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Fostering inclusion through socio-scientific inquiry: A pathway for rethinking science education at elementary level in diverse classrooms

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Abstract: As science education strives to respond to the demands of an increasingly complex and diverse world, classrooms must evolve into spaces where every student feels seen, heard, and empowered to engage critically with real-world issues. Socio-Scientific Issue Inquiry-Based Learning (SSIBL) offers a promising pathway to achieve this goal and to tackle three current and pressing challenges in science education: low interest toward scientific disciplines, gender gap in science and a tailored attention to student diversity and inclusion. This work reports a mixed-methods quasi-experimental case-study based on pre/post-intervention analysis of a specifically design SSIBL instructional unit at elementary level. To this end, an *ad hoc* intentionally non-probabilistic sampling strategy was employed. Sociograms and an adapted version of Index for Inclusion (IFI) (Cronbach's α 0.665) were applied. Noticeably changes were observed after intervention: sociograms redistribution of peer social dynamics and statistically significant gains with very large effect sizes in central indicators (feeling respected. listened to, and accepted within the group). Improvements were also found in students' perception of science. especially among girls. Our study covers a notable research gap in the field: the explicit evaluation of how SSIBL impact on classroom inclusion social dynamic and affective outcomes. Our observations suggest that SSIBL combined with intentional grouping and inclusive pedagogical strategies in elementary classrooms holds promise for building equitable and participatory science learning environments, thus providing a quality science education for all.

Keywors: Socio-scientific issues, Inquiry-based learning, Inclusive practices, Gender, Scientific education

1. Background

Today's society is characterized by continuous access to information (at times including misinformation through hoaxes or fake news) and to knowledge (sometimes pseudoscientific) in a context of growing recognition of diversity in all its forms. This calls for the development of scientifically competent and critical citizens with appropriate Scientific Capital (Archer et al., 2015; Kontkanen et al., 2025) and equipped with values that promote an equitable, inclusive, and a just society able to enhance global economic competitiveness and workforce development, address gender and diversity gaps and to navigate current environmental and health challenges. Scientific Competence, as currently grasp the definition given by the Organisation for Economic Co-operation and Development (OECD, 2023b), include all those dimensions and emphasize that effective science teaching helps support and equip young people with the knowledge, skills, capital (including agency, attitudes, experiences, and personal and social resources such as resilience) and identities necessary for themselves, their communities, and their societies to face the challenges of the coming decades. In this sense, the importance of providing equal opportunities to acquire

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scientific literacy and competence is undeniable for social development. However, over the last years a progressive decline in the interest towards scientific disciplines has been observed (OECD, 2026; Potvin & Hasni, 2014; Putri et al., 2024; Scholes & Stahl, 2022; Sjøberg & Schreiner, 2010, 2019; Toma et al., 2019; Toma & Meneses Villagrá, 2019; UNESCO, 2019; Osborne et al., 2003; Vázquez & Manassero, 2009) an issue especially notable among girls. This issue is critical, as it carries substantial implications for gender equality and social equity. It affects access to science and technology-related educational pathways and, by extension, to perpetuating the Science, Technology, Engineering, and Mathematics (STEM) leaky pipeline and all its implications (Shapiro et al., 2015).

Another increasing and important challenge in education is the growing diversity in classrooms (OECD, 2025) and the corresponding need for differentiated attention (Ardenlid et al., 2025; Ituma, 2025). This situation demands a commitment to building more inclusive learning environments (in a holistic sense) by using appropriate and effective teaching practices (Deehan et al., 2024; McConney et al., 2014). In this regard, socio-scientific issues (Zeidler & Nichols, 2009), and more specifically, socio-scientific issues inquiry-based learning (Knippels & van Harskamp, 2018; Levinson, 2018) can be excellent approaches to face this challenge. Their design principles appeal to the social construction of knowledge in a context in which controversial issues that generate discrepancy are argued about, thus promoting civic values and democratic engagement (Lesnefsky et al., 2023; Mamutse, 2024; Ratcliffe & Grace, 2003). While the pedagogical value of these teaching approaches is not in question, there are few studies providing robust scientific evidence of their benefits in the literature (Gao et al., 2021; Georgiou & Kyza, 2023; Kyza & Georgiou, 2025; Smit et al., 2026). Specifically, we highlight the lack of research evaluating how the implementation of Socio-Scientific Issue Inquiry-Based Learning (SSIBL)-based instructional units influences classroom climate and the degree of inclusion, considering both gender and special educational needs. Addressing this gap in the literature constitutes the core motivation of the present study, which seeks to explore the educational potential of SSIBL not only in terms of learning outcomes, but also in fostering inclusive and equitable learning environments.

