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Attitudes towards Science among Primary Students in Schools with Bilingual Education Programme

Actitudes hacia la ciencia del alumnado de educación primaria de centros con programa educativo bilingüe

Atitudes em relação à ciência por parte dos alunos do ensino básico em escolas com um programa educativo bilingue

双语项目小学学生科学态度的研究

مواقف تلاميذ التعليم الابتدائي تجاه العلوم في المدارس ذات البرامج التعليمية الثنائية اللغ

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Abstract

Developing scientific competence from an early age is essential for achieving scientific literacy among citizens. Given that the attitudinal dimension constitutes a key component of scientific competence, this study aimed to examine the attitudes toward science among sixth-grade students enrolled in British Council Bilingual Education Programme schools and to identify the factors influencing the development of these attitudes. The research involved 2,396 students from 52 schools and employed a predominantly descriptive and inferential methodology within a quantitative framework. Data collection was conducted using a survey based on a preexisting, validated, and reliable questionnaire designed to assess students' attitudes towards science. The variables analysed included gender, class size and professions of family members. The analysis revealed that attitudes towards science are a construct made up of three factors: *adoption of scientific attitudes, attitudes toward scientists, and inclination for science*. The results support the conclusion that attitudes towards science of students at Primary Schools with the British Council Bilingual Educational Programme are adequate and close to excellence. These are also more favourable amongst girls than boys, in those students who have family members dedicated to science and in smaller schools with fewer groups.

Keywords: Attitude, science, bilingual education, primary student, student evaluation.

Resumen

La adquisición de la competencia científica desde las primeras etapas es necesaria para alcanzar la alfabetización de la ciudadanía. Siendo la parte actitudinal una de las vertientes de la competencia científica, en esta investigación se planteó como objetivo investigar cuáles son las actitudes hacia la ciencia en alumnado de sexto de Educación Primaria de los centros con Programa Educativo Bilingüe del British Council y determinar qué factores influyen en el desarrollo de estas actitudes. El estudio, en el que han participado 2396 estudiantes de 52 centros, ha seguido una metodología de investigación mayoritariamente descriptiva y también inferencial con un enfoque cuantitativo. Se ha llevado a cabo con la técnica de encuesta a través de un cuestionario preexistente, validado y confiable para evaluar las actitudes del alumnado hacia la ciencia. Las variables analizadas fueron el género, tamaño del aula y la dedicación de los familiares. El análisis reveló que las actitudes hacia la ciencia son un constructo formado por tres factores: *adopción de actitudes científicas, actitudes hacia los científicos* e *inclinación por la ciencia*. Los resultados permiten afirmar que las actitudes hacia la ciencia del alumnado de centros con Programa Educativo Bilingüe son adecuadas y cercanas a la excelencia. Asimismo, son más favorables en las niñas que en los niños, en aquellos discentes que tienen familiares dedicados a la ciencia y en el alumnado de centros más pequeños y con menos aulas.

Palabras clave: Actitud, ciencia, educación bilingüe, estudiante de primaria, evaluación del estudiante.

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Resumo

A aquisição da competência científica desde as primeiras fases é necessária para alcançar a literacia da cidadania. Sendo a atitude uma das vertentes da competência científica, nesta investigação, propomo-nos como objetivo investigar quais são as atitudes em relação à ciência de alunos do sexto ano do ensino básico de escolas com o Programa Educativo Bilingue do British Council e determinar que fatores influenciam o desenvolvimento destas atitudes. O estudo, no qual participaram 2396 alunos de 52 escolas, seguiu uma metodologia de investigação maioritariamente descritiva e também inferencial com uma abordagem quantitativa. O estudo foi realizado com a técnica de inquérito, utilizando um questionário pré-existente, validado e fiável para avaliar as atitudes dos alunos em relação à ciência. As variáveis analisadas foram o género, o tamanho da turma e a dedicação dos familiares. A análise revelou que as atitudes em relação à ciência são um constructo constituído por três fatores: *adoção de atitudes científicas, atitudes em relação aos cientistas* e *inclinação para a ciência*. Os resultados permitem-nos afirmar que as atitudes face à ciência dos alunos das escolas com um Programa Educativo Bilingue são adequadas e próximas da excelência. São também mais favoráveis nas raparigas do que nos rapazes, nos alunos que têm familiares envolvidos na ciência e nos alunos de escolas mais pequenas e com menos turmas.

Palavras-chave: Atitude, ciência, ensino bilingue, aluno do ensino básico, avaliação do aluno.

摘要

从早期阶段培养科学素养能力对于实现公民科学素养至关重要。作为科学素养的重要组成部分，态度维度在本研究中被重点关注。本研究旨在调查英国文化协会双语项目小学六年级学生的科学态度，并探究影响这些态度形成的因素。研究涵盖 52 所学校的 2396 名学生，采用以描述性为主、兼具推断性的定量研究方法，通过施用一份经验证且可靠的现有问卷对学生的科学态度进行评估。分析的变量包括性别、班级规模及家庭成员的从业情况。分析结果显示，学生对科学的态度是由三个因素构成的：科学态度的采纳、对科学家的态度以及对科学的兴趣倾向。结果表明，参与双语项目的学生整体上具有良好甚至接近卓越的科学态度；此外，女生的科学态度优于男生，有家庭成员从事科学相关职业的学生以及班级规模较小的学生，科学态度表现更佳。

