematics self-efficacy were more present in earlier school years while profiles with low mathematics self-efficacy were more common in later school years (3rd and 4th). As previous research has indicated, it seems that self-beliefs in mathematics tend to decrease with age (e.g., Abín et al., 2020; Dowker et al., 2016; Mata et al., 2012), and when students start secondary education, they come equipped with adequate levels of mathematics self-efficacy which start to drop as schooling progresses. The challenge for mathematics teachers, especially in the first few years, is to protect students' mathematics self-efficacy, with activities that are suited to their possibilities, as well as verbal and non- verbal reinforcement that enhances their own self-assessment of their abilities to successfully complete tasks.

In short, mathematics self-beliefs exhibited different characteristics in terms of academic achievement, but gender and school year, did not moderate this relationship. Nevertheless, the profiles with low mathematics self-efficacy had the worst academic results and were more common in girls and in the latter years of secondary education.

Practical implications

The present study has an immediate practical implication for educational professionals, highlighting how important and necessary it is to promote interventions aimed at improving our students' mathematics self-efficacy (O'Mara et al., 2006). The main objective should be to help students in the process of building appropriate, high mathematics self-efficacy to deal with mathematics tasks. In contrast, it is possible that mathematics anxiety can be managed by students themselves based on their confidence. The key for teachers would be to distinguish what students know and how much they trust themselves, and to provide activities and tasks to improve their self-efficacy. Teachers should be aware that, beyond the moderate levels considered to be optimum (Wang et al., 2015; Yerkes & Dodson, 1908), those who achieve better academic results exhibit high levels of mathematics self-efficacy and low levels of mathematics anxiety. However, the worst results in mathematics were from the profile characterized by low mathematics self-efficacy and low mathematics anxiety, indicating that some level of mathematics anxiety is needed for better results.

Limitations

There are some limitations to the study that must be acknowledged. Firstly, while our data allowed us to identify six differentiated mathematics self-belief profiles, our results were restricted to the sample we analyzed, and although this sample was large, all of the participants were recruited from the same geographical and cultural context. A second limitation was the fact that we analyzed only a single dimension of mathematics anxiety associated with the students' assessments of their concerns and thoughts during mathematics tasks.

Thirdly, we have not considered the four dimensions proposed by Stankov and Lee (2017) in the construct of mathematics self-beliefs (mathematics self-efficacy, mathematics

self-concept, confidence and mathematics anxiety), so our results are restricted to the combination of mathematics self-efficacy and mathematics anxiety.

Finally, taking these limitations into account, we conclude that the present study provides insights into the study of student self-beliefs for the explanation of mathematics achievement.

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Publicación 3

Tercer estudio aceptado para publicación en la revista *Children.*

Abín, A., Pasarín-Lavín, T., Areces, D.; Rodríguez, C., y Núñez, J.C. (in press). The emotional impact of family involvement during homework in children with neurodevelopmental disorders: a systematic review. *Children.*

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MDPI

Review

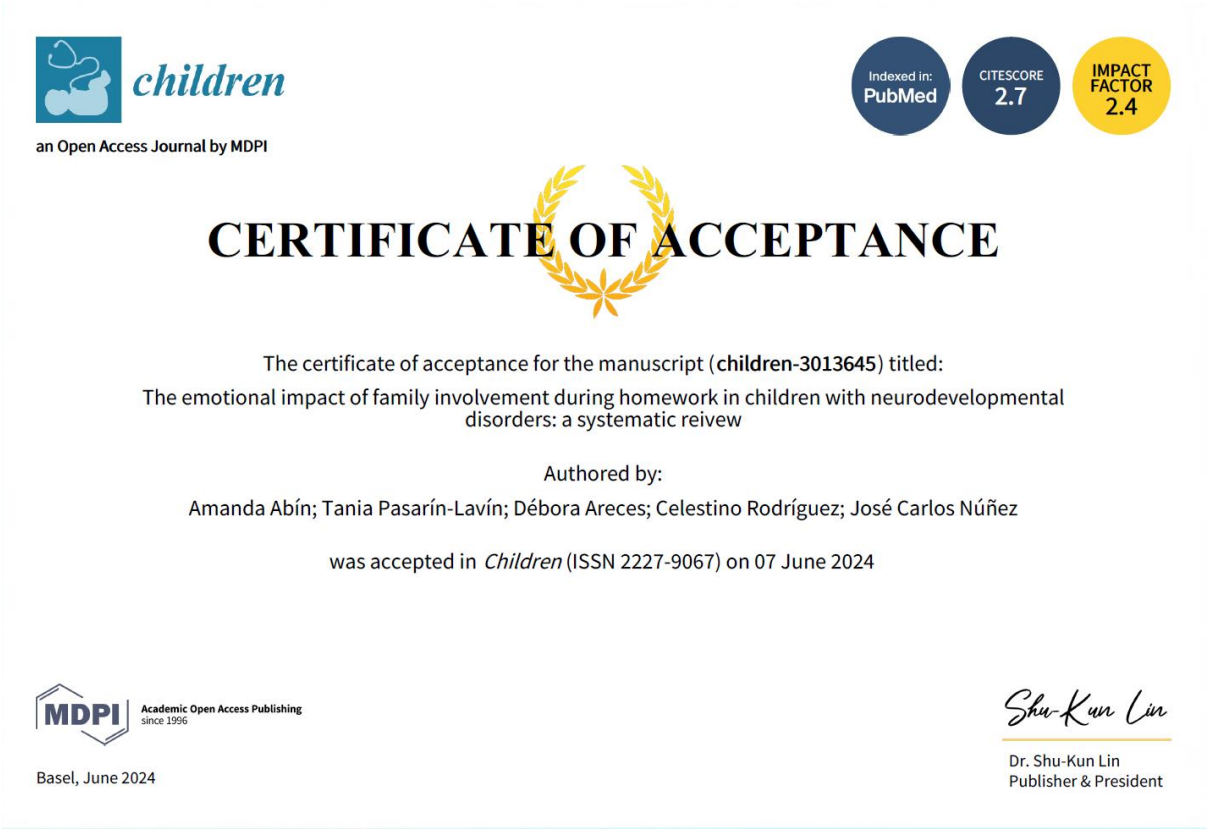
The emotional impact of family involvement during homework in children with neurodevelopmental disorders: a systematic review

Amanda Abín [1], Tania Pasarín-Lavín [2], Débora Areces [3], Celestino Rodríguez [4] and José Carlos Núñez [5,*]

[1] University of Oviedo; abinamanda@uniovi.es
[2] University of Oviedo: pasarintania@uniovi.es
[3] University of Oviedo: arecesdebora@uniovi.es
[4] University of Oviedo: rodriguezcelestino@uniovi.es
[5] University of Oviedo: jcarlosn@uniovi.es
* Correspondence: email: jcarlosn@uniovi.es; Tel.: +34685093388

Abstract: Neurodevelopmental disorders can be studied from two distinct perspectives: an internal approach, which examines the causes and consequences of these disorders; and a contextual approach, which considers the role of the family in the lives of children and adolescents. Research has demonstrated that the most significant form of family involvement in families raising a child with NDD is through homework. This involvement has been shown to have an emotional impact on children with neurodevelopmental disorders such as ADHD or dyslexia. The objective of this study is to review published articles on homework and neurodevelopmental disorders, with particular attention to the role of the family and the emotional health of children and family. **Method**: The review followed the PRISMA guidelines. The final sample consisted of 11 articles, with samples ranging from less than 30 participants to more than 100 at the international level. **Results**: The results demonstrate the complex methodological and bibliometric picture of the final sample, as well as the many emotional and contextual variables that influence the relationship between homework and neurodevelopmental disorders. **Conclusions**: Future research should consider how emotional health affects the engagement of families with children with neurodevelopmental disorders.

Keywords: neurodevelopmental disorders, family involvement, homework, emotional variables, contextual variables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Abstract

Neurodevelopmental disorders can be studied from two distinct perspectives: an internal approach, which examines the causes and consequences of these disorders; and a contextual approach, which considers the role of the family in the lives of children and adolescents. Research has demonstrated that the most significant form of family involvement in families raising a child with NDD is through homework. This involvement has been shown to have an emotional impact on children with neurodevelopmental disorders such as ADHD or dyslexia. The objective of this study is to review published articles on homework and neurodevelopmental disorders, with particular attention to the role of the family and the emotional health of children and family. Method: The review followed the PRISMA guidelines. The final sample consisted of 11 articles, with samples ranging from less than 30 participants to more than 100 at the international level. Results: The results demonstrate the complex methodological and bibliometric picture of the final sample, as well as the many

emotional and contextual variables that influence the relationship between homework and neurodevelopmental disorders. Conclusions: Future research should consider how emotional health affects the engagement of families with children with neurodevelopmental disorders.

Keywords: neurodevelopmental disorders, family involvement, homework, emotional variables, contextual variables.

Introduction

Neurodevelopmental disorders (NDD) are a set of conditions that arise from early ages, even before schooling begins. They are defined as difficulties, differences, or deficits in the development of various processes, producing changes at personal, academic and behavioral levels [1]. NDD may include disorders that affect cognitive and general developmental functioning, as in intellectual disability (ID), or it may include specific disorders such as attention deficit hyperactivity disorder (ADHD), autism spectrum disorder, communication disorders, specific learning disabilities (SLD), and motor disorders [2].

The frequency of NDD varies around the world due to a lack of uniformity in diagnostic criteria between countries, which contributes to variability in incidence and distribution on a global scale. Despite that variability, the estimated prevalence of the most commonly studied neurodevelopmental disorders (NDD), such as ADHD, has been found to be between 7.9% and 9.5% [3,4], while the prevalence of specific learning disabilities (SLD) is estimated to range from 1.2% to 24% [5,6]. These two are the focus of the present article.

ADHD is a neurodevelopmental disorder characterized by inappropriate levels of in-attention, hyperactivity and/or impulsivity, which presents persistently [4,7,8] and results in social, academic, and occupational difficulties [9]. Furthermore, the presence of comorbidities with emotional or behavioral symptomatology may influence the prognosis [10,11].

SLD represents one of the most prevalent academic needs or difficulties, despite the paucity of research in this area [12]. It is defined as a specific NDD affecting basic school skills such as reading, writing or mathematics [12,13]. Children with SLD exhibit an average level of intelligence, despite presenting with low reading skills. They face difficulties in comprehending written material, applying grammatical and syntactic rules, organizing information, performing mental calculations, reasoning in mathematical terms, and so forth [14]. As with ADHD, the presence of SLD may co-occur with emotional and/or behavioral difficulties [15].

It is clear that in addition to the academic challenges associated with ADHD or SLD, neurodevelopmental disorders are also linked to symptoms of anxiety and depression [16,17,18]. A study by Morales-Hidalgo et al. [19] found that NDDs were associated with a higher prevalence and greater severity of concurrent emotional problems than found in people without NDD. Therefore, it is important to identify and treat anxious and depressive symptomatology from an early age, especially in children with NDD. This is required not only to improve mental health, but also to reduce academic problems resulting from the emotional situation and to improve family involvement and mental health [19].

Two distinct but complementary approaches have been used to study NDD in children and adolescents. The first focuses on the factors influencing the severity of NDD from an internal or personal perspective, with a particular emphasis on personal and neuropsychological variables [20,21]. The second examines NDD from a contextual perspective [22], investigating the external variables that may influence prognosis, severity, and sub-sequent development.

The contextual approach allows us to investigate the role of family involvement in the development of children and adolescents with NDD. Given that NDD manifests itself even before children's schooling begins and that the educational stage is of great im-portance for

their development, family involvement during this period has been extensively researched in recent decades. Various theoretical perspectives and models have been proposed to explain this crucial variable in the academic environment. One of the most prominent models is Overlapping Spheres of Influence [23]. This conceptual framework posits that the child is the center around which all spheres or contexts must interact in order to foster the child's holistic development. Furthermore, the model emphasizes the significance of collaborative and cooperative relationships between educational institutions, families, and communities. These relationships have been shown to yield a positive emotional benefit for both students and their families [24,25,26,27].

Epstein [28] identified six areas of collaboration, outlining the ways in which families can engage with and be involved in the school and other external social and healthcare actors. Collaboration area 4, also known as "Learning at home", refers to the support or help that families give their children during homework activity. This area has been the subject of intense debate and controversy in recent years, homework being defined as the activities that aim to provide students with opportunities to practice what has previously been explained in class so that they can apply those skills and generalize their learning [29].

Family involvement is defined as "the time invested by parents or caregivers in their children's education" [30, p. 116]. However, when we refer to specific involvement during homework, we can consider it to be parents' activities at home that are related to the learning that children previously did at school. Furthermore, parental involvement during homework has been demonstrated to have a positive impact on children's cognitive and language development, as well as their emotional well-being [31]. This involvement has also been linked to improvements in self-esteem, emotional regulation, and perceived competence in academic tasks [32].

This is acknowledgement that quality family involvement can have a positive influence on students' emotional development. However, the presence of NDD in children can have a negative impact on their mental health and that of their parents. A study by Cheung et al. [30] found that the presence of an NDD, specifically ADHD, led to a 2.9 times higher risk of parents having mental health difficulties compared to parents of children without ADHD. Another earlier study similarly found that the anxious and depressive symptoms observed in students with ADHD were comparable to those observed in their parents [34].

A number of studies conducted during and following the pandemic have demonstrated adverse effects on parents' mental health resulting from the presence of neurodevelopmental disorders or specific difficulties in their children. In particular, the mental health of families of children with NDD has been found to be more adversely affected, with higher levels of stress than in parents of typically-developing children, leading to emotional states such as sadness or depression [35]. This situation has been further exacerbated by the COVID-19 pandemic, as conditions naturally led to high levels of psycho-logical stress in parents [35,36]. Furthermore, the levels of stress and psychological dis-tress appeared to increase in direct proportion to the severity of the behavioral difficulties associated with the NDD [35,36]. Therefore, the family's emotional variables are also an important factor in the study of neurodevelopmental disorders.

The current study

In summary, it is crucial for researchers to analyze neurodevelopmental disorders from a contextual perspective to understand how family involvement during homework can influence a child's psychological and/or emotional development. This association also takes into account the emotional impact of an NDD on parents. This family involvement at home is essential for any school-aged child but is even more valuable for children with some kind of

need or difficulty, such as NDD. It is similarly vital to assess the impact of the emotional health of the family and children facing these challenges in their overall development.

It is currently clear that the study of homework, how it is set, and how it is done by students diagnosed with NDD is a topic with minimal scientific development [37]. More-over, most studies on the topic have examined samples of parents of children with normative development, which limits the conclusions that can be drawn from them [38,39,40,41,42,43].

Therefore, the objective of this study is to review published articles on homework and special educational needs. In order to explain the influence of the family during homework in a specific sample, such as children with NDD, we decided to focus on a more general term, "special educational needs" (SEN) [44,45]. This term was included in order to study children with neurodevelopmental disorders, which indicates that they present a significant severity level that affects their family and school environment, as well as having emotional affects.

The articles selected for analysis were chosen based on two main criteria: the age of the sample, which had to be in elementary or secondary education, and the publication date, which had to be within the last 10 years (between 2012 and 2023). Furthermore, the study aims to contribute to the understanding of SEN, with a particular focus on neuro-developmental disorders and the internal and contextual variables that may influence this relationship. The study also aims to shed light on the emotional symptomatology that may be present in these disorders and the role of the family during homework. This will enable identification of specific implications at the academic, personal, health and emotional levels, which will help improve parental involvement during their children's homework, particularly in the context of NDDs such as ADHD and SLD.

Method

The study used a retrospective observational research design. The literature review was based on the criteria in the PRISMA statement (An updated guideline for reporting systematic reviews) [46] in order to systematically identify and examine relevant studies. The objectives of this review were approved by the ethics committee of the Principality of Asturias with the reference code "Ethical Research 70/19" following PRISMA guidelines.

The systematic review included studies that: a) analyzed the relationship between homework and SEN. It should be noted that the term SEN was included as an inclusion criterion for children with NDD that influence the different areas of their lives; b) had a sample of students in elementary and/or secondary education; c) were published in Spanish or English in databases such as SCOPUS and WOS; d) and finally, were published in the last 10 years, between 2012 and 2023.

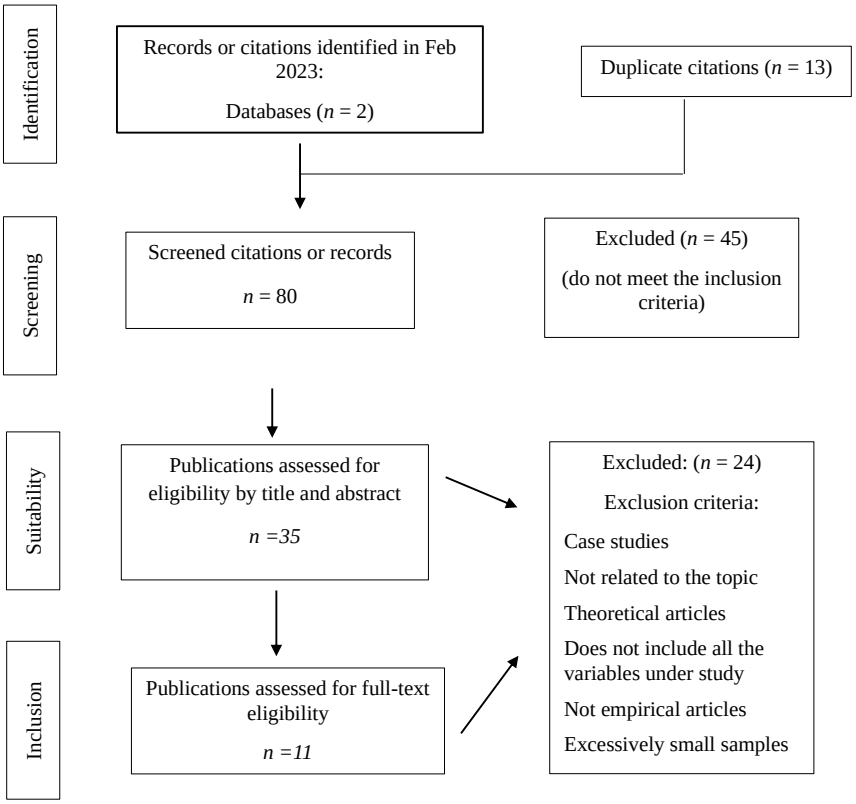
Figure 1 summarizes the selection process for the sample of articles, as well as the results, including the justifications for exclusions during the full-text screening phase. The bibliographic search was conducted during February 2023, specifically between 2 and 4 February 2023, in the main psychology and education databases such as: SCOPUS and Web of Science. In WOS, the search was also refined by Indexed Journals, selecting Science Citation Index Expanded (SCI-Expanded) and Social Sciences Citation Index (SSCI). Boolean search terms were used in title, abstract and/or keywords: (learning disability* OR learning difficult* OR SEN OR special educational needs) AND (homework). In all databases, the search was restricted to the period 2012-2022.