2. Theoretical framework

2.1 Scientific literacy and the challenge of equity in STEM education

Scientific literacy and competence are widely recognized as fundamental dimensions for enabling active, informed participation in contemporary society. In the context of rapid technological advancements and global challenges (e.g., climate change, pandemics, sustainability) fostering students' ability to understand and engage with science becomes essential not only for personal decision-making but also for promoting democratic, socially responsible citizenship (Hodson, 2009; OECD, 2018). Accordingly, science education must go beyond factual and procedural knowledge to cultivate attitudes, and values that empower students to critically interpret scientific information and its societal implications (OECD, 2023b, 2025).

In addressing persistent inequalities in access to and participation in science, the concept of Scientific Capital (Archer et al., 2015; Kontkanen et al., 2025) provides a valuable theoretical lens. Scientific Capital encompasses not only students' scientific knowledge and skills but also their science-related dispositions, practices, social networks, and exposure to science in everyday life. As such, it highlights how science aspirations are shaped by a complex interplay of home background, school experiences, and broader structural factors. This framework integrates Pierre Bourdieu's notions of economic, cultural, and social capital (Claussen & Osborne, 2013) to explain why certain social groups (low-income families' students, ethnic minorities, girls) remain underrepresented in science-related academic and professional pathways. This issue is still up to date under debate in science education research (Avraamidou, 2020; Avraamidou & Schwartz, 2021; Evagorou et al., 2024; UNESCO, 2019).

Among the structural factors affecting science aspiration, gender emerges as a critical dimension. A substantial body of research has documented the persistent gender gap in science, particularly in fields such as physics and engineering (Blondé et al., 2025; Ceci et al., 2009; Chan, 2022; Lv et al., 2022; Master & Meltzoff, 2016; Morgan et al., 2016; Shapiro et al., 2015; Vieira et al., 2025). Girls are often less likely to identify with science, feel less confident in their abilities, and perceive fewer career opportunities within STEM domains. Current research on the field shows that there is a statistically significant and robust positive relationship between students' attitude toward science and their performance in science, with the strength of this association being greater in self-efficacy than in other constructs such as interest or societal relevance (Mao et al., 2021). The relationship between attitude towards science and self-efficacy, together with the lower self-efficacy in science typically observed among girls (Baker, 2013), raises the need of articulating different focuses of analysis, research and interventions. However, these observed patterns may not be solely rooted in ability but, also, in subtle sociocultural dynamics that discourage girls' identification with science and reinforce stereotypical representations of scientific competence as male (Archer et al., 2010; Blondé et al., 2025; Kerkhoven et al., 2016; Kube et al., 2024; Moè et al., 2021; Starr, 2018; Starr & Leaper, 2024). This highlights the need of addressing gender disparities in science education for fostering equity, ensuring diverse representation in scientific fields, and promoting social justice. From this perspective we underline the urgency of designing and applying pedagogical strategies that are not

only cognitively demanding but also socially inclusive (i.e., validates diverse voices, promotes meaningful engagement with science, and broaden students' perceptions of who can participate in and contribute to science).

2.2 Diversity in the classroom: Inclusive education and the need for differentiated pedagogies

Contemporary classrooms are increasingly characterized by diversity, not only in terms of cultural and linguistic backgrounds due to world migration patterns but also in relation to functional diversity, gender identities, and socio-economic contexts (OECD, 2025). This growing heterogeneity profoundly influences teaching and learning dynamics, presenting both challenges and opportunities for educators (Kieferle et al., 2024). Research has consistently shown that students' varied experiences, strengths, and needs demand educational responses that move beyond uniform, one-size-fits-all approaches (Ainscow, 2020; Florian & Black-Hawkins, 2011; Van Mieghem et al., 2020).