关键词: 态度、科学、双语教育、小学生、学生评估。

ملخص

تُعدّ تنمية الكفاءة العلمية منذ المراحل الأولى من التعليم أمرًا ضروريًا لتحقيق التمكّن العلمي لدى المواطنين. ونظرًا لأن البُعد الموقفي يُمثل أحد الجوانب الأساسية لهذه الكفاءة، تهدف هذه الدراسة إلى استقصاء مواقف تلاميذ الصف السادس من التعليم الابتدائي تجاه العلوم في المدارس التي تعتمد برنامجًا تعليميًا ثنائي اللغة بالتعاون مع المجلس الثقافي البريطاني، وتحديد العوامل المؤثرة في تطور هذه المواقف. شارك في الدراسة 2396 تلميذًا وتلميذة من 52 مؤسسة تعليمية، واتبعت منهجية بحث وصفية بالدرجة الأولى، بالإضافة إلى تحليل استدلالي ضمن إطار منهج كمي. وقد أُجريت الدراسة باستخدام تقنية الاستبيان، اعتمادًا على أداة سابقة التحقق من صدقها وثباتها، بهدف تقييم مواقف المتعلمين تجاه العلوم. شملت المتغيرات محل الدراسة كلًّا من الجنس، وحجم الصف الدراسي، ومستوى انخراط أفراد الأسرة في المجال العلمي. وكشف التحليل أن المواقف تجاه العلوم تُعدّ بنية مكونة من ثلاثة عوامل: تبنّي المواقف العلمية، والمواقف تجاه العلماء، والميول نحو العلوم. وتُبيّن النتائج أن مواقف تلاميذ المدارس ذات البرنامج التعليمي الثنائي اللغة تجاه العلوم كانت إيجابية وقريبة من التميز، كما أظهرت الدراسة أن هذه المواقف كانت أكثر إيجابية لدى الإناث مقارنةً بالذكور، ولدى المتعلمين الذين لديهم أقارب يعملون في المجال العلمي، وكذلك لدى تلاميذ المدارس الصغيرة ذات العدد المحدود من الصفوف

الكلمات المفتاحية: الموقف؛ العلوم؛ التعليم الثنائي اللغة؛ تلميذ المرحلة الابتدائية؛ تقويم المتعلم

Introduction

Attitudes toward science are closely linked to scientific literacy, with better attitudes leading to higher levels of literacy (Tai et al., 2022). Therefore, examining students' attitudes toward science at the early stages of the educational system is of significant interest, as it can inform the design of strategies aimed at enhancing these attitudes in later educational stages.

In order to conduct this study, it is necessary to clarify a series of terms. Firstly, it is important to define scientific literacy and its importance. Secondly, both the components of scientific competence and attitudes must be clarified. Thirdly, the understanding of attitudes towards science and the factors that condition them will be explained, as well as the instruments used to measure attitudes. Finally, given the context of the study – schools with the British Council Bilingual Education Programme (BEP) – a brief analysis of these schools and the bilingual programmes in the Spanish Education system will be provided.

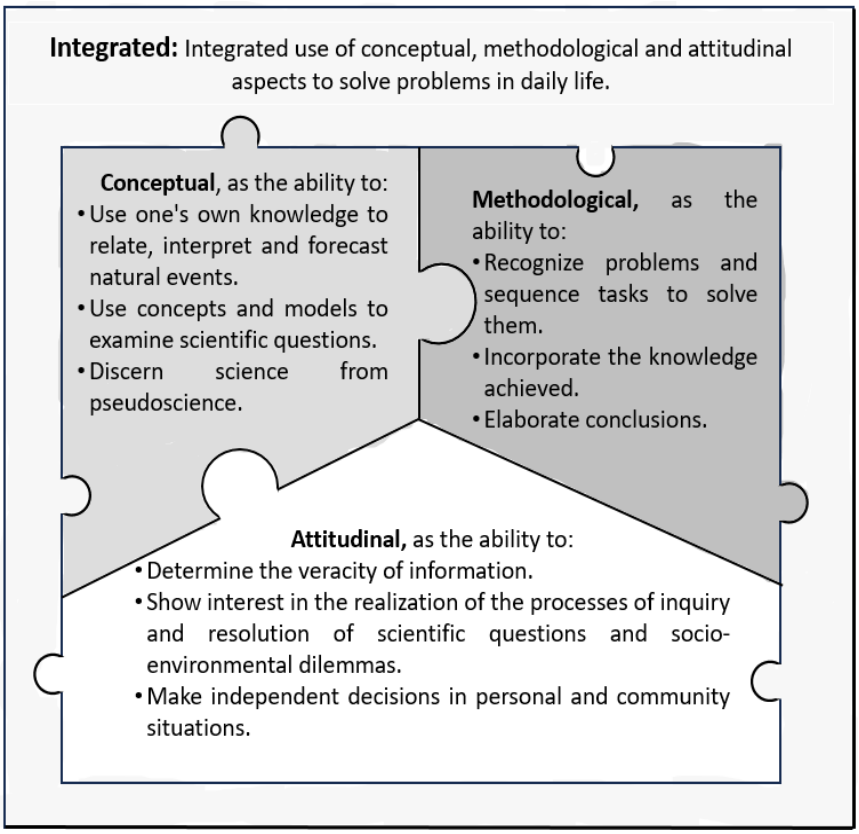
Scientific literacy

Scientific literacy has been shown to engender a multitude of opportunities, including its close correlation with the economic development of a given society. Furthermore, it facilitates problem-solving and responsible decision-making processes, underpinned by sound knowledge (Taghap & Mannan, 2024). Since 2004, there has been a marked increase in the level of interest in science and technology in Spain (FECYT, 2023). However, scientific literacy remains limited and there is a significant absence of scientific knowledge within society. It is imperative that citizens develop a comprehensive understanding of the information pertinent to scientific and technological issues. Moreover, it is essential that they employ scientific knowledge and problem-solving skills not only within the confines of classrooms and laboratories but also in their daily lives (Lu et al., 2023). This dearth of scientific knowledge may be attributable to the decline in students pursuing scientific careers, as evidenced by data from CRUE (2020) in Spain, Tai et al. (2022) in the USA, and Adolphus (2020) in Scotland. Avargil et al. (2020) posit that this results in a decline in the number of qualified individuals in the area. Ideally, this number should be increased to meet the constant evolution of the scientific and technological fields in our society. Consequently, it is imperative to implement effective educational strategies from the earliest stages of science learning to circumvent the aforementioned issues.

Scientific competence

This scientific instruction, as outlined in current educational guidelines, employs a competency-based approach. Consequently, any discourse on enhancing science learning is predicated on the development of scientific competence in all its dimensions. According to Cañal (2012), a seminal figure in this field, this competence comprises four components that are addressed in an integrated manner (see Figure 1).

Figure 1. Components of scientific competence.



Note: Own elaboration based on Cañal (2012).

This conceptualisation is currently upheld by other authors (Vázquez-Rodríguez, 2024), who link the methodological, cognitive/metacognitive and affective-attitudinal components to identify and solve everyday problems. In order to evaluate the acquisition of scientific competence in its entirety, it is necessary to analyse all its components. However, the focus of this paper is limited to the attitudinal aspect.