In the first stage, all possible results were considered, and duplicates between databases and searches were eliminated. In the second stage, titles and abstracts were read to refine the list, excluding those that did not refer to the subject of the review or did not meet the previously established criteria. Finally, the complete texts were reviewed to produce the final sample.

The search results were entered into the EndNote bibliographic manager to eliminate duplicates and work with the information about each article.

Figure 1.

PRISMA flowchart of the systematic review. Adapted from Page et al. [46].



Inclusion and exclusion criteria

The criteria to include the articles were that: a) the articles were published between 2012 and 2022; b) the study samples were elementary- or secondary-school age; c) they examined the relationship between homework and pupils' educational needs; and d) they were published in English or Spanish.

Studies were excluded according to the following criteria: a) studies published as a book chapter or conference abstract and not as a scientific article; b) case studies or studies with excessively small samples; and c) meta-analyses and reviews.

Data collection

Following the PRISMA criteria [46], the two databases noted above were used in the identification phase, yielding a total of 93 articles from the search expression and publication filters (years 2012 to 2022). Each extracted article was then reviewed against the inclusion and exclusion criteria established above. This phase produced 13 duplicates which were eliminated before the Screening phase, leaving a total of 80 pre-selected articles.

In the screening phase, 45 of the 80 pre-selected articles did not meet the proposed inclusion criteria, either because they did not deal with the variables mentioned, they were not scientific articles, or because they were excessively small samples. This meant a total of 35 articles were selected.

The review of Suitability against the exclusion criteria showed that 24 articles did not meet our inclusion criteria for various reasons: they were case studies, not specifically related to the topic, theoretical articles, or meta-analyses, did not include all the variables under study or the variable relationships were not clear, or the samples were excessively small.

Finally, after the Inclusion phase, only 11 articles that met all the criteria were included, which we analyze below.

Results

The following categories were recorded as most relevant to the analysis and extraction of results: a) year of publication, language and publication journal; b) variables related to the sample analyzed (age of the sample, sample size, sample country, special educational needs of the sample); c) informant, and data collection method; d) emotional variables, homework and students with NDD; e) impact of individual and contextual characteristics on homework performance in children with NDD; f) interventions to enhance the abilities associated with NDD and their execution during homework.

Year of publication, language, and journal

Since 2012, research on the topic has been scarce. From 2015 to 2020 only one article was published per year, with 3 publications in 2012 and 2 publications each in 2021 and 2022. The 11 selected articles were published in English in 9 different scientific journals. Only the Journal of Attention Disorders and Learning Disabilities Research and Practice published more than one article in the last 10 years. The rest published a single article each during the decade (**Table 1**).

Variables related to the sample analyzed

The samples used in the studies varied widely. We divided them into 4 groups: between 1 and 30, between 31 and 100, more than 100 and more than 1000. The most common sample size range was the second group (36.36%), between 31 and 100. This was followed by the third group (27.27%) of samples larger than 100 subjects, while groups 1 and 4 were the same percentages (18.18%).

Looking at each sample's special educational needs, 18.18% had ADHD with some type of comorbidity; 27.27% had SEN but not defined; and 54.5% had either Learning Disabilities or ADHD. Therefore, 72.68% had neurodevelopmental disorders.

In addition, 81.82% of the sample attended primary education (6-12 years old) compared to 18.18% who were in secondary education (12-16 years old).

Most of the samples were from the USA (54.55%), with other countries only appearing in a single article each (China, Cyprus, Germany, Israel, and Italy) (**Table 1**).

Informant and data collection method

The selected articles used different information and data collection methods. How-ever, 3 articles (27.27%) addressed the three spheres involved in academic life (student-family-teacher).

Just under half of the data collection (5 articles; 45.45%) was done via questionnaires or scales, although questionnaires were also combined with psycho-pedagogical tests in 27.27% of cases. Intervention tools were used in 2 articles (18.18%) and only one article used school records linked to questionnaires and psycho-pedagogical tests (9.09%) (**Table 1**).

Table 1

Bibliometric properties and methodological characteristics of the articles included in the systematic review (n = 11)

Descriptive variable	**Fr**	**%**
Year of publication		
2012	3	27.27
2015	1	9.09
2016	1	9.09
2017	1	9.09
2020	1	9.09
2021	2	18.18
2022	2	18.18
Language		
English	11	100.0
Journal		
Journal of Affective Disorders	1	9.09
Psychology in the Schools	1	9.09
Journal of Clinical Child and Adolescent	1	9.09
Learning Disabilities Research and Practice	2	18.18
Reading and Writing	1	9.09
Journal of Attention Disorders	2	18.18
The Journal of Experimental Education	1	9.09
Journal of Behavioral Education	1	9.09
Remedial and Special Education	1	9.09
Age of the sample		
Elementary Education (6-12 years old)	9	81.82
Secondary Education (12-17 years old)	2	18.18
Sample size		
1-30	2	18.18
31-100	4	36.36
>100	3	27.27
>1000	2	18.18
Sample country		
China	1	9.09

Cyprus	1	9.09
USA	6	54.55
Germany	1	9.09
Israel	1	9.09
Italy	1	9.09
Special educational needs of the sample		
SLD or ADHD	6	54.55
ADHD + comorbidity	2	18.18
Sample not defined	3	27.27
Informant		
Self-report and family report	2	18.18
Self-report, family and teacher's report	1	9.09
Family report	2	18.18
Expert report, family and teacher's report and self-report	3	27.27
Intervention tool	2	18.18
Data collection method		
Questionnaires or scales	5	45.45
Questionnaires and psycho-pedagogical test	3	27.27
Questionnaires, psycho-pedagogical test and school register	1	9.09
Intervention tool	2	18.18
Total	11	100.0

Main findings of the studies analyzed

The main results of the studies selected for this review are presented in the following table (**Table 2**) – previously used by Álvarez-García et al. [47] – together with the rest of the information classified as relevant to the study. This template is used to summarize each article's title and authors, year of publication, journal it was published in, objective of the study, variables studied, sample and age of the sample, country of the sample, and main results related to the objective.

Table 2

Scientific articles on NDD and homework (2012-2022)

Authors	Sample	Instruments	Conclusions
Booster et al. (2012) [48]	416 students with mono diagnosis ADHD or comorbid ADHD + internalizing and/or externalizing disorders 5-16 yo	DICA-R ADHD Rating Scale – IV Behavior Assessment System for Children WIAT	- Parents of children with ADHD and a comorbid internalizing/externalizing disorder reported more problems with homework than parents of children with mono diagnostic ADHD. - Parents of older children (12-16 yo) reported significantly more homework problems than parents of younger children. - It is important to pay attention to possible comorbidities of SLD for quality interventions.
Katz et al. (2012) [49]	34 students: 50% with LD Sixth grade + families 11 yo	The Child's Inventory for Homework Stress The Parent's Inventory for Homework Stress	- Reducing stress is a necessary but insufficient condition for creating positive emotions and motivation. - The best emotional state for parents and children while doing homework are positive emotions and intrinsic or autonomous motivation.
Mautone et al. (2012) [50]	91 ADHD students + families + teachers 7-12 yo	HPQ-P HPQ-T HPC PTIQ WIAT-II Homework samples	- Parent-scored student competence was positively related to teacher-rated student competence and academic achievement. - Significant differences exist between children with and without difficulties in the variables studied. - It is important to know the individual characteristics of the students, especially if they present SEN.
Houser et al. (2015) [51]	24 students with LD 14-16 yo	Radical Raceway (RR) Intervention Program	- By using RR, homework completion and accuracy increased dramatically - 30% more students completed homework daily - When RR was removed, homework completion and

			accuracy decrease immediately and substantially - RR was an effective way to improve homework completion and homework accuracy
Multhauf et al. (2016) [52]	39 mothers with her children with LD 7-10 yo	WISC-V The Parenting Stress Index Questionnaire Dyslexia Questionnaire (ad hoc questionnaire)	- Parent training would lead to a reduction in general parental stress, dyslexia-specific stress levels, and an increase in parenting competencies - Mothers who participated in the dyslexia intervention achieved their goals in relation to homework situations
King-Sears et al. (2017) [53]	19 students: 4 with LD 12-16 yo	Pencasts Intervention Pro-gram for homework	- Pencasts improved homework performance - Allows students with LD and non-LD to flexibly use the same technology according to their needs - Pencasts are beneficial for improving learning
Friedman et al. (2020) [54]	74 students with ADHD-I and LD 7-11 yo	Woodcock-Johnson Test – III CSI COSS The Academic Competence Evaluation Scale The Homework Problem Checklist Child Life and Attention Skills (CLAS) Intervention Program	- The CLAS Program resulted in more benefits in students with ADHD-I mono diagnosis as opposed to students with ADHD-I + LD comorbidity - Supplemental LD-specific intervention is needed in this sample to reduce underlying deficits - Improvements in homework completion were found after the intervention
Touloupis (2021) [55]	271 families and their children with SLD 10-11 yo	Questionnaire on parental involvement in homework Fear of COVID-19 scale	- Parents of children with LD adopted less beneficial forms of homework involvement - There is high parental fear of COVID-19 and low resilience, which are predictive factors for this type

			of control-focused involvement - The existence of LD causes parents to be more involved in learning at home
Womack et al. (2021) [56]	4393 students (474 with IEPs) + families 10 yo	Ad hoc Questionnaire (homework help, IEP, socio-demographic characteristics, satisfaction, communication, expectations)	- Struggling students experience more difficulty with homework than their peers without educational needs - Parents of children with difficulties are more involved with homework - Parental expectations are lower for students with IEPs - Parents who communicate more with the school are more involved with homework - Parents who are more satisfied with school are less involved with homework
Xiao et al. (2022) [57]	3993 students: 114 with LD 7-11 yo	Questionnaire on Influencing Factors of Children's Chinese Reading Ability SCARED DCCC PRS CPSSS CDI-S	- There is a direct association between dyslexia and depressive symptoms, it is not direct in the case of anxiety symptoms - Stress mediates the relationship between dyslexia and anxiety/depression - Time spent on homework is a mediator be-tween dyslexia and anxiety/depression
Katz et al. (2022) [58]	108 students (54 with LD) + families 11 yo	BPNSFS The Shame and Guilt Scale HSQ	- Increased levels of stress, frustration, shame and guilt of parents when involved in the homework of their children with LD - Mediating role of shame and guilt in parents of children with LD - Shame was related to stress of parents and children with LD

Emotional variables, homework, and students with NDD

Emotional variables, such as stress, anxiety, and depressive symptoms, were ad-dressed in 45.45% of the selected articles. In addition to focusing on aspects related to mental health, the articles attempted to indicate how homework can influence certain emotional states. This is even more pronounced in students with NDD since their difficulties and needs mean that they may suffer greater personal, social, and educational mal-adjustment or even experience negative emotions such as frustration and stress at not being able to achieve the goals set for them in the school environment.

In this regard, Xiao et al. [57] found that students with dyslexia had higher scores on anxious and depressive symptomatology, assessed with the Screen for Child Anxiety Related Emotional Disorders (SCARED) [59] and the Children's Depression Inventory-Short Form (CDI-S) [60]. They also wanted to determine what kind of relationship existed be-tween dyslexia and anxious/depressive symptoms, considering the role of homework. In the case of dyslexia-anxiety, they found no direct relationship. However, they did find a direct relationship between dyslexia-depression. Conversely, stress acted as a mediating variable, so that dyslexia could cause stress-related symptoms, which could in turn cause depressive and/or anxious symptoms. In the case of homework, a variable of great interest in our review, they found dyslexia caused students to take longer to do homework, which could lead to anxious and/or depressive symptoms.

As previously stated, children's and families' emotional health is of paramount im-portance for a child's optimal overall development [35,36]. This is also significant when children who have neurodevelopmental disorders do homework. This was of interest to Touloupis [55], who decided to investigate family involvement in homework during the COVID-19 pandemic. Following a study with 271 families and their children, the conclusion was that families of children with SLD tended to show less beneficial ways of helping during homework and this type of involvement was even more visible and frequent when parents

exhibited greater fear of COVID-19 and a low sense of resilience. In line with other authors, the study concluded that families of children with SLD who scored high on "fear of COVID-19 through the fear of COVID-19 Scale (FCV-19S)[59] and a "low sense of resilience" measured by the Connor-Davidson Resilience Scale (CD-RISC)[62] were more likely to show less beneficial family involvement during homework, which could produce a more conflictual family environment, less use of patience or beneficial methods, emotional problems arising from fear and stress caused by the situation, etc.[63,64,65,66]. In turn, parents of children with SLD also showed higher levels of stress and more feelings of shame, guilt, and frustration of needs during family involvement in homework compared to parents of students without SLD [35,36,49,58]. This seems to increase the likelihood of adopting a less beneficial form of family involvement during homework, with parents controlling and exerting pressure on their children, interfering, and giving orders during the time they participate in homework [53]. In fact, and taking a study conducted by Booster et al. [48] on ADHD, homework, and comorbid disorders as a reference, students with ADHD and an internalizing and/or externalizing disorder presented more problems with respect to the execution and completion of homework tasks. This was assessed by the Diagnostic Interview for Children and Adolescents-Revised (DICA-R)[67], ADHD Rating Scale-IV (ADHD-RS-IV)[68], the Behavior Assessment System for children (BASC-2)[69], The Wechsler Individual Achievement Test (WIAT) [70] and The Home Observation for Measurement of the Environment (HPC)[71]. This is extremely important since, in addition to the presence of the attentional disorder, comorbidity with other emotional and motivational disorders can impair homework completion, leading to the use of behavioral strategies that are not adaptive during this process, and damaging children's relationships with their parents [48].

Impact of individual and contextual characteristics on homework performance in children with NDD

It has been demonstrated in research that the homework performance of students with NDD may vary depending on certain individual or contextual characteristics. This was addressed in two of the selected articles, corresponding to 18.18% of the sample.

In terms of *individual characteristics*, studies suggested that differences in homework performance may be found depending on ADHD diagnostic status and comorbidity status (with dyslexia or internalizing/externalizing disorders).

The objective of a study by Mautone et al. [50] was to understand how homework performance might change depending on these individual characteristics. They used the Homework Performance Questionnaire (HPQ) [72], a questionnaire completed by parents and teachers, composed of 3 family factors—student task orientation/efficiency, student competence and teacher support—and 2 teacher factors—student responsibility and student competence.

Specifically, Mautone et al. [50] found that scores on the HPQ-P were specific and significantly related to measures of homework behavior, academic skills, and parent-teacher relationship quality. Moreover, parent-scored Student Task Orientation/Efficiency was significantly and positively related to teacher-scored Student Responsibility. Parent-scored Student Competence was positively related to teacher-rated student competence and academic achievement. As for the teacher variables, Teacher Support rated by parents was significantly related to parents' perceptions of the quality of the parent-teacher relationship.

The sample of students with ADHD –either with comorbidity or with a mono diagnosis—were expected to have lower scores rated by teachers and families than students without. The study reported significant differences between children with and without difficulties, and that in addition, students with ADHD-dyslexia comorbidity received lower Student Competence scores than children with an ADHD mono diagnosis.

It is true that the focus of this research was on a purely academic level, with a specific sample. Nevertheless, it is important to highlight that in a comparable cohort of children with ADHD, homework performance may be negatively impacted by anxiety disorders. Indeed, the most prevalent comorbidity of ADHD is with internalizing disorders [17,73,74]. The coexistence of an anxious disorder may result in diminished performance in educational tasks, such as homework [75].

Another influential characteristic is contextual since it is related to family involvement in homework. This involvement is what causes students to complete their homework and also significantly improves their performance because it encourages better study habits, generates positive feelings towards academic tasks, improves their emotional development and supports their self-esteem [31, 32, 56, 77]

In some studies [54,74], ordinal logistic regression indicated that certain individual and contextual variables influenced the quality and type of involvement. One of these in-dividual variables was the POC or "parents of color" variable. The authors found that non-white parents were less likely to be involved in homework. In fact, it seems that this involvement existed but only in the family environment, without extending to the school.

Another variable referred to effective collaboration between school, family, and community, as explained in Epstein's model [23,28]. This improvement-oriented collaboration with children with NDD has been demonstrated to lead to positive outcomes in their holistic development [24,77].

Interventions to enhance the abilities associated with NDD and their execution during homework

Due to the great debate surrounding homework, various interventions and methods to improve how it is implemented have been performed, considering some of the personal and

contextual variables mentioned above. Just over a third (36.36%) of the selected articles were along these lines. Of the four intervention programs identified in the results, only two addressed emotional aspects, the study by King-Sears et al. [53] and the study de-signed by Multhauf et al. [52].

One of these interventions was a program called Child Life and Attention Skills (CLAS) [78], which consisted of three empirically supported behavioral interventions tailored to children with ADHD inattentive subtype (ADHD-I) and with comorbidity be-tween ADHD and SLD. The objective was to carry out behavioral training with the par-ents, as well as training the child's academic skills and relying on daily reports from the teacher. The authors looked at a sample of 74 children with an ADHD-I mono diagnosis and the intervention with CLAS, showing that it is an effective program for improving performance and organization during homework in students with neurodevelopmental disorders, although there were differences between students with ADHD-I and students with comorbid ADHD and SLD. For example, although all children showed large improvements after the intervention, children with comorbid SLD and ADHD-I demonstrated greater problems with homework than those with an ADHD-I mono diagnosis. The intervention led to the conclusion that the optimal emotional state for both parents and children with NDD is one in which positive emotions are present, stress and other anxious symptoms are reduced, and there is a high level of intrinsic motivation.