Within this context, projects such as InclusME (ICSE, n.d.) have explored how culturally responsive pedagogies can be effectively integrated into science education. By using students' cultural backgrounds as a resource for inquiry and meaning-making, InclusME demonstrated that connecting scientific learning to diverse cultural contexts not only fosters deeper engagement but also supports inclusion in classrooms with high levels of diversity. Such initiatives underscore the importance of developing inclusive science education that is both socially responsive and pedagogically innovative.

Functional diversity, encompassing students with specific educational support needs (SESN), further reinforces the necessity of designing learning environments that are flexible, responsive, and grounded in the principles of Universal Design for Learning (UDL). In parallel, gender-related issues, including persistent biases and unequal participation in scientific and technological fields, highlight the importance of pedagogical strategies that actively foster equity and inclusivity in the classroom.

Recent international frameworks (Cerna et al., 2021; OECD, 2023a) underline the central role of inclusive education as a driver of equity and social cohesion. The OECD's framework for the future of education, for instance, emphasizes the development of key competencies (critical thinking, collaboration, and global awareness) while also stressing the need to guarantee equal opportunities for all learners, regardless of background. Recent studies further suggest that inclusive approaches not only improve learning outcomes for marginalized groups but also enrich the educational experience for all students, by promoting empathy, respect, and a sense of belonging in diverse classrooms (Ainscow, 2020; Slee, 2019)

In this context, differentiated pedagogies emerge as an essential component of inclusive education. Differentiation does not imply lowering expectations, but rather adapting content, processes, and assessment strategies to ensure that every student can engage meaningfully with learning. Effective strategies include flexible groupings, scaffolded instruction, and contextualization. Such approaches respond to diversity not as a challenge to be managed, but rather as a resource that can enrich classroom learning and contribute to achieve more equitable and democratic educational environments.

2.3 Socio-Scientific Issues and Inquiry-Based Learning: Foundations and potential for inclusive science education

Socio-Scientific Issue Inquiry-Based Learning (SSIBL) represents a pedagogical framework that integrates inquiry-based approaches with the exploration of complex, controversial issues at the intersection of science, society, and ethics. Rooted in socio-constructivist principles, SSIBL emphasizes the co-construction of knowledge through dialogue, reflection, and the consideration of multiple perspectives. The characteristic aspects of integrative approaches are inherent in and can be articulated by SSIBL, as it aims at connecting curricular knowledge with real-world problems while presenting controversial topics where every student can participate in an argumentative manner.

According to Knippels and van Harskamp (2018) and Levinson (2018), the SSIBL approach is guided by three main interrelated pedagogical principles: (1) scientific inquiry, which promotes active exploration and critical examination of scientific concepts; (2) engagement with socio-scientific issues, which situates science learning in socially relevant and often contentious contexts; and (3) citizenship education, which highlights the democratic values of participation, respect for diverse opinions, and evidence-based reasoning.

A central component of SSIBL is the role of dialogic interaction and argumentation. Students are encouraged to engage in structured debates around controversial issues (climate change, genetic modification, vaccine policies) where no single "correct" answer exists. This approach allows learners to weigh evidence, articulate reasoned arguments, and critically evaluate competing viewpoints, thereby fostering both critical thinking skills and scientific literacy. Beyond disciplinary knowledge, SSIBL positions science education as a vehicle for cultivating democratic citizenship, encouraging students to connect scientific understanding with ethical reflection, personal decision-making, and collective responsibility. The goal of SSIBL is not only to enhance students' scientific knowledge, but also to foster critical thinking, ethical reflection, and civic engagement. By situating science learning in contexts of high social relevance, SSIBL promotes inclusive and participatory classrooms where all students can recognize themselves as active agents of change.

The potential of SSIBL extends beyond the development

of cognitive skills. By engaging students in authentic, real-world contexts, it creates opportunities for inclusion and equitable participation in the science classroom. Students from diverse cultural, functional, and gender backgrounds can find personal relevance and motivation in addressing issues that impact their lives and communities, thus enhancing both belonging and agency in the learning process. Despite its theoretical alignment with inclusive values, there remains a notable research gap regarding the explicit evaluation of the impact of SSIBL on classroom inclusion, social dynamics, and affective outcomes. Few empirical studies have examined its potential to reduce gender disparities in students' interest and participation in science (Kyza & Georgiou, 2025), or its effects on broader classroom and learning aspects (Georgiou & Kyza, 2023).