Attitudes related to science and towards science

Fostering positive attitudes towards science from an early age leads to higher academic achievement due to the emotional aspect of learning (Mao et al., 2021). Therefore, the more positive attitudes, the greater the inclination for science and the higher of scientific competence and literacy. But what do we mean by 'science-related attitudes'? Is it the same as 'attitudes towards science'? To clarify this, we review the ideas of foundational authors and current proposals. Klopfer (1971) suggested a multidimensional approach. Attitudes are the sum of acceptance of scientific inquiry as a way of thinking, acquisition of 'scientific attitudes', enjoyment and development of interests in scientific learning experiences, growth of favourable attitudes towards science and scientists, and fostering of interest in a scientific career or related professions. Fishbein and Ajzen (1975) supported the emotional component of attitudes with the theory of reasoned action, defining them as behaviours or opinions towards science prompted by students' feelings, which are in turn conditioned by their scientific knowledge.

Aydeniz and Kotowski (2014) argue that distinguishing between scientific attitudes (SA) and attitudes towards science (ATS) is necessary and beneficial. SA relate to scientific tasks, such as logic, objectivity and scepticism,

while ATS are more emotional. This distinction improves the reliability and validity of methods used to measure ATS. Perez and De Pro (2018) add the experiential to the affective, cognitive and behavioural components.

Aguilera and Perales (2019) insist on differentiating attitudes into SA and ATS, stating that ATS possess four dimensions: the value of science for students; the connection between science and day-to-day life; the enjoyment and curiosity in learning and practicing science; and the feeling of being capable and competent in doing so. They consider attitudes as a tripartite construct: behaviour, emotions and cognition, as does Tai et al. (2022).

Determinants of ATS

Several authors have addressed the determinants of ATS. We highlight the review by Osborne et al. (2003), who proposed: socioeconomic class; classroom and teacher related factors; materials and methodologies; the belief that science is difficult; previous academic achievements; cultural factors conditioned by the country of origin; and gender. Rodríguez et al. (2011) suggest dividing these factors into endogenous, directly affected or influenced by the teaching process (pedagogical forms used, vision of science, previous academic successes, peer attitudes, etc.); and exogenous, which would exist independently of the classroom (self-concept, age, school location, families, gender, etc.).

ATS measurement instruments

Many instruments have been developed to measure ATS, some of which were analysed by Navarro et al. (2016) and Toma and Lederman (2022). Here, we present a brief review of instruments in Spanish for students in the last years of Primary Education (PE). Marbà-Tallada and Márquez (2010) proposed a four-point Likert scale with 16 items, administered without validation to students aged 11 and 16 years. They considered three dimensions: science classes, science and technology opinions, and future in science. Pérez (2013) designed and used an extensive instrument with Likert scales, open and multiple-choice questions, administered without validation to students aged 11 and 16 years. He proposed four dimensions: assessment of the non-formal learning context, identification of scientific contributions, positioning of negative-positive contributions of science, and assessment of science.

Researchers Toma and Greca (2018) translated Fraser's (1981) 70-item questionnaire, which was designed and validated in adolescents. It posed seven dimensions: social implications, normality of scientists, attitude towards research, adoption of scientific attitudes, enjoyment of lessons, interest in leisure time, and motivation towards a career in science. Their work was not reduced to mere translation; they eliminated negatively worded items, reduced the number of items per dimension so as not to fatigue students, and adapted the wording for the later grades of PE. This reduced the instrument to fourteen items. Finally, they changed the Likert scale from five to four points and administered it to 9-year-old children, but it was not validated. However, one year later, Toma et al. (2019) validated it in a sample aged 9-11 years. They discarded the unreliable items, reducing the number of questions to ten. They proposed the existence of four factors: 'Enthusiasm for science', 'Attitude towards science classes', 'Adoption of scientific attitudes' and 'Attitudes towards scientists'.

Tai et al. (2022) modified the mATSI questionnaire, reducing it to 17 questions and identifying five dimensions: perception of the teacher; anxiety towards science; value of science for society; self-confidence in science; and desire to study science.

The uniqueness of the Bilingual Education Programme

Since the end of the last century, the European Union has been promoting plurilingual and intercultural education from an early age and on a lifelong basis. This idea is reinforced today because linguistic diversity

is part of Europe's DNA (Salvi & Tremblay, 2025), and because of the effects that this type of education has on strengthening democratic culture (Council of Europe, 2022). In this regard, the Resolution of March 1, 1996 included the signing of the agreement between the Ministry of Education, British Council and 10 Regional Authorities, whose background is detailed in Jover et al. (2024). Through this agreement, the BEP was developed to teach English language and culture through an integrated curriculum. Almost three decades later, there are 90 schools in BEP, constituting 3.08 % (MEFP, 2023) of the 3020 primary schools that offer bilingual education in Spain. These schools are fairly homogeneous: public, mostly urban, with teachers meeting national criteria, and students with a similar socioeconomic and cultural background. These patterns of homogeneity reduce the variables to be considered and place the BEP schools as an interesting sample for data analysis.

The last Agreement signed between the Spanish Ministry of Education and the British Council (MEFP, 2020) established that between 10 and 12 hours should be taught in English at the EP stage, and the subjects that should be taught entirely in English are: Natural Sciences, Social Sciences and Art Education. In the Natural Sciences section of the Environment subject, the British curriculum emphasises student-led research and experimentation, encouraging understanding through personal discovery, particularly in physics and chemistry. It aims to develop knowledge, understanding of important principles and ideas, and to generate skills to promote critical thinking and problem solving (Agudo, et al., 2004). Therefore, by integrating it with the Spanish curriculum, there is an enrichment of competencias.

Method

Objectives and research questions

The objective of this research is to identify the ATS and the impact of some factors on them in sixth grade students in schools with BEP. The attitude demonstrated and perceived towards content taught in a foreign language is a pivotal factor in the conceptual and methodological acquisition process. The ATS will be measured using its tripartite conception, incorporating behavioural, affective and cognitive components (Aguilera & Perales, 2019; Tai et al., 2022). The following questions are posed: do students in BEP schools possess adequate ATS? Does gender influence ATS? Does the presence of family members dedicated to science influence attitudes towards science? Does the size of the schools and their number of classrooms affect ATS? And does the size of the schools and their number of groups affect ATS?