Another of the interventions focused on new technologies, in this case, applied to chemistry in secondary school. The study used a methodology focusing on the use of Pencasts using the Livescribe Smartpen. A Pencast is an interactive document that can be accessed online and allows students to listen and view handwritten notes and recorded audio prepared by the teacher to work on content. Smartpens are equipped with a microphone for audio recording and an infrared camera that simultaneously tracks the written content or drawing on microdot paper, matching it with verbal content. Students would therefore have access to all

this visual and verbal content to review what they need and do their homework more effectively using this technology. Pencasts for homework problems allowed students with and without NDD to flexibly use the same technology to individualize practice and review content out-side of school hours. The methodology was applied with 19 students, 4 of whom had NDD, and the results show that students benefited from using Pencasts to enhance learning and improve performance in chemistry. Students with NDD specifically used Pen-casts regularly, which helped them work on organization, self-regulation, access to con-tent, and review skills. Moreover, the teacher's records showed that the homework completion rate was 80.5%, also improving the score on that homework, leading to the conclusion that using electronic techniques to do homework is an effective methodology for im-proving academic results and motivation [53].

Considering the importance of homework design and the accompanying feedback as a necessary condition to foster interest and autonomous motivation during homework completion, an intervention called Radical Raceway (RR) was developed that focuses on gamification components. It focuses on small group work and uses mystery motivators and interdependent group contingencies.

The study implementing the Radical Raceway intervention used a sample of 24 students with IEPs and sought to examine the effects this multicomponent intervention to see how it might influence homework completion and accuracy. The results confirmed its effectiveness, as homework completion and accuracy increased immediately and markedly. Furthermore, various studies have shown that RR is an effective way of improving homework performance for students both with and without special needs [51,79]. Moreover, for students with some type of need and who have IEPs, a significant improvement was also seen when using RR. Finally, there was social acceptance from teachers as they felt that it was an intervention that required little time or effort and significantly improved students' performance on their

assignments. Similarly, students also rated RR as an important strategy and a procedure they liked [51].

As already mentioned, the family is a cornerstone of children's education. The need to provide families with information about different educational needs in order to improve their involvement during homework is now well known. Specific training for parents of children with dyslexia was addressed in the article by Multhauf et al. [52]. This group-based cognitive-behavioral intervention for parents of children with dyslexia proved effective as it improved parental stress, dyslexia-related specific stress, and parental competencies to be beneficially involved in homework. The study involved a sample of 39 mothers of only children with dyslexia with an experimental group that received the intervention on emotional and motivational aspects and a control group that did not.

The results regarding parental competencies in dealing with dyslexia are particularly encouraging because the data indicate the effectiveness of the program, which was observed by assessing the mothers with the Parenting Stress Index (PSI) [80] and an ad hoc questionnaire designed to measure the specific effects of the training. The results provide important information. For example, the effects of the intervention were consistent regard-less of where the homework was done, although mothers showed higher levels of stress if their children only did homework at home, as they needed to spend more time and effort on completion of these tasks with appropriate strategies. Where this intervention was implemented, mothers felt more confident in facilitating literacy acquisition and acquired techniques to motivate their children during homework, in addition to reducing their stress levels during homework with improved parental competencies [52,81].

Discussion

This paper reviewed the studies published from 2012 to February 2023 on homework and pupils with neurodevelopmental disorders in both elementary and secondary education, in order to determine the variables influencing this relationship, the individual and contextual factors that could mediate it, and the relationship between the two concepts, also considering methodological characteristics and bibliometric properties. The results show that scientific production on this subject has been rather scarce, and in fact one might say that scientific research on the relationship between homework and neurodevelopmental disorders is non-existent in Spain and is deficient at the European level, where only 4 articles have been published in the last 10 years. This is an important gap, as more studies with samples from more countries are needed, as well as more research on the subject at European level, where homework has been the subject of great debate and social and educational interest. In addition, it is important to highlight that there is far less research if we restrict ourselves to variables referring to SEN or NDD.

After analyzing the 11 articles identified for our study, it is worth mentioning the prevalence of neurodevelopmental disorders such as ADHD and SLD, sometimes occur-ring in comorbidity both with each other and with other internalizing and externalizing disorders. This conclusion, in relation to homework, has allowed different studies to af-firm that many students consider homework to be a "chore" [82] and it can even be an is-sue that causes conflict at home [29]. In relation to this, students with NDD were found to have higher levels of stress related to homework compared to students without needs [53].

In this regard, self-determination theory [83] posits that good emotional state of both parents and children produces positive emotions and autonomous motivation during task performance. This becomes even more important when there is an NDD. As previously

reported, the presence of NDD in children is associated with an increased risk of parental anxious and/or depressive symptomatology [33,34]. In this regard, recent re-search has demonstrated that the more stressed parents of these students were, the more they perceived that their needs were frustrated while helping with homework, and there-fore, the more they felt ashamed, guilty, and stressed [84].

What we saw from the selected studies is that, on the whole, this parental involvement in homework, when it is good support and guidance, free from harmful emotions, becomes even more important for students with NDD, and is a necessary variable for children's school performance, as it results in a positive emotional state and an increase in intrinsic motivation [49,85]. Furthermore, in relation to the support that children with NDD require, it has been claimed that children with SLD tend to require more help from their parents compared to peers without SLD [86].

It is also important to increase the amount of research in secondary education, as most of the articles we identified used elementary-school samples (81.82%). Although as-signing homework in secondary education has different characteristics from elementary-education homework, it is still part of compulsory schooling and therefore more re-search with children aged 12 to 16 would promote understanding of the influential variables at this stage of schooling and would also allow us to determine differences in contextual variables such as family involvement.

Only 2 articles from our sample reported using a secondary-school sample and both referred to methods or intervention strategies that improve homework performance. Au-thors such as Mendicino et al. [85] have stated that digital systems that provide tutoring, modelling, scaffolding, and feedback about process and errors, positively influence learn-ing and homework completion. Despite this, interventions that aim to improve homework execution in

students with NDD do not tend to focus on emotional aspects such as those discussed in the present article.

One of these programs is Child Life and Attention Skills (CLAS) [78]. The study assessing it demonstrated significant improvements in academic aspects such as attention, social skills, organization, and overall functioning rated by teacher; contextual aspects such as organization during homework rated by the family; and especially in emotional aspects such as the realization that positive emotions, reduced stress, and good motivation are needed for the rest of the consequences to be possible [78]. It is used with students with ADHD inattentive subtype (ADHD-I) and with comorbidity between ADHD and SLD and tries to break away from traditional ADHD interventions that only focus on problem behaviors, seeking to reduce hyperactivity and impulsivity. These results indicate the need for intervention strategies and programs to work on comorbidities in NDD, such as ADHD and SLD.

The other program concerning work on emotions is aimed at working from the con-textual point of view, given the potential influence of NDD on parents' mental health and the impact of this parental mental health on the development of children with NDD. The aforementioned intervention [52] enabled mothers of children with SLD, such as dyslexia, to reduce their maternal stress related to both NDD and homework completion, and to in-crease their competencies for coping with their children's personal, academic, and emotional challenges.

The two programs most closely related to the academic impact of homework, Radical Raceway [51] and Pencasts [53], produced the following insight. It can be demonstrated that a supplementary intervention, which is specific to NDD, is necessary to address the multiple underlying deficits, including those related to behavioral and emotional domains [54].

In conclusion, it is crucial to recognize that homework is not solely a component of the academic environment; it is primarily conducted within the home environment, where parental involvement is of paramount importance. In the context of children with neuro-developmental disorders, it is particularly important to prioritize emotional aspects, given their influence on both children and parents, and the potential for anxiety and depressive symptoms to manifest in a direct manner.

Conclusions

The results of this review have significant implications for the field of research on neurodevelopmental disorders. This becomes even more pertinent when we consider the paucity of research in this area, particularly in relation to the widely debated and important topic of homework and the role that parents play in this regard, from an emotional and psychological perspective. For this reason, the practical implications at educational, family, policy and mental health levels are discussed.

The results of the present review indicate that emotional state is a priority in the educational sphere. Pupils with neurodevelopmental disorders are often found to exhibit compromised emotional states, which are frequently associated with comorbid disorders such as anxiety and depression. In this regard, educational professionals need to be trained in mental health in order to be able to prevent this symptomatology at a general level, but especially for pupils with some educational need. It is in the educational environment that quality involvement with the family must be sought, focusing on quality two-way communication that allows the generalization of such interventions at an emotional level to cope with academic demands at home, for example through homework. When it comes to homework, it is clear that setting homework is universal in many countries, irrespective of the presence of a neurodevelopmental disorder. Homework not being adjusted to the needs of the pupil can give

rise to emotional difficulties, which in turn can result in increased stress and anxiety, negatively impacting performance. Consequently, education professionals must receive training to enable them to tailor homework to individual characteristics and needs.

It is important to bear in mind that NDDs in children can also cause a certain emotional maladjustment in parents, which in turn leads to a parenting style that it is not beneficial for the child's development. Consequently, it becomes even more important to develop intervention programs aimed at families so that they can adjust their emotions to the needs of their children and acquire the necessary skills to cope with the academic tasks assigned by teachers. Furthermore, the emotional difficulties experienced by parents of children with NDD have been exacerbated by the COVID-19 pandemic. This means continuity of family support must be provided to these parents in order to prevent a deterioration of their mental and emotional health. Despite the aforementioned considerations, it is important to note that interventions to enhance homework performance in children with NDD cannot solely focus on emotional or behavioral aspects; instead, they have to incorporate academic measures to address other affected academic domains, such as attention, self-regulation, and academic performance.

At the policy level, the most notable implication is the importance of promoting inclusive policies that are in line with the care and enhancement of mental health in all spheres in which children with neurodevelopmental disorders develop. This may also benefit the family during academic tasks or other challenges in the child's day-to-day life. It would be beneficial to design early detection programs and provide access to mental health services for students and families that combine educational work, social work, family work and mental health work.

For mental health professionals, these implications suggest the need to improve communication and collaboration with schools in order to provide comprehensive support to

students with neurodevelopmental disorders and their families. Consequently, specific intervention programs need to be developed for both families and students. In addition, education professionals need high-quality training in order to facilitate early detection and intervention.

The present study is subject to a number of limitations. The sample of articles was small, as the publication of studies on the topic is very limited so far. The selected sample combines studies that also included interventions and that did not solely focus on studying the relationship between NDD and homework, which may lead to some variability in the design, methodology and measures used. Another limitation relates to terminology, as there are differences between countries when referring to special educational needs. Similarly, the term "family involvement" has several facets and considerations [32,33] such as "bonding", "parent-child interaction", "parenting practices", "academic support", which should be considered in future research. Finally, although this study was undertaken considering the Overlapping Spheres of Influence model, it would be interesting to address this same research objective using another model or perspective, such as Bronfenbrenner's ecological model, and therefore consider the infant mesosystem (that is, the interactions between two or more microsystems: family and school, neighborhood, and family, among others). Consequently, this review emphasizes the need for further research to clarify the relationship between neurodevelopmental disorders and homework, with particular con-sideration of family involvement and the emotional status of both parents and children.

Author Contributions

Conceptualization, A.A., D.A. and T.P.-L.; Methodology, A.A, J.C.N. and C.R.; Investigation, A.A. and T.P.-L.; Resources, J.C.N., C.R. and D.A.; writing—original draft preparation, A.A.; writing—review and editing, D.A. and C.R.; supervision, J.C.N. and C.R.;

project administration, J.C.N. and C.R.; funding acquisition, A.A., C.R., and J.C.N. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declared no conflict of interest.

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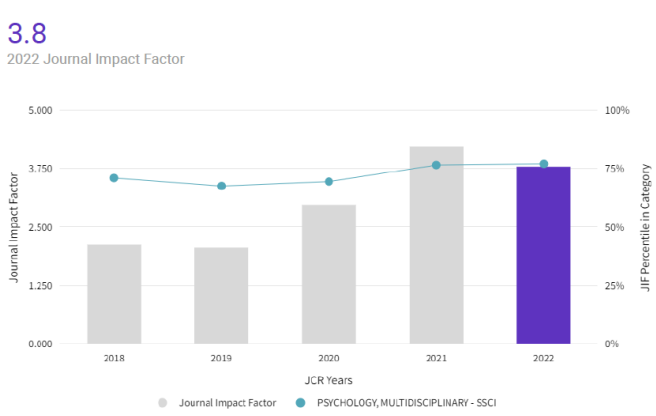
Informe del Factor de Impacto de las publicaciones

En este apartado, se presenta un informe referente al Factor de Impacto de las revistas en las que se han publicado los artículos mencionados. Los tres artículos publicados se encuentran publicados en revistas incluidas en JCR Social Science Edition. La información que se presenta se extrajo de la web Journal Citation Reports de Clarivate, exponiéndose tanto el Factor de Impacto, como el Ranking según la disciplina y otros datos de interés:

Frontiers in Psychology. Esta revista tiene un Factor de Impacto = 3.8 en el año 2022. En la categoría de "*Psychology, Multidisciplinary*" se ha situado en el puesto 34 de 147 revistas incluidas en esta categoría, lo que la sitúa en el primer cuartil (Q1).



EDITION
Social Sciences Citation Index (SSCI)
CATEGORY
PSYCHOLOGY, MULTIDISCIPLINARY
34/147

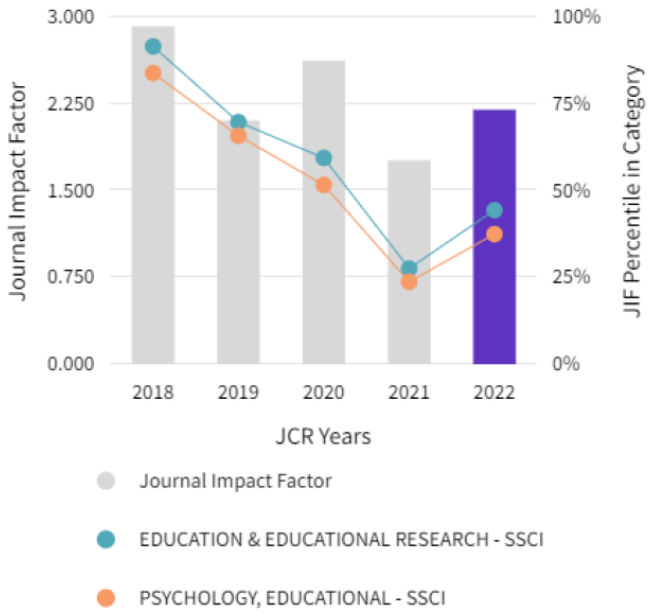
JCR YEAR	JIF RANK	QUARTILE	JIF PERCENTILE
2022	34/147	Q1	77.2
2021	35/148	Q1	76.69
2020	43/140	Q2	69.64
2019	45/138	Q2	67.75
2018	40/137	Q2	71.17
2017	39/135	Q2	71.48
2016	33/129	Q2	74.81
2015	29/129	Q1	77.91
2014	23/129	Q1	82.56
2013	20/129	Q1	84.88

Journal of Experimental Education. Esta revista tiene un Factor de Impacto = 2.2 en el año 2022. En la categoría "*Education and Educational Research*" se ha situado en el puesto 150 de 269 revistas incluidas en esta categoría, lo que la sitúa en el tercer cuartil (Q3). En la

categoría "*Educational Psychology"* se ha situado en el puesto 38 de 60 revistas incluidas en esta categoría, lo que la sitúa en el tercer cuartil (Q3).

2.2

2022 Journal Impact Factor



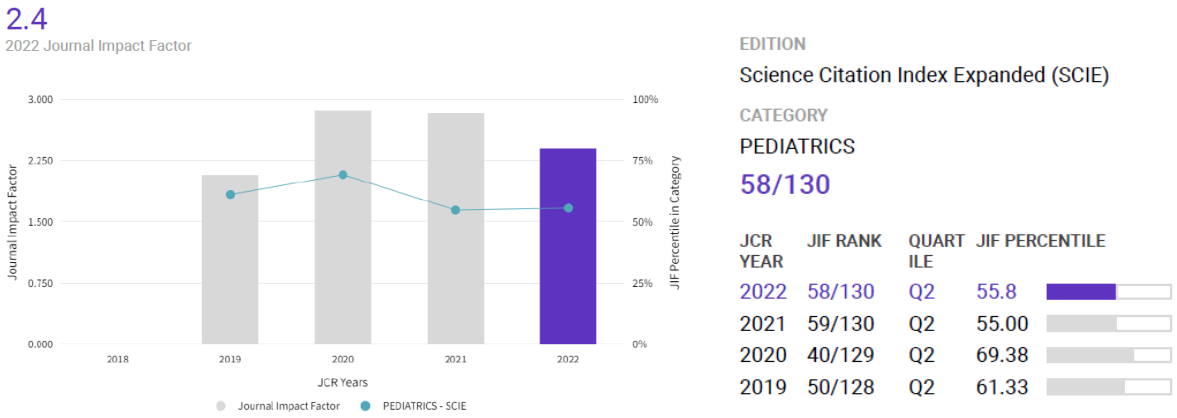
EDITION
Social Sciences Citation Index (SSCI)
CATEGORY
EDUCATION & EDUCATIONAL RESEARCH
150/269

JCR YEAR	JIF RANK	QUARTILE	JIF PERCENTILE
2022	150/269	Q3	44.4
2021	196/270	Q3	27.59
2020	108/265	Q2	59.43
2019	80/263	Q2	69.77
2018	21/243	Q1	91.56
2017	65/239	Q2	73.01
2016	58/235	Q1	75.53
2015	37/231	Q1	84.20
2014	64/224	Q2	71.65
2013	114/219	Q3	48.17

EDITION
Social Sciences Citation Index (SSCI)
CATEGORY
PSYCHOLOGY, EDUCATIONAL
38/60

JCR YEAR	JIF RANK	QUARTILE	JIF PERCENTILE
2022	38/60	Q3	37.5
2021	47/61	Q4	23.77
2020	30/61	Q2	51.64
2019	21/60	Q2	65.83
2018	10/59	Q1	83.90
2017	19/59	Q2	68.64
2016	24/58	Q2	59.48
2015	21/57	Q2	64.04
2014	33/55	Q3	40.91
2013	43/53	Q4	19.81

Children. Esta revista tiene un Factor de Impacto = 2.4 en el año 2022. En la categoría de "*Pediatrics*" se ha situado en el puesto 58 de 130 revistas incluidas en esta categoría, lo que la sitúa en el segundo cuartil (Q2).