We consider that addressing this gap is crucial and totally needed for advancing the field, as it would help clarify the extent to which SSIBL not only supports scientific competence and critical thinking but also its contribution to more equitable and inclusive science education.

3. Objectives and research questions

Considering what have been exposed above, this works is aiming at empirically assess the extent to which SSIBL can support both the improvement of primary students' perceptions, interest and learning of Natural Sciences and the promotion of inclusive classroom climates. Thus, the following Research Questions (RQ) guide the present research: 1) RQ1. Does the implementation of a SSIBL approach foster effective inclusion in primary education classrooms? 2) RQ2. Does the use of an SSIBL-based approach influence primary students' perceptions, interest and learning of Natural Sciences?

This manuscript presents the full results of the study, for which preliminary analyses and partial findings were previously reported at 31 Encuentros de Didáctica de las Ciencias Experimentales (Cabezas-Ramos et al., 2024). The present manuscript provides a comprehensive account of the study's results, including analyses and findings not addressed in the previous conference contribution.

4. Methods

4.1 SSIBL instructional unit description

The SSIBL unit was implemented with 4th-grade primary school students (N = 19) and comprised 30 sessions of 45 minutes each (22.5 hours in total). The intervention was conducted in the regular classroom and involved the use of tablets and digital resources, including Mentimeter, Google Forms, Canva, and the school blog, as well as students' research diaries and paper-based materials. The intervention followed a guided inquiry sequence centered on the socio-scientific controversy surrounding the production and consumption of genetically modified organisms (GMOs). The initial phase introduced the controversy and elicited students' prior knowledge and views. Students watched a television news report presenting contrasting perspectives on GMOs and then expressed their initial ideas using Mentimeter. This activity was followed by an open classroom discussion. Students were subsequently assigned stakeholder roles representing the Government, Environmentalists, Scientists, and Consumers. The teacher guided the discussion to highlight the need for additional evidence and information before reaching a position. The core inquiry sequence consisted of four activities: 1) "What are GMOs?", students developed a visual-thinking representation integrating information about plant cells, DNA, and GMOs; 2) "Taking a position", students considered their position regarding the socio-scientific issue; 3) "The Science Journalists", students collected information about the views of teachers and family members through a Google Forms survey and subsequently organized, represented, and analyzed the resulting data. These activities were intended to expose students to different perspectives and support the comparison of information and arguments. Finally, in activity 4) students completed an individual "Compare and Contrast" activity as a metacognitive assessment, reflecting on their initial knowledge and what they had learned, followed by a whole-class discussion. Argumentation was supported throughout the unit through teacher-guided questioning and discussion, stakeholder-role positioning, guided information searching, comparison and contrast of information, and opportunities for students to formulate and discuss positions concerning the central question: "Should genetically modified foods be produced and consumed?" The intervention culminated in the collaborative production of a Lapbook and a consensual manifesto, which was disseminated through the school blog.

4.2 Data collection and analysis

Participation in the research study was entirely voluntary and independent of participation in the instructional intervention. Students were informed that declining to participate in the research or withdrawing from it at any stage would have no consequences for their academic assessment grades or standing in the course. Only data from students who voluntarily consented to participate were included in the study.

We examine whether the use of SSIBL coupled with an intentionally inclusive collaborative strategy (i.e. heterogeneous grouping based on sociogram study) improves the classroom's climate (measured as the level of inclusive learning) and the interest in science. Inclusive learning is understood here as the convergence of three key aspects: (1) integration, participation and consideration of students with specific educational support needs (SESN)

into the class group; (2) improvement of interpersonal relationships within the group and (3) the extent in which the science learning experience meets the potentials of all learners irrespective of their gender and needs.

The SSIBL approach was centered on the topic of Genetically Modified Organisms (GMOs) and their environmental implications. It integrated curricular content from Natural Sciences and Mathematics, with a strong emphasis on epistemic notions. Evaluating the impact of the intervention involved a complex design that necessitated specific methodological choices: (i) a mixed-methods approach combining qualitative and quantitative data, (ii) a quasi-experimental design with pre- and post-intervention analysis, and (iii) an intentionally non-probabilistic sampling strategy.