The present study focuses on three key determinants of ATS: gender, family and the size of the schools. Contradictory results have been reported in previous studies; therefore, the present study aims to resolve these contradictions. The objective of this study is to demonstrate whether gender, family and school size truly influence students' ATS in the sixth year of PE. In addition, an innovative contribution is made through the testing of the adequacy of the ATS of students in schools with BEP.

Design

This study presents a quantitative research approach with a non-experimental cross-sectional design and a mostly descriptive research methodology. Descriptive statistical analysis (measures of central tendency and dispersion) has been performed to describe the situation of the sample, and also inferential analysis (confidence intervals and hypothesis contrasts) to estimate the behaviour of a population. The technique used is the survey, with the use of the questionnaire as an instrument.

Sample and context of the study

The non-probabilistic convenience sample comprised 2,396 students in the sixth year of PE between the ages of 11 and 12. The sample is representative of the population of interest as it includes 52 of the 90 schools with BEP from 10 autonomous regions and 1 autonomous city.

The sample constituted 60 % of the sixth grade students of the schools with BEP (percentage calculated from the data of MEFP, 2023). The administration of the questionnaire occurred during the 2022/2023 academic year, targeting students who had successfully completed their entire EP educational stage in accordance with the LOMCE. Consequently, the designated subject in the questionnaire will henceforth be referred to as Natural Sciences.

During the course of the study, all ethical aspects stipulated by Spanish legislation were adhered to. Permission was also obtained from the British Council in Spain and partners, and the questionnaire was only administered in classrooms whose tutors gave permission and agreed to take part in the study, and to students whose parents agreed to their participation. It is important to note that, in order to maintain the privacy and anonymity of the students and to avoid any influence on the sample, the tutors were provided with a link to the questionnaires and all the necessary information to administer them by sharing the link with the students. The questionnaire did not require any personal or student-identifiable data. Following the formulation of the questionnaire, the responsibility of the researchers was to collect the data in the Excel spreadsheet that had been generated by Microsoft Forms. Thereafter, they were required to analyse and interpret the data obtained. In a similar manner, the administration of the questionnaire was conducted through the utilisation of Microsoft's 365 application. This application is licensed by the University of Valladolid, to which the authors of this study are affiliated. The licensing of this application ensures the maintenance of anonymity and the protection of personal data of the participants.

Table 1 shows the sample configuration according to the different variables.

Table 1. Distribution of the sample in the different subgroups

Variable	Condition	Frequency
Gender	Girls	1128
	Boys	1199
	PNA (prefer not to answer)	69
Family environment	A family member dedicated to science	1187
	No family member dedicated to science	1209
School size	Small-1 class	167
	Medium-between 2-3 classes	1688
	Large- 4 or more classes	541

Instrument

The instrument utilised was the questionnaire developed by Toma et al. In the 2019 study, the researchers employed a 4-point Likert scale (1=Strongly disagree, 2=Disagree, 3=Agree, 4=Strongly agree) comprising 10 items. The item 'When I grow up, I would like to work with people who make scientific discoveries' was replaced with one of Fraser's original questions (1981), 'When I grow up, I would like to be a scientist' (see questionnaire in Appendix 1), as it provides a clearer position on the question of considering a future career in science. This modification was made to provide a clearer indication of the participant's future career aspirations, specifically their inclination for a scientific vocation. Small changes were also introduced to make the language more inclusive, replacing 'científico' with *'científico y científica*' or 'profesor' with *'profesora o profesor*'. The reasons for selecting this questionnaire were: it was adapted for the age of the sample; it was an instrument that had already been validated and was reliable for measuring the ATS construct in PE students; and it would not produce

fatigue in sixth grade PE students due to its concise nature (Toma et al., 2019).

Of the ten items in the questionnaire, those that assess the affective dimension are 1, 2, 3, 6, 7 and 9, since they contain terms such as "I like/like", "It is better", "I prefer" or "More interesting", and refer to feelings (Toma & Lederman, 2022). Items 4 and 8 measure the cognitive dimension, reflecting opinions and perceptions about scientists (Toma, 2021). Finally, 5 and 10 are those that evaluate behaviour by evidencing future actions (Toma & Lederman, 2022). In addition to the ten questions of the questionnaire, three further questions of a sociodemographic nature were included: school code, gender, and the presence of a family member dedicated to science (see Appendix 2). The questionnaire thus comprised a total of 13 questions.

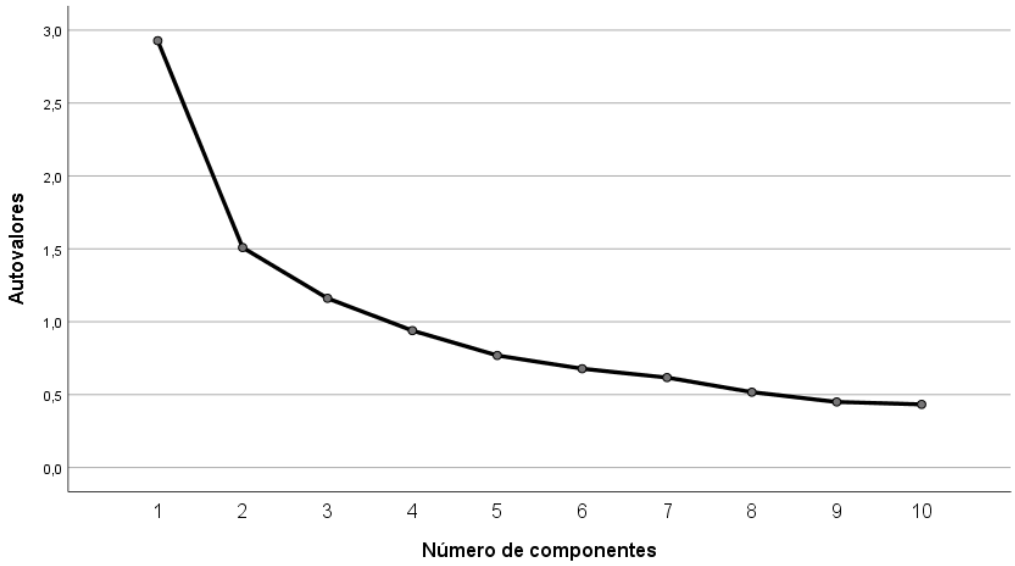
The instrument was self-administered *online*, through a link as indicated above, and was completed by students on electronic devices in their classrooms during school hours (Abascal & Grande, 2005). The development of this instrument was undertaken in the Spanish language with the objective of ensuring its alignment with international assessments such as TIMSS and PISA, which are customarily administered in the native language of the participating countries, regardless of the language of instruction.