Trabajos complementarios

Estudio 3

García, T., Núñez, J.C., Abín, A., Van der Ven, S., Cueli, M., Valle, A., y Rodríguez, C. (under review). Motivational profiles and mathematical performance in students from 7th to 10th grade: a person-centered perspective. *International Journal of Educational Research.*

Estudio 3

En la presente Tesis Doctoral se incluye un trabajo complementario que se encuentra actualmente en proceso de revisión en la revista *International Journal of Educational Research*. Este trabajo se corresponde con el estudio 3.

Motivational profiles and mathematical performance in students from 7th to 10th grade: a person-centered perspective

Trinidad García, José Carlos Núñez, Amanda Abín, Sanne Van der Ven, Marisol Cueli, Antonio Valle y Celestino Rodríguez

Abstract

This study aimed to identify different motivational profiles in a sample of 2,282 students (grades 7 to 10) from Spain, based on the combination of three main goals (Mastery goals, Performance goals, and Performance-avoidance goals). We also examined gender and school year effect in the relationship between these profiles and mathematical performance. Four motivational profiles were identified via Latent Profile Analysis: Average All Goals Profile, Approach High Profile (high scores in Mastery and Performance goals, with low scores in Performance-avoidance goals), High All Goals Profile, and Low All Goals Profile. A higher number of girls was found in the Approach High Profile, with boys predominating in the other three profiles, especially High All Goals, and the Low All Goals Profile (demotivated profile). In addition, there were statistically significant differences between the motivational profiles in mathematical performance. Students in the High All Goals Profile statistically outperformed the other three profiles, which exhibited no differences between them. School year also produced some differences, with students in the later years of secondary school demonstrating low motivation in all achievement goals (Low All Goals Profile). These results are discussed in light of previous research on Person-centered approaches and especially the synthesis by Wormington and Linnenbrink-García in 2017, from which practical and research implications arise.

Keywords: Motivational profiles; Mathematics performance; Secondary school; LPA

Introduction

Students do not always find it easy to learn mathematics, often finding the logical nature of the subject a challenge, as well as having difficulty grasping the usefulness of what they are learning (Cipkova et al., 2019; García et al., 2016). International reports such as the Program for International Student Assessments (PISA), which assesses students' knowledge and skills

in reading, mathematics, and science, show that mathematics is one of the most difficult areas for secondary school students. Overall, 15% of the students assessed in the PISA report were only proficient at the most basic level of mathematics knowledge. In addition, in 26 countries, between 20% and 50% of students did not reach this first level of mathematics' knowledge (Organization for Economic Co-operation and Development [OECD], 2019).

Among the factors involved in learning mathematics, motivation has been the focus of various studies (e.g., Chen & Lin, 2020; Mercader-Rubio et al., 2022; Rojo-Robas et al., 2020). This variable can both increase and hinder students' desire to participate, learn, and discover, which will in turn affect attitudes towards the subject and future performance (Graesser et al., 2022; Regueiro et al., 2018). Within this perspective, it has been suggested that students' success in achievement settings might be influenced by the motives (goals) they have (Wormington & Linnenbrink-García, 2017). However, there is still debate about which goal orientation—or combination of orientations—is more adaptive for students.

The objective of the present study is to provide evidence, from a person-centered perspective and based on a large sample of adolescents (7^{th} to 10^{th} grade), about the combinations of goals that they exhibit, establishing different goal profiles and examining how adaptive they are (in terms of mathematical performance). The study also seeks to determine whether gender and school year can affect the expression of these profiles and mathematical performance.

Achievement Goal Theory (AGT)

Motivation explains the beginning, direction, and perseverance of goal-oriented behavior (Atit et al., 2020; García et al., 2016; Pintrich, 2000a, 200b). Linnenbrink and Pintrich (2002) define motivation as a dynamic, multifaceted phenomenon. Thus, any attempt to

understand a student's motivation must consider multiple aspects, such as their goals and values, among other factors.

Many authors have studied the motivational implications of academic goals, establishing a classification of the different types of goals. The Achievement Goal Theory (Dweck & Leggett, 1988), identifies two types of orientation: *Mastery goal orientation* and *Performance goal orientation* (Elliot & Dweck, 1998). Mastery goal orientation involves a personal intention to learn and to improve one's ability and skills (developing competence); while Performance goal orientation involves demonstrating competence, often relative to others (Wormington & Linnenbrink-García, 2017). Thus, students who exhibit the first type of motivation are not concerned about demonstrating competence in comparison to others, but rather their academic dynamic is focused on achieving ambitious goals and persisting despite possible failures or problems. On the other hand, students who display Performance goal orientation compare their performances to others. Performance goals can be further divided into the goal of demonstrating competence in front of others—*Performance-approach goals*—and avoiding unfavorable judgments about their competence (alternatively: avoiding failure in front of others)— or *Performance-avoidance goals* (Elliot & McGregor, 2001). Our study focuses on these three main orientation goals: *Mastery-approach* go*als, Performance*-approach goals, and *Performance-avoidance* goals.

Each of these goals results in a distinct pattern of success and educational outcomes. According to earlier research, Performance-approach and Mastery-approach goals are both positively correlated with academic success, but Performance-avoidance goals are adversely correlated with interest and performance (e.g., Guo et al., 2022; Luo et al., 2011). Skaalvik (2018) reported an association between different goal orientations, anxiety, and coping strategies related to mathematics learning. In a sample of middle school students, they found that having a Mastery-approach goals perspective was positively related to the use of

responsive problem-focused coping mechanisms, reduced levels of mathematics anxiety, and less use of maladaptive self-protective coping strategies. In contrast, showing Performance-avoidance goals had the opposite effect. However, concerning Performance-approach goals, there is some disagreement about whether endorsing them may be always beneficial (Huang, 2011). In Skaalvik´s (2018) study this approach was not associated with mathematics anxiety or self-protective coping mechanisms but was weakly negatively correlated with problem-focused coping strategies. In contrast, Scheltinga et al. (2016) found that Performance-approach goals were the most adaptive profile in terms of performance in Dutch, English and mathematics in their sample of 13,970 Dutch secondary school students. In addition, classroom-based research has found maladaptive effects of Performance-avoidance goals in terms of engagement, affect and achievement (Huang, 2011; Wormington & Linnenbrink-García, 2017). However, as those authors indicated, there are inconsistencies between studies, either because of how goal profiles are labelled or by the data analysis approach used, which can explain different results.

Person-centered approach research

Previous studies have shown that orientation goals can be combined, resulting in a *Multiple Goal Perspective* (Horstra et al., 2017; Inglés et al., 2015; Mansfield & Wosnitza, 2010; Wormington & Linnenbrink-García, 2017). Students can pursue both Mastery and Performance goals at the same time, focusing on one or the other depending on their individual characteristics, the academic task, and other contextual variables. From this viewpoint, it makes sense to talk about *motivational profiles* as opposed to motivation.

In this line, Horstra et al. (2017) conducted a cross-sectional study with 722 students aged 8-12, examining the relationship between motivational profiles and performance in language and mathematics. Their results showed that a profile characterized as High Mastery

goals and Low Performance and Avoidance Approach goals would be associated with higher performance. Similarly, Wormington and Linnenbrink-García (2017) conducted a review of motivational profiles including multiple studies (from primary school to college). They found ten different profiles, showing that students with a high level of Mastery-approach goals and with average or low endorsement of performance and work-avoidance goals (Mastery High profile, 13.02% of the sample studied) systematically showed an adaptive profile in terms of motivation, well-being, engagement and achievement. The Approach High profile (high endorsement of Mastery-approach and Performance-approach goals, with average or low endorsement of Avoidance goals) was present in 14.29% of the studies and was also adaptive, demonstrating higher levels of achievement than in the first group, though slightly lower levels in other indicators. They also found a High All Goals profile (10.07%; high levels in Mastery, Performance-approach and Performance-avoidance goals), which showed higher levels of well-being than other profiles, as well as good levels of motivation, engagement and achievement. On the other hand, less adaptive profiles in terms of motivation and engagement were found in the Average All Goals (37.12%) and the Low All Goals (1.95%) profiles. The first group also showed lower levels of well-being than students with the previous profiles, while the second group showed the lowest levels of achievement out of the ten profiles, and considerably low levels of engagement. Nevertheless, the percentage of studies finding that last profile was 1.95% of the total sample of studies. They also found interesting results concerning profiles including avoidance goals: a group with high levels of avoidance, labelled Work-Avoidance High (0.58% of the sample of the studies), and a group consisting of students with low work Avoidance and/or Performance-avoidance goals but average Mastery and Performance-approach goals, labelled by the authors as Performance/Work Avoidance Low (3.39% of the studies). The first was maladaptive in terms of well-being and was associated with lower levels of engagement (no information was provided for achievement), while the

second was adaptive for almost all the indicators (quite adaptive for engagement, but especially adaptive for achievement motivation and engagement).

On the other hand, Inglés et al. (2015) looked at a sample of 2,022 Spanish secondary school students and showed that motivational profiles were not only related to performance, but also to the attribution of success or failure. They identified four motivational profiles: A group with a high overall motivation profile, a group with a reduced generalized motivation profile, a group with predominance of learning (Mastery) goals and achievement goals, and a group with predominance of social reinforcement goals (i.e., avoidance of failure). Students with a high motivation for Mastery and Performance and less tendency to Avoidance exhibited the most adaptive attribution pattern (attributing their successes to competence and effort). Nevertheless, the complex framework behind the study of motivational orientation goals is not complete if some variables, such as gender and school year, are not considered.

Gender, school year, and motivational profiles in the mathematics

Some previous studies have advocated the need to consider gender and school year in the expression of different motivational profiles and their implications for learning and performance. Wach et al. (2015) found, in a sample of 140 boys and 185 girls at fifth grade, that girls seem to report greater interest and effort towards the task (Mastery goal), while boys tend to report more interest in achieving a good performance because of the social recognition it will lead to. Moreover, they also found that boys assessed their mathematics abilities based on their cognitive ability while girls did so based on their expectations and beliefs, leaving intelligence aside. Previously, Thorkildsen and Nicholls (1998), had reported an increased presence of learning goals in girls, who would exhibit goals focused on the self, on Performance and Avoidance approaches. In their study, girls also demonstrated greater intrinsic interest and

effort in the task (Mastery goals), while boys reported being more inclined to achieve a good Performance because of the social recognition that would entail.

Also, González-Torres and Torrano (2013) conducted a study with 374 high-school students and found that, overall, boys were more oriented toward Performance goals than girls, tending to seek favorable judgments of competence and to avoid rejecting judgements.

However, other studies have suggested a more adaptive motivational profile in boys than in girls. Liew et al. (2014) observed that girls had higher levels of Avoidance goals than boys but found no significant differences in mathematics achievement between them. Valle et al. (2016a) also found some gender differences in a trial of 897 students from fifth and sixth grades. Boys exhibited higher perceived competence in mathematics, lower levels of anxiety, and higher levels of intrinsic motivation (Mastery goals) than girls. They also reported more positive attitudinal and motivational states in fifth grade than in sixth grade, showing that mathematics interest tends to diminish over time.

Nevertheless, while in mathematics male students have traditionally been reported to have higher achievement, recent studies suggest that this relationship is not always observed. Steegh et al. (2019), for instance, indicated that gender differences in mathematics cannot be explained by gender disparities among top performing students alone. Leder and Forgasz (2018) suggested that such differences might depend on the mathematics domain to be considered. In any case, there are also studies suggesting that gender differences in mathematics performance, if present, tend to disappear at undergraduate levels (Arroyo-Barriguete et al., 2023), and even some advantages can be found in favor of female students (Voyer & Voyer, 2014). More recently, Reilly et al (2019) showed that gender differences in this domain might not be universal, as there is considerable cross-cultural variability.

Looking at the effect of school year, Mansfield and Woznitza (2010) found that students in their first year of secondary school tended to show higher levels in all goals (High All Goals profile) than in subsequent school years. This is consistent with the analysis by Wormington & Linnenbrink-García (2017), who concluded that this profile was more frequently presented in elementary-aged samples than in middle school, high school, or college students, while profiles characterized as low goal endorsement (e.g., Low All Goals) were not identified among elementary school students. Also, Lazarides et al. (2016) found a decrease in motivation at the end of secondary school, which is in line with previous studies such as Frenzel et al. (2009).

The present study

In the last decade, mathematics has been recognized as one of the topics of greatest interest in educational research (Huang et al., 2019), given its application in all areas of life (Graesser et al., 2022). Motivation has been conceptualized as one of the greatest determinants of learning in general (Hattie et al., 2020; Wigfield et al., 2012), and for mathematics in particular (Lazarides et al., 2020). From the various approaches referring to motivation (Murphy & Alexander, 2000), most research has used a variable-centered approach (Hong et al., 2020). In other words, although motivation is composed of multiple factors (Hattie et al., 2020), research has frequently ignored this fact, analyzing each dimension separately in its relationship with the various processes and results (e.g., engagement, effort, procrastination, self-regulated learning, achievement).

Perhaps, given that the most important approaches to motivation (e.g., Expectancy-value Theory, Achievement Goal Theory, Attribution Theory, Social Cognitive Theory, and Self-determination Theory) recognize that particular motivation variables interact with each other to influence the learning process (Koenka, 2020), a person-centered approach has been adopted in an increasing number of studies (Fong et al., 2021; Held & Hascher, 2023; Hong et

al., 2020; Jiang & Zhang, 2023; Ketonen et al., 2023; Lazarides et al., 2020, 2022; Lee et al., 2020 ; Oppermann et al., 2021; Parhiala, et al., 2018; Raufelder et al., 2022; Wormington et al, 2012; Xu, 2023). The assumption with this approach is that individuals can, at the same time, exhibit different types of motives for getting involved in tasks (e.g., academic, social), and that this personal combination of reasons could explain inconsistency in the results of studies using a variable-centered approach. For example, studies based on Achievement Goal Theory have shown a consistent positive relationship between Mastery-approach goals, learning and performance, while the effect of Performance-approach goals has been only very rarely or inconsistent (Hulleman et al., 2010). These inconsistencies have led researchers to consider a multiple-goal perspective (Barron & Harackiewicz, 2001). However, rather than exclusive, the two perspectives (variable-centered and person-centered approaches) are necessarily complementary (Wormington & Linnenbrink-García, 2017). Also, as those authors noted, the use of different labels for motivational profiles in previous studies makes it difficult to compare findings and reach generalizable conclusions on the frequency and adaptive nature of the different combinations of motives.

This study aims to identify different motivational profiles in a large sample of secondary school students from Spain, as well as the profiles' relation to academic achievement in Mathematics, considering the possible effect of gender and school year in this relation and in the expression of the different profiles. Based on the results of previous studies—especially those seeking profiles based on the same three goals used in the present study: Mastery-approach, Performance-approach, and Performance-avoidance goals (e.g., Luo et al., 2011)—and mostly based on the synthesis and labeling system by Wormington and Linnenbrink-García (2017), we formulate the following hypotheses:

1. Different profiles will be identified as combinations of the three goals (i.e., mastery-approach, performance-approach, and performance-avoidance). Some of these profiles

will correspond to those found by Wormington and Linnenbrink-García (2017), the most common will be: (i) Average All Goals profile (AAGP) (average endorsement of all goals, with no goals meeting the criteria to be considered high or low); (ii) Approach High profile (AHP; high endorsement of Mastery-approach and Performance-approach goals, with average or low endorsement of Avoidance goals); (iii) Mastery High profile (MHP; high Mastery-approach goals, with average or low endorsement of Performance and Avoidance goals); and (iv) High All Goals profile (HAGP; strong endorsement of all achievement goals, including Avoidance goals).

2. Considering the results from Wormington and Linnenbrink-García (2017), students with the Approach High profile, High All Goals profile, and the Mastery High profile will demonstrate more adaptive profiles (in this case, greater mathematical performance) than the Average All Goals profile.
3. School year and gender may act as moderator variables for both the expression and adaptive nature of goal profiles (i.e., Mathematics achievement). Based on previous literature, male students would exhibit more adaptive profiles in terms of achievement than girls. However, also according to more recent studies, it is possible that these differences will not be found. Concerning school year, students in the later years of Secondary School will probably demonstrate lower academic achievement in Mathematics and lower goal endorsement (e.g., Average All Goals profile) than students in the earlier years (Wormington & Linnenbrink-García, 2017).

Materials and Methods

Participants

This study examined a sample of 2,263 secondary school students (12 to 16 years old) from various schools in northern Spain. The proportions of girls and boys in the total sample

were similar (girls: 49.74%). The participants were in one of the four years of compulsory secondary education (corresponding to the 7th to 10th grades in other educational systems but without making a step change). The 4 years are part of the same educational stage and therefore students commonly stay at the same school during the whole period. The distribution by school year was as follows: 7^{th} grade = 18.3%, 8^{th} = 21.7%, 9^{th} = 30.5%, and 10^{th} = 29.5%.

Nine schools were initially asked to participate, randomly selected from the total of 66 schools in the central urban area in the Principality of Asturias (north of Spain), where students' families generally have a medium socio-economic level. Three of the nine selected schools decided not to participate, so the authors resorted to convenience and accessibility procedures to select three new schools. In addition, a small number of students in each school did not participate (e.g., absent from one or more of the evaluation sessions or lacking permission from their family). Students from a migrant background made up 9.2% of the sample (6.7% South American, 0.9% Asian, 0.4% African, 1.2% Romany).