Factor analysis

The sample adequacy for factor analysis was tested with the calculation of the Kaiser-Meyer-Olkin index (KMO) and Bartlett's test of sphericity: KMO= .75492, χ^2= 6340.5; gl 45; p= .000, demonstrating the sufficiency of the data for factor extraction. We performed the analysis with *Factor Analysis* software (Lorenzo-Seva & Ferrando, 2023), thus confirming that the modified questionnaire presented factors that could be replicated. Following Freiberg et al. (2013), as the dependent variables were ordinal (4-point Likert scale) we used a polychoric correlation matrix for principal component analysis and a parallel analysis followed by a standardised Varimax rotation.

The Kaiser criterion and the sedimentation plot study were utilised in order to ascertain the number of extant factors. The exploratory principal component factor analysis revealed the presence of three factors, or latent dimensions, with eigenvalues K > 1 ($Eigenvalue_{Factor\ 1}$ = 1.59, $Eigenvalue_{Factor\ 2}$ = 1.21, $Eigenvalue_{Factor\ 3}$ = 3.29), which collectively accounted for 60.95 % of the variance. The sedimentation plot (see Figure 2) also demonstrates the existence of three factors.

Figure 2. Sedimentation plot



According to Palacios et al. (2014), the inclusion criteria for items were: factor loadings greater than .4 for the principal factor and no cross-loadings for other factors (loadings ≤ .35 for non-principal factors). The reliability of the questionnaire was measured by calculating the ordinal alpha, rather than Cronbach's alpha (α), as it was determined by Lozano et al. (2008) that this would not be appropriate for this scale. This is due to the fact that the dependent variables are ordinal, with four possible options.

In accordance with the findings of Domínguez-Lara (2018) and the ordinal reliability values calculated with the Factor Analysis program (Lorenzo-Seva & Ferrando, 2023), it has been demonstrated that the questionnaire demonstrates acceptable reliability, thus permitting the inclusion of all items. The results of the ordinal alpha for each factor are displayed in Table 2.

Table 2. Factorial structure of the ATS questionnaire and ordinal alpha of the factors

Ítems	**Factor 1**	**Factor 2**	**Factor 3**
1. Me gusta hablar sobre la ciencia fuera de clase.			.691
2.Las CCN es la asignatura más interesante.			.713
3. Prefiero resolver un problema haciendo un experimento en lugar de recibir una respuesta.	.855		
4. Un científico o científica se parecen mucho a las demás personas.		.843	
5. Cuando sea mayor, quiero estudiar algo que tenga que ver con la ciencia.			.758
6. Me gustaría tener más horas de CCN a la semana.			.763
7. Es mejor descubrir la respuesta mediante un experimento antes que preguntar a la profesora o profesor.	.828		
8. Los científicos y científicas son igual de simpáticos/as que las demás personas		.796	
9. Me gustaría recibir materiales científicos para hacer experimentos en casa.	.561		
10. Cuando sea mayor, me gustaría ser científico o científica.			.769
Alfa ordina	.786	.803	.857

Note: Only values that meet the inclusion criteria are shown.

The items that make up each factor of the ATS construct and the equations for its calculation are as follows:

- Factor 1-*Adoption of scientific attitudes*= Sum score of items 3, 7 and 9 / 3.
- Factor 2-*Attitudes towards scientists*= Sum score of items 4 and 8 / 2.

Factor 3-*Inclination for science*= Sum score of items 1, 2, 6, 5 and 10 / 5.

Factors 1 and 2 correspond to two of the four factors proposed by Toma et al. (2019): *Adoption of scientific attitudes* and *Attitudes towards scientists*. These factors comprise the same items, hence their nomenclature has been maintained. Conversely, factor 3 in the present study incorporates the other two factors identified by Toma et al. (2019). Based on these correspondences and the factor analysis, we can affirm the robustness of the three factors identified. The calculation of overall scores (*Global Attitudes* construct) was achieved by summing the scores of all items.

Data analysis

The SPSS 27.0.0 program (IBM Corp., 2020) was employed for the descriptive and inferential statistical analysis of the participants' responses. The application of the Kolmogorov-Smirnov normality test to the variables yielded p-values ≤ .05. Consequently, it cannot be assured that these variables follow a normal distribution. However, statistical inferences using parametric tests were performed, since according to the central limit theorem, "statistical inferences can be made from samples using normal distribution properties, even if the population from which they come does not follow the normal distribution" (Martínez et al., 2020, p.83). For this purpose, the sample must meet a single criterion: it must be large. Therefore, sample values of 60 or more, as demonstrated in all the subgroups of the study sample (see Table 1), indicate an optimal adaptation to the normal distribution (Martínez et al., 2020). Consequently, the implementation of parametric tests to contrast the null hypotheses (H_o) becomes feasible.

In order to establish a contrast between the H_o variables and two subcategories, the Student's t-test was applied, to determine whether the mean value was equivalent between the two subcategories. In order to contrast the null hypotheses of variables with k subcategories, the one-factor ANOVA test was applied, with the hypothesis being "All the means of the subcategories are equal". The confidence level that had previously been established for the analysis of the hypothesis contrast tests (i.e. the probability that the interval contains the true value of the population) was 90 %, a level that has been considered adequate in the scientific literature (see Castañeda & Fabian, 2004; Madrid & Martínez, 2014). Consequently, the probability of committing a type 1 error (i.e. the likelihood of rejecting the null hypothesis when it is true) is 10 %, α= .10. The confidence intervals are presented in each of the tables. The confidence level that has been chosen is appropriate for the sample size (2396 participants), as it decreases the length of the interval and increases its precision, which is .04. The ANOVA test followed the Bonferroni *post hoc* tests (when variances were equal) or the Games-Howell tests (when variances could not be assumed equal) for pairwise multiple comparisons. The p value, or statistical significance level (Sánchez-Rodríguez, 2021), is distinct from the α significance level of the confidence interval. The p value was set at p ≤ .05, although it should be emphasised that the p values of the statistically significant comparisons shown in the results range from .001 to .036. In order to enhance the robustness of the study, the statistical power, and effect size (f_{Cohen} o d_{Cohen} indexes) were calculated with SPSS 27.0.0 (IBM Corp., 2020) and G Power (Faul et al., 2009).