Instruments

Motivation goals were evaluated through Questionnaire for the Assessment of Academic Goals in Secondary School (CEMA-II; Núñez et al., 1997). This questionnaire was developed according to the Achievement Goal Theory, and was additionally based on the contributions of earlier instruments (for example, the questionnaires by Hayamizu and Weiner, 1991; and by Skaalvik, 1997). CEMA-II has been used in various studies to assesses different types of academic goals, both in the typical population (e.g., Regueiro et al., 2018; Valle et al., 2016b) and in students with learning difficulties (e.g., Núñez et al., 2011). In all cases, the reliability of the scale was good.

Although there are other questionnaires on motivation and academic goals for Spanish-speaking students, they tend to focus on aspects such as interest and expectations (e.g., *Patterns*

of Adaptive Learning Survey; Midgley et al., 2000); expectations, values and affectivity (e.g., *Motivational Strategies for Learning Scales*; Suárez & Fernández, 2005); or positive judgments on competence (e.g., *MAPE-II: Motivation Towards Learning or Execution;* Montero & Alonso, 1992). Therefore, the CEMA-II seems to be the most appropriate instrument to pursue the research objective in our context. This questionnaire was implemented during the second semester of the academic year (spring semester).

We used three scales to measure three types of goals: *Mastery-approach Goals* (6 items, e.g. "I strive in my studies because learning makes me more competent"; $\alpha = .86$), *Performance-approach Goals* (6 items, e.g. "I strive in my studies because I want to have one of the best academic records in my class"; $\alpha = .81$) and *Performance-avoidance Goals* (6 items, e.g. "I usually avoid getting involved in tasks that might make me look stupid"; $\alpha = .82$). Students indicated how much they agreed with the statements on a Likert scale from 1 (strongly disagree) to 5 (strongly agree).

Mathematical performance was obtained based on students' achievement in a mathematics performance test set for each academic year based on the curriculum for that educational stage. Conceptual and procedural knowledge were evaluated through tasks designed by the tutors (mathematics teachers who participated in the research), common to all schools. Given that the tests had different numbers of items and the scoring of the different tasks had different weighting, the final score was based on a single five-point scale: 1 (minimum) to 5 (maximum). The mathematics test was completed by students at the end of the spring semester.

Procedure

The study was carried out in accordance with The Code of Ethics from the World Medical Association (Declaration of Helsinki), which reflects the ethical principles for research

involving humans (World Medical Association, 2013). The Ethics Committee of the Principality of Asturias approved the study (reference: CPMP/ICH/135/95) and all processes complied with pertinent laws and institutional guidelines.

First, once agreement and permission from school authorities was obtained, consent from parents and/or legal guards was requested. The research was explained to parents by the school administration. Principals, parents and students all gave their informed consent after being made aware that the study was voluntary and anonymous. In addition, participants had the option of dropping out at any time.

Students completed the different assessment instruments in class (approximately 20 minutes) in the presence of their main teacher and a member of the research project. Three qualified educational psychologists from the research project collected the data.

Data Analyses

First, statistical properties of the variables were examined, and the missing values were treated through multiple imputation. Second, Latent Profile Analysis (LPA) was conducted. In mixture modeling, indicator variables are used to identify an underlying latent categorical variable. Three measures of academic goals (i.e. mastery-approach, performance-approach, and performance-avoidance) were used to identify the motivational profiles. Considering the potential relationship between sex, school year and academic goals, gender and school year variables were included as covariates in the estimation of latent classes. The estimation to determine the best model was carried out by adding successive latent classes to the model. The model that best fits the data is the one using the optimal number of classes to describe the existing relations between variables. LPA (Lanza et al., 2003) was used to obtain the motivational profiles, using Mplus v.6.11 (Muthén & Muthén, 1998–2012). The best model was selected based on the following criteria: the Lo-Mendell- Rubin Adjusted Likelihood Ratio

Test (LMRT; Lo et al., 2001), the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC) and the sample-size-adjusted BIC (SSA-BIC), as well as the value of the entropy and the sample size of each subgroup. Lower values in IAC, BIC and SSA-BIC indicate more parsimonious models, and better fit, while the *p*-value associated with the LMRT indicates whether the solution with more classes ($p < .05$) or less classes ($p > .05$) fits better (Nylund et al., 2007).

In order to compare the results of this research with those of the previous research, the profiles were labelled following the criteria suggested by Wormington and Linnenbrink-García (2017). While the raw scores were used for labelling, standardized scores were used as a visual aid. According to Wormington and Linnenbrink-García (2017), the following criteria were used to label the different profiles (the measurement scale ranges from 1 minimum to 5 maximum). Goal levels that were closer to the end point than to the midpoint of the scale were labeled as high or low within each profile. Specifically, as the midpoint of the scale is 3, scores were considered high if the goal level was ≥ 4 and low if it was ≤ 2. They were also considered high or low if their values were closer to 4 or 2 (respectively) than to the midpoint of the scale. Finally, goals were considered average if they did not meet the criteria for high or low goals.

Once all goals in a profile were identified as high, low, or average, we examined the pattern of goals within the profiles. Profiles with goals that met the criteria for highly endorsed goals were labeled as high in those goals. In contrast, profiles with goals that met the criteria to be considered low-supported goals, and that did not contain any high-supported goals, were labeled as low in those goals. Finally, profiles that did not contain high or low goals were labeled as average across goals.

Third, once the final model with an appropriate number of classes was chosen, we used the automatic Mplus command DE3STEP to estimate the mean of a distal continuous outcome

(i.e., mathematics performance) across latent profiles. This command reports mean levels across profiles for each auxiliary variable and tests the equality of outcome means across the various profiles using a Wald chi-square test. Effect sizes were assessed using Cohen's *d* (Cohen, 1988): $d < .20$ = non-significant effect, $d \geq .20$ and $d < .50$ = small effect, $d \geq .50$ and $d < .80$ = moderate effect; $d \geq .80$ = large effect. Maximum Likelihood estimation with robust standard error (MLR) was used for the analysis.

Results

Preliminary Analyses

Table 1 provides the descriptive statistics of the variables, as well as the Pearson correlation matrix. Bartlett's sphericity test showed that the variables were correlated, $\chi^2(15) = 750.68$, $p < .001$. Skewness and kurtosis values for motivation goals and mathematics performance were within the intervals indicating a normal distribution (between -2 and +2; George & Mallery, 2010). In terms of correlations, girls exhibited higher Mastery goals and lower Performance-avoidance goals and had better performance in mathematics than boys. There were also effects of school year: in higher years, all three types of motivational goals and performance were higher than in lower years. Furthermore, better mathematics performance was positively related to Mastery goals and negatively related to Performance-avoidance goals, while it was not significantly related to Performance-approach goals.

Table 1

Pearson Correlations and Descriptive Statistics

	Gender	School Year	MG	PG	PAG	MP
Gender	–					
School year	-.03	–				
MG	-.06**	-.17**	–			
PG	-.01	-.13**	.43**	–		
PAG	.13**	-.04*	.02	.17**	–	
MP	-.10**	-.15**	.19**	.03	-.22**	–

M	0.50	2.71	3.56	3.52	2.57	2.44
SD	0.50	1.07	0.72	0.75	0.91	1.28
Skewness	-0.00	-0.28	-0.35	-0.21	0.21	0.54
Kurtosis	-2.00	-1.19	0.22	0.15	-0.35	-0.83

Note. MG (Mastery-approach Goals); PG (Performance-approach Goals); PAG (Performance-Avoidance Goals); MP (Mathematical Performance). MG, PG, PAG and MP (1-minimum, 5-maximum).

Identification of motivational profiles

Four latent class models were specified (models with two to five classes). The fit indices of the models are shown in Table 2. Model specification was stopped after five classes, given that a statistically non-significant LMRT was obtained (LMRT5C = 115.537, $p > .05$) for this model. The LMRT test also indicated that the four-class model had a better fit to the data than the three-class model (LMRT4C = 345.342, $p < .001$, and lower values in AIC, BIC and SSA-BIC than the two-class and three-class models). Although the five-class model gave the lowest values for AIC, BIC and SSA-BIC, the *p* value from LMRT was greater than .05 ($p = .0826$). Finally, the entropy values (classification power of the model) of the four-class model were greater than the values for the three- or five-class models (entropy 4CL = 0.774). Classification accuracy of the four-class model was adequate (greater than .80 in all four classes).

Table 2

Fit of Latent Class Models

	Two-class model	Three-class model	Four-class model	Five-class model
AIC	15726.291	15449.418	15108.626	15002.595
BIC	15794.985	15552.459	15246.012	15174.329
SSA-BIC	15756.859	15495.269	15169.760	15079.014
LMRT	385.911	282.772	345.342	115.537

(*p* LMRT)	(.023)	(.000)	(.000)	(.0826)
Entropy	0.565	0.764	0.774	0.736
Size $n \leq 5\%$	0	0	0	0

Note. Mastery-Approach goals, Performance-Approach goals and Performance-Avoidance goals were the three variables used for the Latent Class Analysis. AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; SSA-BIC = Sample-Size-Adjusted BIC; MLRT = Lo-Mendell-Rubin Adjusted Likelihood Ratio Test; Size $n \leq 5\%$ = number of classes with fewer than 5% of subjects the total sample; Entropy = quality classification of subjects into classes.

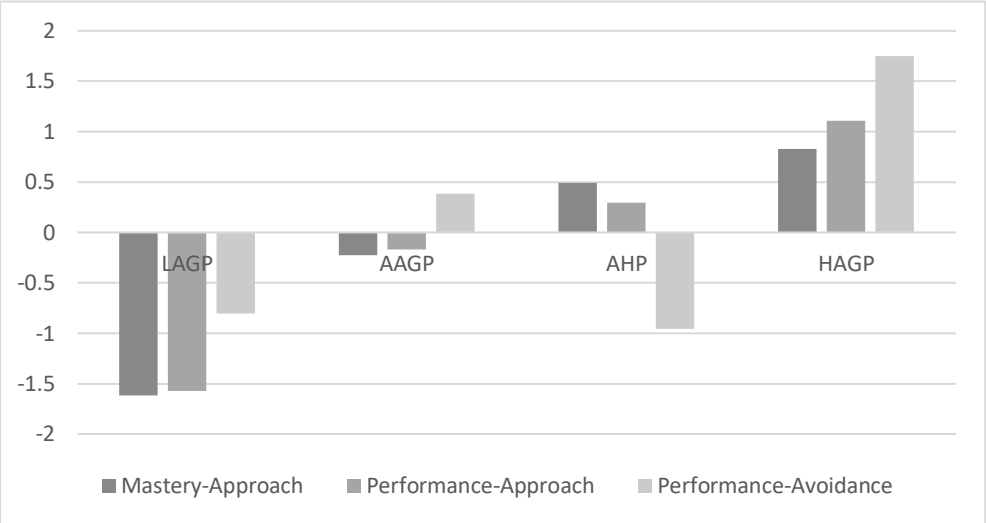
Description of the motivational profiles

Two profiles contained a small number of students (Classes 1 and 2: 6.36% and 8.39%, respectively), while the other two included the majority of students (classes 3 and 4: 53.20% and 32.03%, respectively). **Table 3** provides the means and standard deviations of each of the three motivational goals within each profile. In order to compare the four profiles, scores for the three motivational goals were standardized ($M = 0$, $SD = 1$). **Figure 1** provides a graphical representation of each motivational profile with *z* scores.

The selected model is made up of four groups of students that are well differentiated in terms of motivational profiles. The largest group of students (53.204%) was characterized by an *Average All Goals profile* (AAGP). A second large group (*Approach High profile* -AHP; 32.037%) had a profile characterized by a predominance of learning and performance-approach goals, and low performance-avoidance orientation. Thirdly, there was a much smaller group (8.396%) with a motivational profile exhibiting a high level in the three goals, *High All Goals profile* (HAGP). Finally, the smallest group (6.363%) showed a pattern characterized as low endorsement for the three types of goals, including avoidance goals (*Low All Goals profile*: LOGP).

Figure 1

Graphical Representation of Motivational Profiles in the 4 Latent Classes Model



Note: LAGP profile (demotivation profile; Low All Goals Profile); AAGP profile (Average All Goals Profile); AHP profile (Approach High Profile, high mastery-approach and performance-approach goals with low performance-avoidance orientation); HAGP profile (High All Goals Profile).

Table 3

Descriptive Statistics for the three academic goals (mastery-approach, performance-approach, and social-approach) in the Four Latent Classes

			Confidence Intervals	
	Estimate *(z)*	*S.E.*	LO 5%	UP 5%
Profile 1 (*n* = 144; 6.363%)				
Mastery-Approach	2.395 (-1.617)	0.120	2.198	2.591
Performance-Approach	2.334 (-1.575)	0.099	2.171	2.497
Performance-Avoidance	1.845 (-0.804)	0.094	1.691	1.999
Profile 2 (*n* = 190; 8.396%)				
Mastery-Approach	4.164 (0.831)	0.053	4.077	4.250
Performance-Approach	4.367 (1.111)	0.048	4.287	4.446
Performance-Avoidance	4.173 (1.751)	0.067	4.063	4.283
Profile 3 (*n* = 1204; 53.204%)				
Mastery-Approach	3.398 (-0.229)	0.026	3.355	3.440

Performance-Approach	3.400 (-0.166)	0.027	3.356	3.444
Performance-Avoidance	2.927 (0.384)	0.026	2.885	2.969
Profile 4 (*n* = 725; 32.037%)				
Mastery-Approach	3.917 (0.490)	0.032	3.865	3.970
Performance-Approach	3.751 (0.298)	0.040	3.686	3.817
Performance-Avoidance	1.705 (-0.957)	0.034	1.649	1.760

Note. Mastery-approach, performance-approach, and performance-avoidance goals (1-minimum, 5-maximum).

Table 4 shows a comparison between the profiles found in the present study and those reported by Wormington and Linnenbrink-Garcia (2017) according to an aligned nomenclature. A description of each profile in terms of their endorsement in the three different motivational goals (Mastery, Performance, and Avoidance goals) is also provided.

Table 4

Description and percentages of the profiles from the present study, compared to those from Wormington and Linnenbrink-Garcia (2017)

Wormington & Linnenbrink-Garcia (2017)	%	Current study profiles	%	Description
Average All Goals Profile	37.12	Average All Goals Profile (AAGP)	53.20	Average endorsement in all goals, without objectives fulfilling the conditions for classification as either high or low
Approach High Profile	14.29	Approach High Profile (AHP)	32.03	High endorsement in Mastery and Performance-approach goals, with low endorsement in Avoidance goals
High All Goals Profile	10.07	High All Goals Profile (HAGP)	8.39	High endorsement in all achievement goals, including those related to Avoidance
Low All Goals Profile	1.95	Low All Goals Profile (LAGP)	6.36	Low endorsement in all the achievement goals

Although there were similar proportions of boys and girls in the total sample, there were notable differences in gender distribution in each of the four profiles (Cramer's $V = .133$, $p < .001$). Girls were mostly present in the AHP profile (Approach High profile), while boys predominated in the other three profiles, especially in the HAGP (High All Goals profile) and LAGP (Low All Goals profile). Girls also exhibited greater mathematical performance than boys in three of the four profiles (HAGP, AAGP and LAGP) ($F = 6.820$, $p < .01$). Likewise, there were notable differences in profiles by school year (Cramer's $V = .121$, $p < .001$). The LAGP and AHP profiles predominated in 10th grade, the AAGP (Average All Goals profile) in 9th grade, and the HAGP profile in 8th grade. Also, except for the group with low endorsement in all goals (LAGP), mathematical performance generally decreased as schooling progressed (HAGP: $F = 3.662$, $p < .01$; AHP: $F = 15.102$, $p < .001$; AAGP: $F = 5.268$, $p < .001$).

Relationships between the motivational profiles and mathematics performance

The means in **Table 5** show similar average mathematical performance for three groups (HAP, AAGP, and LAGP), and somewhat higher performance for the AHP group. Overall, the equality tests of means showed statistically significant differences between the motivational profiles in terms of final mathematical performance (see Table 5), with an effect size close to medium ($d = 0.457$). Pairwise comparisons indicate statistically significant differences when the comparison group is AHP (HAGP vs. AHP; AAGP vs. AHP; LAGP vs. AHP), and non-statistically significant differences when the other three groups (AHGP, AAGP and LAGP) are compared to each other.

Table 5

Equality tests of means across classes using posterior probability-based multiple imputations with 3 degree(s) of freedom for the overall test and 1 degree of freedom for the pairwise tests (external variable: mathematics performance)

	Mean	S.E.	
HAGP profile (*n* = 190 students)	2.200	0.088	
AHP profile (*n* = 725 students)	2.906	0.054	
AAGP profile (*n* = 1204 students)	2.236	0.037	
LAGP profile (*n* = 144 students)	2.207	0.122	
	χ^2	*p*	*Cohen's d*
Overall test	112.285	< 0.001	0.457
HAGP *vs.* AHP	45.782	< 0.001	0.459
HAGP *vs.* AAGP	0.136	0.712	----
HAGP *vs.* LAGP	0.002	0.966	----
AHP *vs.* AAGP	94.159	< 0.001	0.453
AHP *vs.* LAGP	26.748	< 0.001	0.356
AAGP *vs.* LAGP	0.052	0.820	----

Note: HAGP profile (High All Goals Profile); AHP profile (Approach High Profile, high mastery-approach and performance-approach goals with low performance-avoidance orientation); AAGP profile (Average All Goals Profile); LAGP profile (demotivation profile; Low All Goals Profile).

Conditional effect of gender and school year

The conditional effect of gender and school year on the relationship between motivational profiles and mathematical performance was analyzed by studying the interactions profiles x gender, profiles x school year, and profiles x gender x school year. The descriptive statistics corresponding to the Factorial Analyses of Variance are provided in **Table 6** (gender) and **Table 7** (school year). No statistically significant interaction of motivational profiles with either gender ($F(3,2274) = 0.637$, $p = .591$) or school year ($F(9,2266) = 1.705$, $p = .083$) was found. **Figures 2 and 3** visually show the absence of significant interaction.

Table 6

Descriptive statistics for motivational profiles and Academic Achievement (by gender)

Motivational Profiles	Gender	*M*	*SD*	*N*
LAGP	Girl	2.282	1.4001	60
	Boy	1.999	1.2268	83
AAGP	Girl	2.311	1.2014	576
	Boy	2.133	1.1640	637
AHP	Girl	2.973	1.3146	433
	Boy	2.903	1.3982	297
HAGP	Girl	2.378	1.1738	78
	Boy	2.080	1.0799	118

Note: Mathematical Performance (dependent variable). LAGP profile (demotivation profile; Low All Goals Profile); AAGP profile (Average All Goals Profile); AHP profile (Approach High Profile, high mastery-approach and performance-approach goals with low performance-avoidance orientation); HAGP profile (High All Goals Profile).

Table 7

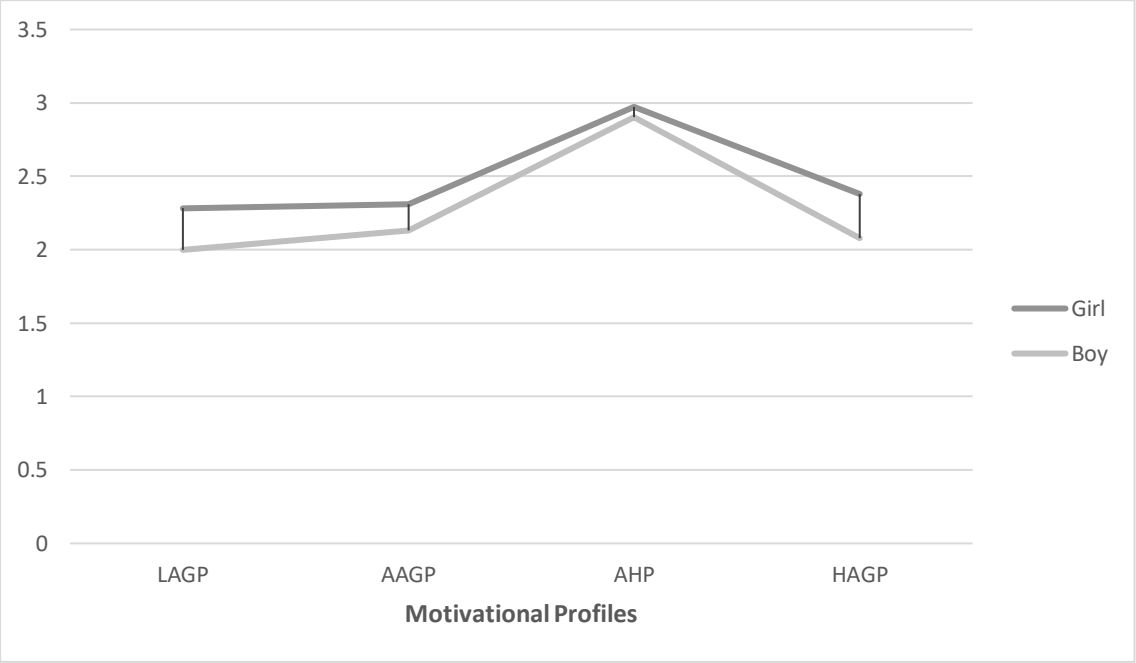
Descriptive statistics for motivational profiles and Academic Achievement (by school year)

Motivational Profiles	**School year**	***M***	***SD***	***N***
LAGP	7th	2.077	1.0377	13
	8th	2.148	1.4332	27
	9th	2.176	1.3893	48
	10th	2.061	1.2503	55
AAGP	7th	2.546	1.4287	174
	8th	2.156	1.2105	244
	9th	2.171	1.1643	431
	10th	2.157	1.0326	364
AHP	7th	3.485	1.2500	174
	8th	2.975	1.3916	160
	9th	2.778	1.3308	176
	10th	2.629	1.2823	220
HAGP	7th	2.545	1.1356	55
	8th	2.130	1.1235	69
	9th	1.795	1.0047	39
	10th	2.240	1.1113	33

Note: Mathematical Performance (dependent variable); LAGP profile (demotivation profile; Low All Goals Profile); AAGP profile (Average All Goals Profile); AHP profile (Approach High Profile, high mastery-approach and performance-approach goals with low performance-avoidance orientation); HAGP profile (High All Goals Profile).

Figure 2

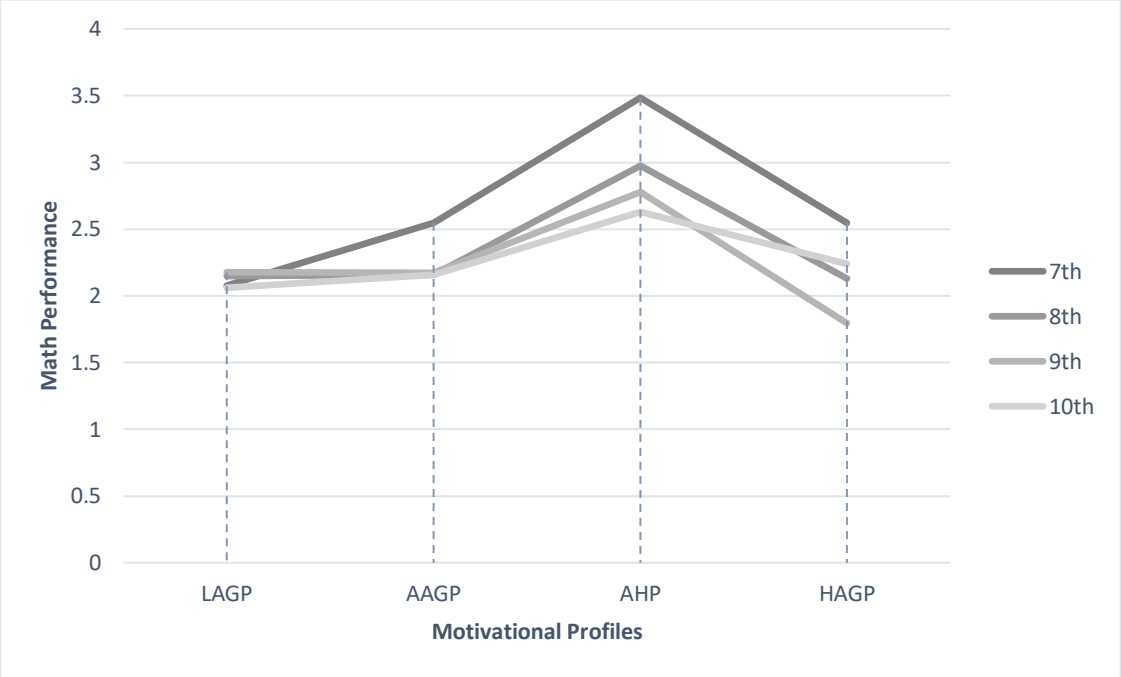
Motivational profiles, gender and mathematics performance



Note: LAGP profile (demotivation profile; Low All Goals Profile); AAGP profile (Average All Goals Profile); AHP profile (Approach High Profile, high mastery-approach and performance-approach goals with low performance-avoidance orientation); HAGP profile (High All Goals Profile).

Figure 3

Motivational profiles, school year, and mathematics performance



Note: LAGP profile (demotivation profile; Low All Goals Profile); AAGP profile (Average All Goals Profile); AHP profile (Approach High Profile, high mastery-approach and performance-approach goals with low performance-avoidance orientation); HAGP profile (High All Goals Profile).

Conclusions

The purpose of this study was to provide some insights into what has been debated over the last decade in the Achievement Goal Literature, while highlighting the need to consider a person's centered approach in the study of motivation profiles. Given the inconsistency in previous studies related to definition and labeling the different motivational profiles, the present study focused on three main goals: Mastery-approach, Performance-approach, and Performance-avoidance goals (Luo et al., 2011) while adopting the labeling system by Wormington and Linnenbrink-García (2017). LPA was used to identify different motivational

profiles. Also, the relationship between these profiles and achievement in mathematics was examined, considering the possible effect of gender and school year in this relationship.

From our LPA analysis, the best-fitting model had four classes (the five-class model did not improve on the four-class model). This model showed the presence of four student profiles that mostly agreed with previously hypothesized profiles (i.e., AAGP, AHP, AHGP, and LAGP), although the initially hypothesized group of students showing a Mastery High profile (students who strongly endorsed mastery-approach goals, with average or low endorsement of performance goals and avoidance goals) was not found. This group had been reported in 13.02% of the studies analyzed by Wormington and Linnenbrink-García (2017). In addition, the LAGP group emerged from our results. This profile, characterized as low endorsement in all goals, including avoidance goals, was relatively infrequent in Wormington and Linnenbrink-García´s study (2017), as well as in the present study (1.95 % vs. 6.36% in the present study).

Although there were some differences in the frequency of each motivational profile in comparison to Wormington and Linnenbrink-García's (2017) findings, our study exhibited a similar pattern. The most frequently found profile was AAGP (i.e. students showing average levels in all the goals; 37.12% in the previous study vs. 53.20% in the present study), followed by the AHP (high endorsement in Mastery and Performance goals and low levels of Avoidance goals; 14.29% in the previous study vs. 32.03% in the present study). There was a similar frequency for the HAGP group in both studies (10.67% in the previous study vs 8.39% in the present study).

In summary, our results, from a large sample of students—from 7th to 10th grade, with similar proportions of boys and girls—are closely in line with the results by Wormington and Linnenbrink-Garcia (2017), in the sense that the largest group was characterized as students

with an average endorsement in all goals, followed by those with high endorsement in Mastery and Performance goals but low endorsement in Avoidance goals, a group with high multiple goals at the same time (including avoidance goals), and a small group showing a demotivation profile (low endorsement in all goals). Therefore, the data from our study seem to confirm the conclusions drawn by Wormington and Linnenbrink-Garcia, with the exception of the Mastery High Approach, which we did not find. This is worth noting, since this profile was correlated to an adaptive profile in terms of motivation, well-being, engagement and achievement in the previous study. This profile involves low or average levels of Avoidance goals, which in previous studies can refer either to performance-avoidance or to work-avoidance. As Wormington and Linnenbrink-Garcia (2017) suggested in their synthesis of studies, the observed profiles might vary depending on the variables used to build the goal profiles. More specifically, "findings may vary depending on which avoidance goal is included (e.g., work-avoidance, performance-avoidance, and/or mastery-avoidance)" (p. 414).

Relation between motivational profiles and mathematical performance

Our data confirm part of the hypothesis formulated about which profiles should be more adaptive or less adaptive. Our results agree with the results of the synthesis study by Wormington and Linnenbrink-Garcia (2017), Luo et al. (2011), and Hong et al. (2020), in that the most adaptive of the four profiles was the AHP group. However, in our study the performance of students in the group with high endorsement in all goals (HAGP) was significantly lower than the performance of the AHP group, while Wormington and Linnenbrink-García (2017) reported that they were similarly adaptive in terms of achievement. Furthermore, our data indicate that the performance of students showing the HAGP profile was just as low as students with average endorsement in all goals (AAGP), and even as low as those with a seemingly demotivated profile (LAGP).

Our study suggests, like Hong et al. (2020), that Performance-avoidance goals may play an important motivational role. Accordingly, for a profile to be more adaptive it must have high approach goals (Mastery and Performance) but also low or very low Avoidance goals (in our study, performance-avoidance). When Mastery and Performance approach goals were accompanied by high Performance-avoidance goals (i.e., HAGP) mathematical performance was low; as low as that of students with a demotivation profile (LAGP). This result, however, is contrary to those reported in the synthesis by Wormington and Linnenbrink-Garcia (2017), in which a high endorsement in all three goals (HAGP) produced similar performance to the AHP group. This difference could be examined according to some characteristics of the present study, mainly the school level (middle school: grades 7-8, and high school: grades 9-10) and the goal model (trichotomous). While the performance of the HAGP group reported by Wormington and Linnenbrink-Garcia (2017) was based on all the studies where that profile was found, only 5 out of 12 studies showing this profile were using middle school or high school samples, and only two of them were presenting a trichotomous design (Wormington and Linnenbrink-Garcia, 2017, p. 426). Maybe if we limit the analysis to those studies, the HAGP would be less adaptive in terms of performance than it was in the general sample of studies. It seems in our study that avoidance goals might be playing a more negative role than in previous studies. Nevertheless, Wormington and Linnenbrink-Garcia (2017) reported differences (in favor of the AHP group) between these two profiles in motivation and well-being, which indicate that they might not be equally adaptive in general terms.

However, since we did not find a Mastery High Approach profile in our study, we cannot discuss whether the profile with only high Mastery-approach goals is more adaptive than when Mastery and Performance approach goals go together. In any case, perhaps the most interesting thing is that pursuing both types of goals, and not pursuing avoidance goals (AHP group), seems to be a more adaptive profile. Furthermore, this profile is abundant in the present

sample (about 32%) and intrinsically very realistic. Perhaps more realistic than a Mastery High Approach profile (taking into account current teaching processes, social values, etc.). Although we agree that "...students should be encouraged to adopt a mastery goal orientation and that classrooms should be structured to facilitate and foster a general mastery orientation is still a valid conclusion" (Pintrich, 2000b, p.553), today, considering the quality of teaching processes, it might be more useful to deploy a profile showing both goals (Mastery and Performance-approach goals).

Overall, these findings suggest a need to approach the study of academic motivation from a *multiple goals perspective* (Horstra et al., 2017; Inglés et al., 2015; Mansfield & Wosnitza, 2010; Pintrich, 2000a; Wormington & Linnenbrink-García, 2017). The results also suggest that motivational studies should consider not only Mastery and Performance-approach goals, but also, and very importantly, *Avoidance-approach goals.* Our results are consistent with previous research (e.g., Horstra et al., 2017; Inglés et al., 2015; Luo et al., 2010; Wormington & Linnenbrink-García, 2017) which showed that a profile with moderate-to-high Mastery and Performance goals and low Avoidance-approach goals was linked to enhanced educational outcomes such ass success in school, time management, subjective task value, class and homework engagement, greater self-efficacy, and meta-cognitive or self-regulation skills, among other outcomes. High Performance-approach goals, when combined with high Performance-avoidance goals, may have detrimental impacts on performance as well as affective outcomes, according to Luo et al. (2010).

Within this context, some authors have tried to provide explanations for students adopting avoidance goals, most being based on Expectancy-Value Theory (Wigfield & Eccles, 2000), which indicates that students are more likely to interact with and perform better on an academic task when they value it and have high competence beliefs. More recently, Jiang et al. (2018) added a new component to the equation by introducing “cost” (or the detected negative

outcomes of task engagement) as a predictor, referring to this new paradigm as the Expectancy-value-cost approach. Using two data sets (N = 637 and N = 211) of middle and high school students, they analyzed the potential effect of an expectancy-value-cost approach for predicting adolescent students' academic motivation and Mathematics achievement. They found that, beyond what could be predicted by expectancy and value, cost could effectively describe additional variance in a variety of different variables linked to academic motivation and achievement. Cost was found to be a significant predictor of adolescent students' adoption of avoidance goals, unpleasant classroom experiences, unfavorable academic results, and test scores. Their results broaden the application of Expectancy-value Theory by highlighting the significance of combining expectancy, task value, and cost to predict students' levels of academic motivation and success. This new perspective on the theory gives us some theoretical background for part of our results, for specially those concerning the strategies and academic performance of the group showing high endorsement in all goals. This group of students, despite having high motivation, cannot perform at a high level because their "cost" is too high, which is detrimental to their involvement, commitment and use of strategies.

Motivational profiles, gender, and school year

Our study also examined the effect of gender and school year on both the expression of the different motivational profiles and their relationships with Mathematics achievement (González-Torres & Torrano, 2013; Liew at al., 2014). First, there were more girls than boys in the AHP group, which was considered the most adaptive in the present study. They also exhibited better mathematical performance than boys in three of the four profiles (HAGP, AAGP and LAGP). However, the analysis of the interaction between gender and motivational profiles was not statistically significant, which is consistent with previous research reporting gender differences in motivational goals. The direction of these differences seemed not to be clear according to the literature. On the one hand, girls have been shown to have higher intrinsic

motivation and greater presence of Mastery goals than boys (Thorkildsen & Nicholls, 1998; Wach et al., 2015). In this regard, boys would be more inclined towards Performance goals, Avoidance of negative judgments and superficial involvement in tasks (González-Torres & Torrano, 2013). On the other hand, there is evidence to the contrary. For example, Liew et al. (2014) and Valle et al. (2016a) found a more adaptive motivational profile in boys, along with higher levels of Avoidance goals in girls. Thus, the data from our study seem to indicate that boys and girls differ in the less adaptive profiles, and there were no differences in the adaptive profile. However, more research is needed from a person-centered perspective on gender differences and their effects on mathematics performance.

Looking at the relationship between school year, motivational profiles and mathematical performance, our data indicate that, except for the group with low endorsement in all goals (LAGP), mathematical performance generally decreases as schooling progresses. There was a sharp drop between 7th and 8th school year, with a shallower fall in the following two years. The analysis of the interaction between school year and motivational profiles was not statistically significant, being these findings consistent with previous research by Mansfield and Wosnitza (2010) and Lazarides et al. (2016), who found statistically significant differences in motivation goals and achievement in different school years. Our results showed that the High All Goals profile (HAGP) was more frequent at the beginning of the academic stage, while at the end of the stage the demotivation profile (LAGP) was more frequent. Accordingly, Lazarides et al. (2016) had reported that secondary school students in later years were more likely to fall into the category of a moderately motivated person than a highly motivated person. On similar lines, Wormington & Linnenbrink-García (2017) suggested a more frequent presence of low goal endorsement in the later years of compulsory school compared to earlier years, such as primary school. This conclusion is also consistent with earlier studies demonstrating that older students have lower mathematics self-concepts, place less intrinsic

value on the subject (Frenzel et al., 2009), and usually show lower levels of academic achievement in the subject than younger students (García et al., 2016; Grissom, 2004).