Results

ATS of students in 6th grade of primary education in schools with BEP

Given that responses to each item were based on a 4-point Likert scale, the minimum attainable score was 1 point, while the maximum was 4. Consequently, a score ranging from 1 to 1.9 was deemed to be inadequate for the students, as it would indicate "Strongly disagree" or "Disagree" responses to each statement that expressed positive attitudes towards science. This would, in turn, suggest the presence of a negative ATS. A satisfactory outcome for students would be a score falling within the 2 to 2.9 range, as this would indicate agreement with the item and a positive ATS. Finally, scores between 3 and 4 were considered excellent, as they indicated "Agree" or "Strongly agree" responses and very positive ATS.

Firstly, the scores for individual items were studied. These are: item1= 2.342±0.831, item2= 2.600±0.893, item3= 3.060±1.000, item4= 2.530±0.971, item5= 2.260±1.096, item6= 2.190±1.023, item7= 2.830±1.028, item8= 3.420±0.805, item9= 3.140±0.964 and item10= 1.810±0.899. Analysing these scores with the previously explained criteria, the students of the schools with BEP are in an adequate situation in items 1, 2, 4, 5, 6 and 7 and in an excellent situation in items 3, 8 and 9. On the contrary, they are in an inadequate

situation in item 10-When I *grow up, I would like to be a scientist*, in which they do not reach 2. Considering the dimensions assessed by the different items (explained in the "Instrument" section), the affective and cognitive dimensions are in an adequate or excellent situation and the behavioural dimension is in an inadequate situation. When studying the mean scores of each of the factors, Factor 1= 3.010 ± 0.745, Factor 2= 2.977 ± 0.716 and Factor 3= 2.240 ± 0.678, the situation would be excellent for Factor 1 and adequate for Factors 2 and 3.

For *Global Attitudes*, a minimum of 10 points and a maximum of 40 points were possible. Scores between 10-19 were considered inadequate, 20-29 adequate, and 30-40 excellent. The *Global Attitudes* results were 26.18 ± 5.02, an adequate situation close to the excellence range.

Influence of gender

Table 3 shows the results of the scores obtained according to gender. It shows that girls have higher scores and demonstrate better attitudes for the ATS factors and its construct *Global Attitudes.*

Table 3. Means, standard deviations and CIs of the scores for the gender variable

Factor	Subcategory	Means	SD	Confidence Interval (CI) (Confidence level 90 %)	
				Lower limit	Upper limit
Global attitudes	Girl	26.497	4.7027	26.660	26.727
	Boy	25.978	5.2591	25.728	26.228
	PNA	24.580	5.4917	23.477	25.682
Factor 1	Girl	3.053	.7054	3.018	3.087
	Boy	2.975	.7784	2.938	3.012
	PNA	2.981	.7355	2.771	3.066
Factor 2	Girl	2.988	.6749	2.955	3.021
	Boy	2.980	.7469	2.945	3.016
	PNA	2.732	.7979	2.572	2.892
Factor 3	Girl	2.273	.6575	2.241	2.305
	Boy	2.219	.6959	2.185	2.252
	PNA	2.073	.6686	1.938	2.207

That superiority in girls' score after applying the ANOVA test proved to be statistically significant with small effect size in *Global Attitudes* (F_{ANOVA}= 6.736, p= .001, f_{Cohen}= .1 and statistical power= 97 %), Factor 1-*Adoption of scientific attitudes* (F_{ANOVA}= 3.687, p= .025, f_{Cohen}= .1 and statistical power= 82 %), Factor 2-*Attitudes toward scientists* (F_{ANOVA}= 4.186, p= .015, f_{Cohen}= .1 and statistical power= 81 %), and Factor 3-*Inclination for science* (F_{ANOVA}= 4.042, p= .018, f_{Cohen}= .1 and statistical power= 81 %).

Post hoc ANOVA analyses showed that between specific pairs there are statistically significant differences (Table 4). Girls have better *global attitudes* towards science than boys and PNA; they have a higher Factor 1-*Adoption of scientific attitudes* than boys and a higher Factor 2-*Attitudes towards scientists* than PNA. Likewise, PNA participants showed less favourable ATS than boys for Factor 2. Thus, girls have more favourable attitudes towards science as evidenced by statistical significance (p-value and CI), practical

significance (there is a small effect size) and statistical power.

Table 4. Post hoc between groups according to gender

Factor	Comparisons		Difference in means (1-2)	Standard error of the difference	p-value	90 % CI	
	Gender 1	Gender 2				Lower limit	Upper liimit
Global attitudes	**Girl**	**Boy**	**.5181***	**.2066**	**.033**	**.094**	**.942**
	Girl	**PNA**	**1.9168***	**.6758**	**.016**	**.508**	**3.325**
	Boy	PNA	1.3986	.6784	.105	-.015	2.812
Factor 1	**Girl**	**Boy**	**.0774***	**.0308**	**.032**	**.014**	**.141**
	Girl	PNA	.1344	.0910	.308	-.055	.324
	Boy	PNA	.0571	.0914	.807	-.133	.247
Factor 2	Girl	Boy	.0072	.0295	.968	.053	.068
	Girl	**PNA**	**.2557***	**.0981**	**.029**	**.051**	**.460**
	Boy	**PNA**	**.2485***	**.0985**	**.036**	**.043**	**.454**
Factor 3	Girl	Boy	.0544	.0281	.159	-.006	.114
	Girl	PNA	.2004	.0840	.051	-.022	.379
	Boy	PNA	.1461	.0839	.245	-.033	.325

Influence of the family environment

Table 5 shows the results for students in schools with BEP in the *Global Attitudes* and the three factors that comprise them, depending on whether the student has family members involved in science.

Table 5. Means, standard deviations and CI of the scores as a function of the family environment variable.