Practical implications

From an educational viewpoint, our findings underscore the importance of identifying the type of motivational profile students have to tailor different strategies to them. There is a motivational diversity that teachers and educators need to consider in order to help avoid school failure and students dropping out, by promoting reinforcement of students' personal variables, such as self-esteem, self-determination and accurate attributions of success or failure. Although low motivation is an important issue in students with Learning Difficulties (e.g, mathematics or reading problems) (Parhiala et al., 2018), it would be a mistake not to consider it in all students, since it can have effect on their academic performance, as we have seen in our study. Thus, the need to provide all students with support in both academic skills and motivation. In this regard, it has also been proposed that teachers may have a considerable role in promoting different motivational goals in students. Matos et al. (2017) looked at Peruvian secondary-school students and teachers and found that perceived teacher-promoted Performance-avoidance goals were related to worse educational performance, at the same time it was found that perceived teacher-promoted Mastery goals positively predicted deep learning strategies at a class level. There are also implications for the family environment. Lazarides et al. (2015) observed that students' perceptions of their parents' valuing mathematics were positively related to high-motivation profiles and higher mathematics achievement at secondary school.

By studying motivational components and additional variables that can explain the existence of more adaptive goal orientation patterns in more detail, we could facilitate students moving from a higher-risk profile to a more adaptive profile, described by high motivation and Mastery-goal approaches, low Performance-avoidance goals, less mathematics anxiety, less

fear of failure, greater use of adaptive problem-focused coping strategies and less use of maladaptive self-protective coping strategies, with implications for both academic performance and affective components. On the contrary, when students endorse slightly lower mastery and performance-approach goals and higher performance-avoidance goals, there are different results in terms of achievement, but also in students' social and emotional well-being, cognitive engagement, and motivation (Huang 2011; Hulleman et al. 2010; Linnenbrink-Garcia et al., 2008).

Suggestions for future research

There are some weaknesses that must be acknowledged in the present study. First, while our data allowed us to identify four differentiated motivational profiles, our results are restricted to the sample analyzed and the three academic goals. Future studies, with different samples, may well lead to the identification of additional motivation profiles. Moreover, recent research suggests the inclusion of new types of goal (i.e., Pro-social goals) in the teaching-learning context (Brinkman et al., 2020; Poortvliet & Darnon, 2010; Shin, 2021; Wentzel, 2003). These studies found that Mastery goals and Pro-social goals that encourage peer cooperation interact to predict greater levels of positive learning attitudes and lower levels of surface learning motives. Students who displayed Pro-social goals, Performance-approach goals, and Mastery-approach goals had more adaptive use of strategies, learning motivations, and achievement aspirations in mathematics. Second, some contextual variables, such as classroom or family environment, and their interaction with the motivational goals should be considered for future research. Variables such as teacher and peer support, parents' attitudes towards learning, and the types of orientation goals that both parents and teachers promote in students should be considered. In addition, some mathematics-related variables, such as mathematics anxiety, enjoyment, and perceived value must be taken into consideration, given their implications for academic achievement in the subject (García et al., 2016). Anxiety, for

example, could help explain the adoption of Performance-avoidance goals, especially by girls (Stoet & Geary, 2012). Third, our results indicate the need for longitudinal research on the topic in order to better identify different motivational profiles and their connections with mathematical performance, even though the possible effect of age and gender was considered (Lazarides et al., 2016; Madamurk et al., 2018). While we did examine the effect of school year in our study, this analysis was based on a transversal approach. Given that different goal orientations may have different developmental trajectories, it is possible that both the expression and the effect of different goals on performance may change over time (Held & Hascher, 2023; Touminen et al., 2020). Lastly, one substantive limitation of the study is that the data structure (i.e., subjects within classes) has not been taken into consideration in the data analysis. In future studies it would be important to consider this structure, which would allow us to assess the potential extent of its effects on the study.

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Discusión de resultados

La presente Tesis Doctoral se ha desarrollado como compendio de artículos, obteniéndose tres artículos publicados y un trabajo complementario enviado para publicación, los cuales han seguido una estructura en dos fases. En la primera fase de investigación, se pretende analizar las variables emocionales y motivacionales influyentes en el rendimiento matemático, lo que ha dado lugar a tres estudios. En la segunda fase de investigación, se pretende identificar otras variables de carácter individual como las necesidades educativas, y de carácter contextual como la implicación familiar durante el desarrollo de los deberes, con el objetivo de describir su relación e influencia en el desarrollo y rendimiento, lo que ha dado lugar a un estudio.

De esta manera, se plantean 4 objetivos generales, uno para cada estudio realizado. El primero de los objetivos trata de analizar la fuerza predictiva de variables cognitivas, motivacionales y emocionales en el rendimiento matemático de alumnado de Educación Secundaria. Por otra parte, el segundo objetivo pretende determinar los perfiles de creencia matemática para analizar su relación con el rendimiento matemático en esta misma muestra de estudiantes. El tercer objetivo, derivado de los hallazgos de los dos estudios anteriores, busca conocer las metas académicas que persigue este alumnado para así identificar perfiles de motivación. Finalmente, y debido al interés por conocer la influencia de otras variables relacionadas con el contexto de desarrollo del alumnado, se plantea un cuarto objetivo relacionado con la familia, los deberes y la presencia de necesidades educativas en el alumnado. En concreto, se trata de analizar cómo la implicación familiar durante el desarrollo de los deberes puede influir en el desarrollo y rendimiento del alumnado con necesidades educativas, desarrollándose una revisión empírica según la metodología PRISMA.

De este modo, atendiendo a los objetivos planteados, la presente Tesis Doctoral se ha propuesto contribuir a responder a las siguientes preguntas de investigación relacionadas con los estudios comentados anteriormente:

1. ¿En qué medida las variables cognitivas, motivacionales y emocionales predicen el rendimiento matemático?
2. ¿Cómo se combinan las variables anteriores para formar perfiles de creencia matemática y qué relación tienen con el rendimiento matemático?
3. ¿Qué tipo de metas académicas persigue el alumnado y cómo se relacionan entre ellas y con el rendimiento matemático?
4. ¿Cómo es la relación existente entre las variables individuales (necesidades educativas del alumnado) y contextuales (implicación familiar durante los deberes escolares) y cómo esto influye en el desarrollo y rendimiento del alumnado?

El primer objetivo, relacionado con el estudio de las variables cognitivas, emocionales y emocionales se aborda a través de la publicación 1 "Predicting mathematics achievement in Secondary Education: The role of cognitive, motivational, and emotional variables" (Abín et al., 2020). Esta publicación permite responder a la primera pregunta de investigación que busca determinar cómo dichas variables predicen el rendimiento matemático. Concretamente, el análisis de variables cognitivas como la capacidad intelectual, de variables emocionales como la ansiedad matemática, y de variables motivacionales como la competencia percibida, la utilidad percibida, la motivación intrínseca, la motivación para el éxito y las atribuciones causales, permite conocer la fuerza predictiva que estas tienen sobre el rendimiento matemático de alumnado de Educación Secundaria del Principado de Asturias.

La principal innovación de este estudio radica en que examina las variables de manera conjunta, en lugar de analizarlas de forma individual como se había hecho en investigaciones

previas. Además, a pesar de encontrarse que la capacidad intelectual es un fuerte predictor del rendimiento matemático, el porcentaje de varianza explicado aumenta sustancialmente al tener en cuenta variables de carácter emocional y motivacional, por lo que a nivel educativo se resalta la importancia de ir más allá de la capacidad intelectual del alumnado a la hora de explicar su rendimiento. Esto se ha visto en trabajos previos como el realizado por Miñano y Castejón (2011), donde se observó que al integrar las variables aptitudinales y las motivacionales, las segundas eran capaces de explicar un porcentaje mayor de varianza y de manera significativa, concluyendo por tanto que el mejor rendimiento académico del estudiante no viene dado únicamente por sus habilidades intelectuales, sino que es superiormente explicado por sus experiencias de éxito o fracaso, por su motivación y por otras variables con esta naturaleza motivacional o emocional. Más recientemente, en un estudio realizado por Gilar-Corbi et al. (2019) se encontraron resultados en línea con lo expuesto anteriormente. Estos estudios permiten afirmar que, a pesar de que la capacidad intelectual es un fuerte predictor del rendimiento tanto en grupos de estudiantes con alto cociente intelectual como en grupos de estudiantes con bajo cociente intelectual, no es la variable que genera diferencias entre ambos grupos. De hecho, las variables que explican estas diferencias son de carácter motivacional, como el autoconcepto académico, las orientaciones académicas o la metacognición; o de carácter contextual como el rol de la implicación familiar.

Los hallazgos desde esta perspectiva motivacional y emocional respaldan la noción de que el sentimiento de competencia en las tareas matemáticas (también conocido como competencia percibida) es más influyente que la habilidad cognitiva real para abordarlas de manera adecuada, permitiendo la fijación de objetivos de aprendizaje más ambiciosos que favorecen, en definitiva, el rendimiento (Erturan y Jansen, 2015; Du et al., 2021; Hwang et al., 2015; Lee et al., 2014; Pérez-Fuentes et al., 2020). Además, cuando los estudiantes perciben las matemáticas como algo útil y relevante para la vida cotidiana, esta percepción se convierte

en un predictor positivo y significativo, tal y como se identificó en el estudio 1. En esta línea, y a pesar de observar un efecto pequeño, la motivación por aprender matemáticas también es un predictor significativo y positivo del rendimiento matemático en la muestra analizada, coincidiendo con la evidencia científica existente sobre el tema (Miñano y Castejón, 2011; García et al., 2016a; Lipnevich et al., 2016). De manera concreta, es la motivación intrínseca la que permite que el estudiante disfrute más del aprendizaje de las matemáticas y favorece un mayor nivel de esfuerzo, lo que repercute de manera positiva en su rendimiento posterior (Cheng, 2019; García et al., 2016a; Hammoudi, 2019; Rojo-Robas et al., 2020; Trujillo-Torres et al., 2020). Finalmente, en relación con las atribuciones causales, se evidencia que solo las atribuciones de éxito y fracaso a causas externas son predictores significativos y negativos del rendimiento matemático. Esto apoya lo aportado por estudios anteriores donde se afirma que los estudiantes que atribuyen sus éxitos y fracasos a causas externas, inestables e incontrolables tienen menos probabilidad de éxito académico (Spencer et al., 2021; Rodríguez-Rodríguez y Guzmán-Rosquete, 2019).

Por otro lado, y en relación con las variables emocionales como la ansiedad matemática, cabe esperarse una relación negativa y significativa con el rendimiento matemático, tal y como se expone en estudios como los desarrollados por Suárez-Pellicioni et al. (2015), Chang y Beilock (2016) y Henschel y Roick (2017). En ellos se afirma que, a mayor ansiedad matemática -caracterizada por sentimientos negativos, elevada preocupación y evitación de las matemáticas-, menor es el rendimiento matemático del estudiante. Esta variable, además, ha supuesto una gran preocupación a nivel nacional ya que en el informe PISA de 2022 se evidenció que los estudiantes españoles experimentan ansiedad ante las matemáticas en una medida superior a la media del resto de países que participan en estudios de esta índole. A pesar de la evidencia de esta relación, no se identifica esta asociación en la muestra analizada. Sin embargo, este resultado puede atribuirse al empleo de análisis de regresión que incorporan la

evaluación de la ansiedad matemática junto con otras variables motivacionales y cognitivas (Erturan y Jansen, 2015) o a la evaluación de una dimensión específica de la ansiedad matemática, dejando a un lado otros componentes de este constructo (Mammarella et al., 2018).

A lo largo del estudio, se observan las diferencias en cuanto a la influencia o capacidad predictiva de las variables cognitivas, emocionales y motivacionales según el género y el nivel académico. En lo que respecta al género, se evidencian diferencias en los factores predictivos del rendimiento matemático. Específicamente, se ha visto que la percepción de utilidad de las matemáticas es un predictor positivo del rendimiento matemático en los chicos, pero no en las chicas. Por otro lado, la ansiedad matemática, a pesar de no ser una variable significativa, muestra una característica cualitativa interesante al hacer el análisis por género que también se evidenció en estudios anteriores (Erturan y Jansen, 2015). En este sentido, no se encuentran diferencias de género relacionadas con la magnitud de la asociación entre ansiedad y rendimiento matemático, aunque estas diferencias sí aparecen según la dirección de la relación (positiva para los chicos, negativa para las chicas). Sin embargo, las demás variables, como las habilidades cognitivas, la competencia percibida y la motivación intrínseca, mantienen la misma capacidad predictiva para ambos géneros. En relación con el curso académico, se llega a la conclusión de que la influencia de las variables cognitivas, emocionales y motivacionales examinadas en el rendimiento matemático disminuye con la edad, corroborando hallazgos reportados durante décadas en diversas investigaciones (Peetsma et al., 2005; Roskam y Nils, 2007; Mata et al., 2012; Regueiro et al., 2015; Dowker et al., 2016).

Estos resultados son especialmente relevantes para la actuación educativa, ya que el trabajo en las variables motivacionales y emocionales tiene un mayor peso sobre el rendimiento que la focalización exclusiva en las habilidades intelectuales como mayores predictores del rendimiento. También implica un mayor interés en explorar cómo la combinación de estas variables puede dar lugar a perfiles motivacionales y comprender su impacto en el rendimiento

matemático, lo que motiva el desarrollo de los estudios 2 y 3 incluidos en la presente Tesis Doctoral.

En cuanto al segundo de los objetivos, la publicación 2 "A person-centered approach to the relationship between mathematics self-belief profiles and achievement" (Cueli et al., 2023) permite responder a la segunda pregunta de investigación que trata de estudiar la combinación de variables para formar perfiles de creencia matemática. Este objetivo se complementa, además, con el análisis de la relación de dichos perfiles de creencia matemática con el rendimiento matemático, teniendo en cuenta el género y el curso académico de una muestra de estudiantes de Educación Secundaria del Principado de Asturias. Estos perfiles de creencia matemática han sido objeto de interés dado que surgen de la combinación de diferentes niveles de autoeficacia y ansiedad matemática, dos variables estudiadas en la publicación 1 (Abín et al., 2020) donde se utiliza la misma muestra de estudiantes.

La autoeficacia y la ansiedad matemática pueden interactuar entre ellas para formar diferentes perfiles de creencia matemática. En este caso, se encuentran seis perfiles de creencia matemática diferentes, fruto del Análisis de Perfiles de Latentes llevado a cabo. De esta manera, ha sido posible agrupar los perfiles en función de los niveles de autoeficacia y de ansiedad matemática experimentados por los estudiantes. Uno de los resultados permite afirmar que los altos niveles de autoeficacia pueden actuar como un factor protector a la hora de desarrollar ansiedad matemática en los estudiantes, lo que llevaría a un mejor rendimiento matemático. Bien es cierto que, en función de la muestra utilizada y del contexto cultural en el que se desarrolle la investigación, pueden encontrarse estudiantes con altos niveles de autoeficacia y también de ansiedad matemática que los llevan, igualmente, a un elevado rendimiento matemático (Foley et al., 2017; Tan y Yates, 2011; Yi y Na, 2020).

Por esta razón, desde una perspectiva centrada en la persona y teniendo en cuenta los seis perfiles de creencia matemática resultantes, se encuentran diferencias significativas entre ellos a la hora de explicar el rendimiento matemático. De manera general, los perfiles con una baja autoeficacia matemática son los que rinden peor en esta materia y, aquellos con altos niveles de autoeficacia matemática obtienen un mejor rendimiento matemático. Esto ya había sido afirmado por Martin et al. (2012) en un estudio donde observaron que los altos niveles de autoeficacia permitían a los estudiantes generar altos niveles de confianza en sí mismos que los llevaba a un mejor desempeño matemático. Además, ya se había establecido que el rol de la ansiedad matemática se ve opacado cuando existen altos niveles de autoeficacia (Jiang et al., 2014; Karakolidis et al., 2016; Pitstia et al., 2017; Stankov y Lee, 2017). A pesar de esto, la ansiedad matemática sigue siendo una variable importante, ya que es capaz de afectar a la relación entre la autoeficacia y el rendimiento matemático (Pérez-Fuentes et al., 2020) y se ha visto que a mayores niveles ansiosos peor es el rendimiento académico general (Geary et al., 2019; Yi y Na, 2020). Los resultados del estudio han permitido constatar que los perfiles caracterizados por alta ansiedad matemática tienen un menor rendimiento matemático, pero solo cuando la autoeficacia es baja.

La realización de este estudio contempla el análisis del género y del curso académico en lo concerniente a los perfiles de creencia matemática, aunque no se encuentran interacciones significativas que permitan dar explicaciones del rendimiento matemático. En relación con el género, se observa que la distribución de los géneros es diferente en los perfiles de creencia matemática, lo que se podría explicar desde una perspectiva centrada en los factores sociológicos y psicológicos (Pérez-Mejías et al., 2021) y acorde a los hallazgos de estudios como el realizado por Else-Quest et al. (2010). Con respecto al curso académico, y al igual que se observa en la publicación 1 (Abín et al., 2020), los niveles de autoeficacia matemática

parecen ir disminuyendo a medida que aumenta la edad de los estudiantes (Dowker et al., 2016; Mata et al., 2012).

Los hallazgos obtenidos son relevantes al contemplarse desde una perspectiva centrada en la persona que permite conocer diferentes perfiles de creencia matemática con diferente influencia en el rendimiento matemático. Esto, a su vez, permite considerar dichos perfiles desde una perspectiva más individualista que contempla diferentes niveles de variables como la autoeficacia y la ansiedad matemática (Canedo et al., 2022; Fan et al., 2019; Howard y Hoffman, 2018).

Por su parte, el estudio 3, titulado "Motivational profiles and mathematical performance in students from 7th to 10th grade: a person-centered perspective" tiene como objetivo conocer las metas académicas perseguidas por la misma muestra de estudiantes de Educación Secundaria del Principado de Asturias de los dos estudios anteriores y su relación con el rendimiento matemático. De manera complementaria, también se estudia el efecto del género y del curso académico en la relación de estos perfiles y el rendimiento matemático.