Factor	Subcategory	Mean	DS	CI (Confidence level 90%)	
				Lower limit	Upper limit
Global attitudes	A family member dedicated to science	26.792	4.9353	26.556	27.028
	No family member dedicated to science	25.583	5.0407	25.345	25.822
Factor 1	A family member dedicated to science	3.055	.7316	3.020	3.090
	No family member dedicated to science	2.966	.7547	2.930	3.002
Factor 2	A family member dedicated to science	3.003	.7080	2.970	3.037
	No family member dedicated to science	2.950	.7239	2.916	2.985
Factor 3	A family member dedicated to science	2.324	.6733	2.292	2.356
	No family member dedicated to science	2.157	.6731	2.125	2.189

The H_o were contrasted through Student's t-test. The results showed that there are statistically significant differences with medium-large effect size in Global Attitudes (t=-5.930, p= .001, d_{Cohen} = 4.989 and statistical power= 100 %) Factor 1-*Adoption of scientific attitudes* (t= -2.938, p= .002, d_{Cohen}= .743 and statistical power= 100 %), Factor 2-*Attitudes toward scientists* (t= -1.811, p= .035, d_{Cohen}= .716 and statistical power= 100 %), and Factor 3-*Inclination for science* (t= -6.072, p= .001, d_{Cohen}= .673 and statistical power= 100 %).

It was found that students in schools with BEP who have family members dedicated to science have more favourable attitudes towards scientific research, scientists and a greater inclination for science, which leads to better attitudes in the global ATS construct. This is supported by statistical significance (p-value and CI), practical significance (there is a medium-large effect size) and statistical power.

Influence of the size of the school

We classified the size of the school taking into account the number of groups it has in PE: with one group we considered it to be a small school, with two or three groups we considered it a medium-sized school, and with four or more groups we considered it a large school. Table 6 shows the results of the scores obtained by students in schools with BEP according to the size of the school.

Table 6. Means, standard deviations and CI of the scores according to the school size variable.

Factor	Subcategory	Means	SD	CI (Confidence level 90%)	
				Lower limit	Upper limit
Global attitudes	Small	26.521	4.883	25.896	27.146
	Medium	26.251	4.985	26.051	26.450
	Large	25.863	5.180	25.496	26.230
Factor 1	Small	2.975	.714	2.883	3.066
	Medium	3.010	.743	2.981	3.040
	Large	3.020	.760	2.966	3.074
Factor 2	Small	2.991	.749	2.895	3.087
	Medium	2.960	.715	2.934	2.990
	Large	3.023	.708	2.973	3.073
Factor 3	Small	2.323	.663	2.238	2.408
	Medium	2.260	.674	2.233	2.287
	Large	2.152	.688	2.103	2.200

The ANOVA results revealed that there are only statistically significant differences with a small effect size for Factor 3-*Inclination for science* (F_{ANOVA}= 6.622, p= .001, f_{Cohen}= .1 and statistical power= 95 %).

Post hoc ANOVA analyses were conducted to determine the specific pairs that exhibited statistically significant differences (see Table 7) for Factor 3-*Inclination for science*. It is evident that students from both small and

medium-sized BEP schools exhibit superior attitudes in this regard. Consequently, it can be concluded that school size exerts a significant influence on specific latent dimensions of the ATS, as evidenced by statistical and practical significance, as well as statistical power

Tabla 7. Post hoc entre grupos en función del tamaño de centro

Dependent variable	Comparisons		Difference in means (1-2)	Standard error of difference	p-value	90 % CI	
	Size 1	Size 2				Límite inferior	Size 1
Factor 3	Small	Large	.172	.060	.012	.044	.299
	Medium	Large	.108	.035	.004	.037	.180

Discussion and conclusions

This research has shown that minor modifications to the Toma et al. (2019) questionnaire maintain its validity and reliability for measuring ATS in PE. Additionally, it was observed that the ATS construct comprises three factors: *Adoption of scientific attitudes*, *Attitudes towards scientists*, and *Inclination for science*. Previous studies (Toma et al., 2019) identified four factors, but the present study has demonstrated a strong association between two of these factors, which were termed 'Attitude towards science classes' (measured by items 2 and 6) and 'Enthusiasm for science' (measured by items 1, 5 and 10). These two factors were found to be strongly associated and actually form a single factor. Overall, the results (not taking into account the different variables) indicate that the ATS of students in schools with BEP is at a medium-high level. The only deficiency revealed is in the behavioural dimension, with a low score for item 10 ('When I grow up, I would like to be a scientist'), but this is a general issue among students of this age (Vega-Agapito et al., 2024).

A comparison with other international or national studies on ATS is challenging due to the utilisation of diverse questionnaires for measurement, the absence of universal Likert scale application, and the variation in the age groups assessed and the dimensions measured. By narrowing the comparisons with other studies carried out on students of the same or very similar age and with questionnaires that measure the same dimensions, it can be concluded that the ATS of students in schools with BEP are similar to previous studies (Lupión & Girón, 2020; Vega-Agapito et al., 2024) and somewhat lower than those of the study by Toma et al. (2019). It should be noted that the latter was conducted in the context of students attending extracurricular science activities, who would be more likely to have more favourable ATS. The findings of this study indicate that ATS are predominantly favourable and elevated in the specific sixth grade students of the schools with BEP.

Regarding the influence of gender on ATS, we conclude that it is a conditioning factor. The results of our study show that ATS are more favourable in girls than in boys. Girls present better *Global attitudes* towards science than boys, due in particular to Factor 1- *Adoption of scientific attitudes.* In addition, girls also show better attitudes than the students who did not want to answer the gender question.

These results are contrary to those presented by several authors who have observed better attitudes in boys (Denessen et al., 2015; Hacieminoglu, 2016), others who show that there are no gender differences (Cermik & Fenli-Aktan, 2020; Eren, 2015; Jiménez & Menéndez, 2021; Soslu, 2022; Toma & Meneses, 2019), and others who show better attitudes on the part of girls (Lupión & Girón, 2020: Marrero et al., 2022). Looking at the differences between studies, in this research the size of the effect of gender on attitudes is small and has become visible due to the large

sample. In contrast, although Toma and Meneses (2019), Cermik and Fenli-Aktan (2020) or Jiménez and Menéndez (2021) have conducted their studies in the same age range, they have had small samples (between 151 and 709 students). Thus, when they conclude that there is no effect due to gender, based exclusively on the p-value≥ .05, they may be underestimating the differences due to the size of the sample. In addition, it should be emphasized that, although they find no significant differences, in the cases of Eren (2015) and Toma and Meneses (2019), the values for girls are higher. It is also noteworthy that none of the studies under discussion make reference to statistical power or effect size. A further salient point pertains to the observation that studies showing better attitudes in boys are older. Conversely, Denessen et al. (2015) have advocated the utilisation of the terminology 'science and technology' and not solely 'science', with the objective of prompting students to contemplate the inclusion of other facets. In the case of Hacieminoglu (2016), although the sample is large, the effect size is not reported. Furthermore, the results are the mean of students in PE and Secondary Education, and it is well known that age influences ATS (Susilawati, 2022), with a decrease in girls as they progress through the educational stages. Consequently, there is no apparent contradiction with previous literature, and we reaffirm that ATS are more effective in girls at the sixth level of PE. This data is significant as it facilitates the proposal of future studies, the objective of which is to ascertain the factors that influence the change in ATS in girls in educational stages following PE.

Regarding the influence of the family, reflected by the response to the question "*Do you have a family member involved in science or technology?*, there are studies that claim that a scientific family environment improves attitudes (Cermik & Fenli-Aktan, 2020; Marrero et al., 2022) and, however, others claim that it has little influence (Owen et al., 2008). The data of the present study clearly show with statistical significance, a medium-large effect size and high power, that having family members dedicated to science does influence the ATS. Therefore, those students who have family members dedicated to science have more favourable attitudes towards science, increasing the three factors that make up the construct *Global Attitudes*.

Regarding school size and its possible influence on attitudes towards science (ATS), it can be concluded that school size influences attitudes, but this influence is not comprehensive. Factor 3-*Inclination for science* is affected in such a way that the larger the school and the more groups it has, the lower the inclination for science. One possible explanation is the attention to students or the possibility of planning non-regulated actions for the dissemination of science in schools of different sizes. In this way, the student body of a smaller school would be in better conditions to have a more personalised and closer attention, as well as to work more easily by projects, cooperatively or using context-based instruction, methodological issues that are related to better ATS (Aguilera & Perales-Palacios, 2020).

This study is not without limitations. Although it is considered that the instrument used provides reliable measures of ATS, most of the items - six out of ten - quantify the attitudinal dimension of attitudes, which could lead to a bias in the measurement of global attitudes. On the other hand, the questionnaire only collected information from students, but no information from teachers. Likewise, the non-probabilistic and convenience method of choosing the sample may condition the results, despite the large number of students and their homogeneity.

These limitations give rise to future lines of research, such as the creation of a more balanced questionnaire with more items related to the behavioural and cognitive dimensions of ATS. In addition, the development of an instrument for teachers to record data on their ATSs and the methodologies employed is imperative, as asserted by White et al. (2022). This is due to the recognised influence of teachers' attitudes on students' attitudes. It is evident that a comprehensive understanding of

teachers' ATS would facilitate the establishment of correlations between students' attitudes and teachers' attitudes and methodologies. This assertion is supported by the findings of studies conducted by Denessen et al. (2015), which underscore the significance of identifying methodologies that promote favourable attitudes.

In relation to the positive influence on ATS of having a family member in an environment dedicated to science, a more detailed investigation into the specific causes could be undertaken. One hypothesis that may be put forward is that it is related to the type of activities they do in their leisure time. Reading science magazines or books, visiting museums and watching TV programmes have been shown to be related to better attitudes towards science (Cermik & Fenli-Aktan, 2020; Marrero et al., 2022; Soslu, 2022; Susilawati, 2022). However, it is also possible that the same effect exists when it is the mother who is engaged in science or has a higher level of education than the father, as observed by Cermik and Fenli-Aktan (2020).

It is imperative to recognise the significance of acquiring a more profound understanding of this issue, particularly with regard to the reproduction of these conditions within the school environment, whilst maintaining the necessary distances. It is recommended that science be integrated into the school environment through references in the decoration, including scientific content in different subjects (history, language, music, plastic arts, and physical education), thematic games and inviting scientists to school. This approach aims to break down the barriers between different subjects and bring the scientific world closer to the students.

An alternative line of enquiry would involve the assessment of the conceptual and methodological dimensions of students, with a view to evaluating their scientific competence in its totality. A final suggestion for focus of future research and given that BEP schools teach science subjects through English, would examine whether there are any correlations between students' English proficiency and their attitudes.

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Ethics Committee

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Appendices

Appendix 1. Attitude questions in the format used online

4

Select the number that represents your degree of agreement or disagreement with the following statements, being:
1. Strongly disagree
2. Disagree
3. Agree
4. Strongly Agree

- If you **DON'T LIKE IT AT ALL** you should select 1 (Strongly Disagree).
- If you **ALMOST DO NOT LIKE IT** you should select 2 (Disagree).
- If **YOU LIKE IT A LITTLE**, you should select 3 (Agree).
- If you **LIKE IT A LOT**, you should select 4 (Strongly Agree). *

Science Attitudes Questionnaire, Toma, Ortiz-Revilla and Greca (2019), adapted TOSRA scale.

	1	2	3	4
1. I like talking about science outside of class	○	○	○	○
2. Natural Sciences is the most interesting subject	○	○	○	○
3. I prefer to solve a problem by doing an experiment rather than getting an answer	○	○	○	○
4. A scientist is very similar to other people	○	○	○	○
5. When I grow up, I want to study something related to science	○	○	○	○
6. I would like to have more hours of Nature Science per week	○	○	○	○
7. It is better to find out the answer through an experiment rather than asking the teacher	○	○	○	○
8. Scientists are just as nice as other people	○	○	○	○
9. I would like to receive scientific materials so that I can do experiments at home	○	○	○	○
10. When I grow up, I would like to be a scientist	○	○	○	○

Appendix 2. Presentation of the questionnaire and sociodemographic questions in the online format used

Attitudes towards the Natural Sciences

This questionnaire is part of a larger study and is intended to find out what you think about the Sciences. We need you to help us by answering these questions about your attitudes towards Science. As you will see, it is an anonymous questionnaire where neither your name nor your e-mail address is asked, and it will not count towards your class grade. We need you to be as honest as possible.
Thank you very much!

1

Write the code of your school, your course, your classroom and your class number. It is very important to put it, and also to do it well (ask your teacher for the code, example: 40003411-6A-4). *

Escriba su respuesta

2

I am a... *

- ○ Girl
- ○ Boy
- ○ I prefer not to answer

3

Do you have a family member who is involved in science or technology (doctor, engineer, researcher, electrician, veterinarian, etc.)? *

- ○ Yes
- ○ No

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