Este estudio parte de los resultados de la publicación 1 (Abín et al., 2020), donde se observa la fuerza predictiva de la motivación en la explicación del rendimiento matemático y de la existencia de perfiles de creencia matemática obtenidos en la publicación 2 (Cueli et al., 2023) lo que permite hipotetizar que puedan existir otros perfiles de carácter motivacional en la muestra de estudiantes analizada. Por esa razón, y bajo la sombra de la Teoría de las Metas Académicas (Dweck y Leggett, 1998) y del metaanálisis realizado por Wormington y Linnenbrink-García (2017), se decide indagar más en el rol de la motivación y la identificación de diferentes perfiles motivacionales basados en las metas académicas del alumnado.

De manera concreta, se encuentran cuatro perfiles motivacionales tras llevarse a cabo un Análisis de Perfiles Latentes. Este trabajo surge como estudio comparativo con respecto al

metaanálisis realizado por Wormington y Linnenbrink-García (2017) lo que permite discutir y comparar ciertos hallazgos. En primer lugar, pese a las diferencias en la frecuencia de aparición de los perfiles motivacionales de ambos estudios, se observa un patrón familiar en los perfiles llamados AAGP, AHP, HAGP y LAGP. A pesar de esto, uno de los perfiles relativamente frecuentes que Wormington y Linnenbrink-García (2017) encontraron en su muestra, caracterizado por altas metas de dominio y bajas-medias metas de aproximación y evitación del rendimiento, no pudo ser detectado en el presente trabajo, lo que puede ser debido a las variables utilizadas para construir los perfiles motivacionales (Wormington y Linnenbrink-García, 2017).

De manera adicional, se hipotetiza que la existencia de estos cuatro perfiles motivacionales pueda estar relacionada de alguna manera con el rendimiento matemático, encontrándose por tanto perfiles adaptativos y otros que no lo son tanto. Específicamente, el perfil que se relaciona con el rendimiento matemático en mayor medida es el llamado AHP, caracterizado por altas metas de dominio y de aproximación al rendimiento y bajas-medias metas de evitación. Estos hallazgos van en la línea de lo expuesto por Wormington y Linnenbrink-García (2017), Luo et al. (2011) y Hong et al. (2020). Por otro lado, y tomando como referencia el rol de las metas de evitación del rendimiento por su estudiada correlación negativa con el rendimiento académico y el interés (Guo et al., 2022; Luo et al., 2011), se observa que precisamente en aquellos perfiles con altas metas de evitación, como por ejemplo los perfiles HAGP o LAGP, el rendimiento matemático es bajo. A pesar de encontrarse este resultado, los hallazgos de Wormington y Linnenbrink-García (2017) afirmaron que el perfil motivacional HAGP, a pesar de tener altas metas de evitación, se asocia con un rendimiento matemático adecuado, tal y como se ve en el perfil AHP. Estos resultados contradictorios pueden deberse a las diferencias de las edades utilizadas entre ambas investigaciones o al modelo de metas utilizado, en el que se priorizan y utilizan tres tipos de metas académicas.

Cabe preguntarse entonces por los motivos que llevan a los estudiantes a adoptar metas de evitación del rendimiento. La respuesta se puede encontrar en la Teoría de la Expectativa-Valor (Wigfield y Eccles, 2000) y en los resultados de un estudio realizado por Jiang et al. (2018). Concretamente, este último estudio añadió a la Teoría de la Expectativa-Valor el término de "coste", referente a los resultados negativos por realizar una tarea académica, lo que se convirtió en un predictor significativo de la adopción de metas de evitación y resultados académicos desfavorables.

De manera complementaria, al igual que se hizo en los estudios 1 (Abín et al., 2020) y 2 (Cueli et al., 2023), se analiza el efecto del género y del curso académico tanto en la aparición de los diferentes perfiles motivacionales como en sus relaciones con el rendimiento matemático, tal y como realizaron autores como González-Torres y Torrano (2013) y Liew et al. (2014). Con relación al género, se observan diferencias en el tipo de meta motivacional que muestran los chicos con respecto a las chicas. Los resultados han sido contradictorios en las investigaciones realizadas sobre el tema, donde algunos autores encontraron perfiles más adaptativos con bajas metas de evitación en las chicas (Thorkildsen y Nicholls, 1998; Wach et al., 2015; González-Torres y Torrano, 2013) y otros encontraron justo lo inverso, con patrones más adaptativos en los chicos (Liew et al., 2014; Valle et al., 2016a). Con respecto al curso académico, y en línea con lo expuesto en la presente Tesis Doctoral, el rendimiento matemático se reduce a medida que aumentan los años en la escolarización. En concreto, se observa que al principio de la Educación Secundaria es más frecuente encontrarnos con perfiles con altas metas académicas tanto de dominio como de aproximación al rendimiento (ej: HAGP), a diferencia de los cursos superiores donde es más frecuente encontrarse con patrones con alta desmotivación (ej: LAGP). Estos resultados aportan a lo ya establecido previamente por Lazarides et al. (2016) y Wormington y Linnnenbrink-García (2017).

La identificación de los perfiles motivacionales presentes en la educación permite conocer su importancia tanto para el buen desempeño académico como para ofrecer estrategias educativas adecuadas a las necesidades y características del alumnado. Finalmente, tras discutir los resultados más relevantes a la luz de investigaciones previas, se concluye que desde una perspectiva centrada en la persona es de suma importancia conocer el rol de otras variables individuales como el género o el curso académico en el que se encuentran, con el fin de explicar las relaciones entre los perfiles y el rendimiento matemático.

Con el desarrollo de los estudios anteriores se deja constancia de la importancia de las variables emocionales y motivacionales por su influencia en el desarrollo matemático. Además, este interés ha dado pie a estudiar, desde una perspectiva centrada en la persona, los diferentes perfiles motivacionales y perfiles de creencia matemática existentes en el alumnado de Educación Secundaria. Bien es cierto que, de manera complementaria a lo anterior, es crucial el desarrollo de investigaciones desde una perspectiva contextual centrada en el entendimiento de la implicación familiar al ser una esfera con gran impacto en el desarrollo y rendimiento del alumnado.

Es evidente que la gran mayoría de estos estudios relacionados con la implicación familiar se han centrado en su actuación durante los deberes y también se han desarrollado con muestra de alumnado con desarrollo normativo. Por tanto, la evidencia científica disminuye significativamente cuando se tienen en cuenta otras variables de carácter individual como las necesidades educativas del alumnado, muy presentes en la esfera académica. Por esta razón, a lo largo de la publicación 3 (estudio 4) titulada “The emotional impact of family involvement during homework in children with neurodevelopmental disorders: a systematic review” (Abín et al., in press) se revisan los artículos publicados sobre los deberes escolares y los trastornos del neurodesarrollo, por su gran prevalencia a nivel educativo. Además, dentro de este objetivo, se presta especial atención al rol de la familia durante el desarrollo de los deberes escolares con

hijos con algún tipo de trastorno del neurodesarrollo, como el trastorno por déficit de atención e hiperactividad (en adelante, TDAH) o las dificultades específicas del aprendizaje. Todo ello permite responder a la última pregunta de investigación que plantea el conocimiento de la relación existente entre esas variables individuales y contextuales en el desarrollo y el rendimiento del alumnado.

Lo que se observa a lo largo de esta revisión empírica es que existe muy poca producción científica referente al tema entre 2012 y 2022. Además, los trabajos publicados suelen darse fuera de Europa, a pesar del gran debate generado en este continente en los últimos años. Por otro lado, de los escasos estudios analizados, la mayoría han trabajado con necesidades educativas compatibles con los trastornos del neurodesarrollo como las dificultades específicas de aprendizaje o el TDAH. Es precisamente en esta muestra donde se encuentra una mayor dificultad para hacer frente a los deberes escolares en comparación con los estudiantes sin necesidades educativas (Touloupis, 2021). De manera específica, parece que estas dificultades durante los deberes se deben a problemas a nivel emocional tanto en los niños como en los padres, pilar fundamental durante el desarrollo de las tareas académicas en el hogar (Cheung y Teule, 2016; Xia et al., 2015). Esto se observa en los estudios analizados en dicha publicación, donde se ve que cuando los padres ejecutan su rol durante los deberes lejos de emociones negativas, su implicación tiene un impacto positivo mucho más grande y significativo en los estudiantes con trastornos del neurodesarrollo, lo que también se ha corroborado en estudios como el desarrollado por Katz et al. (2012).

La evidencia científica desarrollada en los últimos años ha dado lugar a intervenciones centradas en la mejora de la prescripción de deberes desde el punto de vista del profesorado, como el método MITCA (Valle et al., 2020), encontrando en la muestra analizada intervenciones similares que tienen como objetivo la mejora del alumnado en su desempeño en el ámbito educativo (Houser et al., 2015; King-Sears et al., 2017). En este sentido, y siguiendo

con los resultados obtenidos, resulta importante trabajar los aspectos emocionales tanto de las familias como de los hijos durante el desarrollo de los deberes escolares. Por esa razón, otras intervenciones analizadas se centran en el impacto emocional teniendo en cuenta la presencia de trastornos del neurodesarrollo en los niños (Multhauf et al., 2016; Pfiffner et al., 2014). Estas intervenciones de carácter emocional no dejan a un lado los aspectos académicos, ya que de manera paralela trabajan habilidades como la atención, las habilidades sociales y la organización del estudiante. Además, tal y como se viene defendiendo a lo largo de este punto, incluyen el impacto del contexto en el desarrollo emocional y rendimiento del alumnado, trabajando con las familias con hijos con trastornos del neurodesarrollo para mejorar su implicación familiar durante los deberes, favoreciendo las emociones positivas en la familia, reduciendo el estrés parental y el estrés en los hijos y, en definitiva, aumentando la motivación y el compromiso por aprender, lo que se ha afirmado en diferentes estudios sobre el tema (Ayar et al., 2021; Katz et al., 2012; Multhauf et al., 2016; Mphahlele et al., 2020; Morales-Hidalgo et al., 2023; Xia et al., 2015).

Los avances en esta perspectiva contextual nos permiten comprender que la familia es un entorno de gran importancia para el desarrollo académico y para el desarrollo emocional de los estudiantes, especialmente cuando nos referimos a alumnado con algún tipo de necesidad educativa como pueden ser los trastornos del neurodesarrollo.

Implicaciones prácticas

Considerando los resultados obtenidos, una de las implicaciones más reseñables que se puede extraer de la presente Tesis Doctoral es la necesidad de analizar y tener en cuenta el rol de las variables emocionales y motivacionales puesto que son capaces de explicar el rendimiento matemático en mayor medida que la capacidad intelectual, lo que supone ciertos cambios metodológicos que favorecerían, en definitiva, este desarrollo académico. De esta

manera, la intervención en variables como la motivación, la competencia y la utilidad percibidas en relación con las matemáticas tendría un impacto positivo en el rendimiento. Además, es preciso que los profesionales de la educación trabajen específicamente la autoeficacia matemática de los estudiantes, ya que funciona como factor protector de estados emocionales negativos (ej: ansiedad matemática) y favorece el rendimiento matemático. Al igual que con la autoeficacia, los profesionales de la educación también deben comprender los diferentes perfiles motivacionales existentes en el alumnado, lo que ayudará a evitar el abandono escolar y el bajo rendimiento, potenciando a su vez variables personales como la autoestima, la autodeterminación y las correctas atribuciones a los éxitos y fracasos que tienen lugar durante la etapa académica de cualquier estudiante.

Otra implicación que se puede extraer de los resultados de los estudios realizados hace referencia a la consideración de otras variables que también influyen en el proceso de enseñanza-aprendizaje del alumnado, como pueden ser las necesidades educativas del alumnado y la implicación familiar, entre otras. Es evidente que la motivación es una variable que se encuentra en bajos niveles al coexistir con una necesidad educativa, por lo que es especialmente importante tener en cuenta en este grupo de alumnado las variables motivacionales.

Por último, se resalta la importancia del estado emocional tanto del alumno como de su entorno familiar, especialmente cuando se tiene que hacer frente a tareas escolares como los deberes, tan debatidos y criticados en las últimas décadas. Se ha podido evidenciar la importancia de generar intervenciones para una buena gestión emocional y conductual en ambas esferas en alumnado con trastornos del neurodesarrollo, aunque es algo que se debe generalizar a todo el grueso del alumnado.

Limitaciones y líneas futuras

Es significativo señalar las limitaciones presentes en los estudios que componen la presente Tesis Doctoral. En primer lugar, sería conveniente no generalizar los resultados a pesar de que para el desarrollo de los tres primeros estudios se utilizó una muestra amplia y representativa en términos de género y edad. Por esta razón, y a pesar de haber identificado diferentes perfiles motivacionales y de creencias matemáticas, debe tenerse en cuenta que se restringen únicamente a la muestra de estudiantes utilizada en los estudios. Por otro lado, y de manera específica para el estudio 3, se encuentra una limitación con respecto a la estructura de los datos utilizada ya que no se tuvo en cuenta la distribución de los sujetos en las clases o grupos, lo que se debería de tomar en consideración para futuros estudios sobre el tema. En tercer lugar, se encuentra otra limitación relacionada con la utilización de una dimensión singular y específica de la ansiedad matemática. Por último, en la revisión empírica realizada el número de artículos es limitado dado que no hay publicaciones al respecto en los últimos 10 años. Esto tiene cierta implicación futura puesto que todos los estudios al respecto favorecerán un gran conocimiento con importantes implicaciones educativas a nivel internacional.

Teniendo en cuenta la información expuesta, como línea futura, se plantea continuar con el análisis de las variables emocionales y motivacionales en alumnado de otras etapas educativas, como es la Educación Primaria. De manera complementaria, también se ha iniciado una nueva línea de investigación centrada en el análisis de la implicación familiar durante los deberes escolares para comprobar, a su vez, cómo puede impactar o influir en el rendimiento matemático del alumnado de Educación Primaria.

Conclusiones

- Las variables emocionales y motivacionales presentan mayor poder de predicción que las variables intelectuales.
- La competencia percibida es una variable con más relevancia que la capacidad intelectual, permitiendo que el alumnado se fije objetivos de aprendizaje más ambiciosos.
- La percepción de utilidad de las matemáticas y la motivación intrínseca del estudiante funcionan como predictores positivos y significativos del rendimiento matemático.
- Las atribuciones causales de tipo externo presentan una correlación significativa de tipo negativo con el rendimiento matemático.
- En la muestra de estudiantes analizada, la ansiedad matemática no guarda una relación estadísticamente significativa con el rendimiento matemático.
- Las habilidades cognitivas, la competencia percibida y la motivación intrínseca mantienen la misma capacidad predictiva para ambos géneros.
- La influencia de las variables cognitivas, emocionales y motivacionales en el rendimiento matemático disminuye con la edad.
- Al combinar la autoeficacia matemática y la ansiedad matemática se obtienen seis perfiles de creencia matemática.
- Los perfiles con autoeficacia elevada son los predictores del rendimiento matemático alto, independientemente de los niveles de ansiedad matemática presentes en el alumnado de Educación Secundaria. Esto es así porque la autoeficacia alta puede funcionar como factor protector de determinados estados emocionales negativos, como la ansiedad ante las matemáticas.

- Los perfiles de creencia matemática caracterizados por una baja autoeficacia son los que rinden peor en matemáticas. Por otro lado, los perfiles de creencia matemática con altos niveles de ansiedad matemática tienen un peor rendimiento matemático, pero solamente cuando la autoeficacia es baja.
- Se identifican cuatro perfiles motivacionales al considerar las diferentes metas académicas del alumnado de Educación Secundaria, tales como las metas de dominio, las metas de aproximación al rendimiento y las metas de evitación del rendimiento.
- El perfil que se relaciona con un mayor rendimiento matemático es aquel caracterizado por altas metas de dominio y de aproximación al rendimiento y bajas-medias metas de evitación (AHP).
- Los perfiles con altas metas de evitación (ej: HAGP o LAGP) son los que se relacionan con un menor rendimiento matemático.
- Se precisa de más estudios que analicen los deberes escolares en alumnado con necesidades educativas.
- El alumnado con dificultades de aprendizaje o con TDAH son los que tienen una mayor dificultad para hacer frente a los deberes escolares, en comparación con los estudiantes sin necesidades educativas. Estas dificultades no se refieren solamente al rendimiento durante los deberes, sino que también dan cuenta de las dificultades a nivel emocional de los niños/as y de las familias.
- Resulta fundamental el diseño de intervenciones para la mejora de la prescripción y desarrollo de los deberes que consideren las variables emocionales y el rol de la familia como contexto de desarrollo de los estudiantes.

Conclusions

- Emotional and motivational variables are more predictive than intellectual abilities.
- Perceived competence is a more relevant variable than intellectual ability, allowing students to set more ambitious learning goals.
- Perceived usefulness of mathematics and student intrinsic motivation function as positive and significant predictors of mathematical achievement.
- External causal attributions are significantly negatively correlated with mathematical achievement.
- In the sample of students analyzed, mathematical anxiety is not statistically significantly related to mathematical achievement.
- Cognitive skills, perceived competence and intrinsic motivation maintain the same predictive power for both genders.
- The influence of cognitive, emotional, and motivational variables on mathematical achievement decreases with age.
- Combining mathematical self-efficacy and mathematical anxiety generate six mathematical self-belief profiles.
- High self-efficacy profiles are predictors of high mathematics achievement, irrespective of the levels of mathematics anxiety experienced by students in secondary school. This is because high self-efficacy may function as a protective factor against certain negative emotional states, such as mathematics anxiety.
- Mathematics self-belief profiles characterized by low self-efficacy are those who perform worse in mathematics. On the other hand, mathematics self-belief profiles

with high levels of mathematics anxiety perform worse in mathematics, but only when self-efficacy is low.

- Four motivational profiles are identified when considering secondary students' different academic goals, such as mastery goals, performance-approach goals and performance-avoidance goals.
- The profile that is related to higher mathematical achievement is the one characterized by high mastery and performance-approach goals and low-medium avoidance goals (AHP).
- Profiles with high avoidance goals (e.g., HAGP or LAGP) are those associated with lower mathematical performance.
- More studies are needed to analyze homework in students with educational needs.
- Students with learning disabilities or ADHD have greater difficulties in doing homework compared to students without educational needs. These difficulties are not only related to homework performance, but also reflect difficulties at the emotional level of children and families.
- It is essential to design interventions to improve homework prescription and performance that take into account emotional variables and the role of the family as a context for students' development.

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