The selected classroom consisted of 19 fourth-grade elementary education students, with a balanced gender distribution (47% boys and 53% girls) and a notable educational diversity, including 21% of students presenting a specific educational support need. Group configuration and classroom climate was assessed by pre/post-intervention sociogram results, which were analyzed using MAXQDA 2020 (VERBI Software, 2020). Student's responses were anonymized and coded using alphanumeric identification tags (ID tags) for each student. Data was imported into MAXQDA2020 and analyzed focusing on the frequency and co-occurrence of ID-tags for each student. An adapted version of the Index for Inclusion (Booth & Ainscow, 2011) was also employed to evaluate the impact of the proposal (see Appendix 1). Instrument adaptation involved translation into the students' native language and slight modifications to refer explicitly to Natural Science classes. Its validity and reliability were assessed by an expert panel and the evaluation of its psychometric properties after piloting. The resulting Cronbach's alpha was 0.665, falling within the acceptable range for a pilot/exploratory study (i.e., $0.6 < \alpha < 0.7$) (SPSS Analysis, n.d.) and for social studies, which, according to Hatcher and Stepanski (1994) a Cronbach alpha as low as 0.55 can still be recognized and accepted for statistical consideration (Hatcher & Stepanski, 1994). Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS), Version 29.0.2 (IBM Corp., 2022). Given the small sample size (N = 19), the Shapiro–Wilk test was applied to assess data normality, which confirmed a non-normal distribution. Consequently, non-parametric tests—Mann–Whitney U and Wilcoxon signed-rank tests—were used for the analysis.

The Index for Inclusion (IFI) adapted instrument employed in this study comprises 34 standalone items that are not grouped into subscales or latent dimensions, according to the original version. However, a *post hoc* dimensional analysis was performed by grouping selected items under relevant thematic categories: 1) Inclusion (i2-i7, i12-i20; i28-i34); 2) Perceptions of Natural Science classes (i1 and i24) and 3) Learning and Metacognition (i8-i10; i21-i23; i25-i27). Each of these categories was analyzed using pre/post-intervention data for the entire group, as well as disaggregated by gender (girls and boys) and by SESN status. Comparative analyses among these subgroups enabled a targeted interpretation aligned with the study's research questions. Pre/post comparative differences on inclusion level, students' perceptions, interest and learning of Natural Sciences were evaluate using the Wilcoxon signed-rank test. Pre/post changes among groups after intervention were evaluated using the Mann-Whitney U test over delta (d) values calculated as post-pre rank changes (i.e., d = ipost – ipre) for each item. This allowed to examine potential differences between the groups under study after intervention. No statistical adjustment for multiple comparisons was applied in the analyses. The statistical tests were conducted using a significance level of $\alpha = .05$.

5. Results

In this section we provide the results obtained through data collection and analysis. As such, the main results are shown and explained according to the statistical methods applied. A contextualized and contrasted discussion with relevant scholarly literature can be found in the following section (discussion).

5.1 Inclusion

The level of inclusion was assessed based on the results obtained from the analysis of pre/post sociograms and the IFI questionnaire, which are described below.

5.1.1 Sociogram results

Classroom climate (i.e., nature of interactions, perceptions, and relationships among peers) was evaluated using pre/post-intervention sociograms designed according to the IFI test. As such, it consisted of a series of questions that explicitly asked students about their relationships and perceptions of their classmates. Students' selections of preferred and non-preferred peers were analyzed and grouped into two overarching categories of peer feedback, positive and negative, as shown in Figure 1.

Changes were observed in peer perceptions following the SSIBL intervention. Figure 1, panel a) depicts an overall increase in positive feedback among peers' post-intervention, with several students receiving more frequent favorable mentions. Panel b) shows a general reduction in negative feedback, suggesting a shift toward more inclusive peer interactions. The comparative sociograms in panels c) and d) visually reinforce these trends, highlighting a more balanced and equitable distribution of peer nominations in the post-intervention phase, particularly regarding students who were previously less acknowledged.

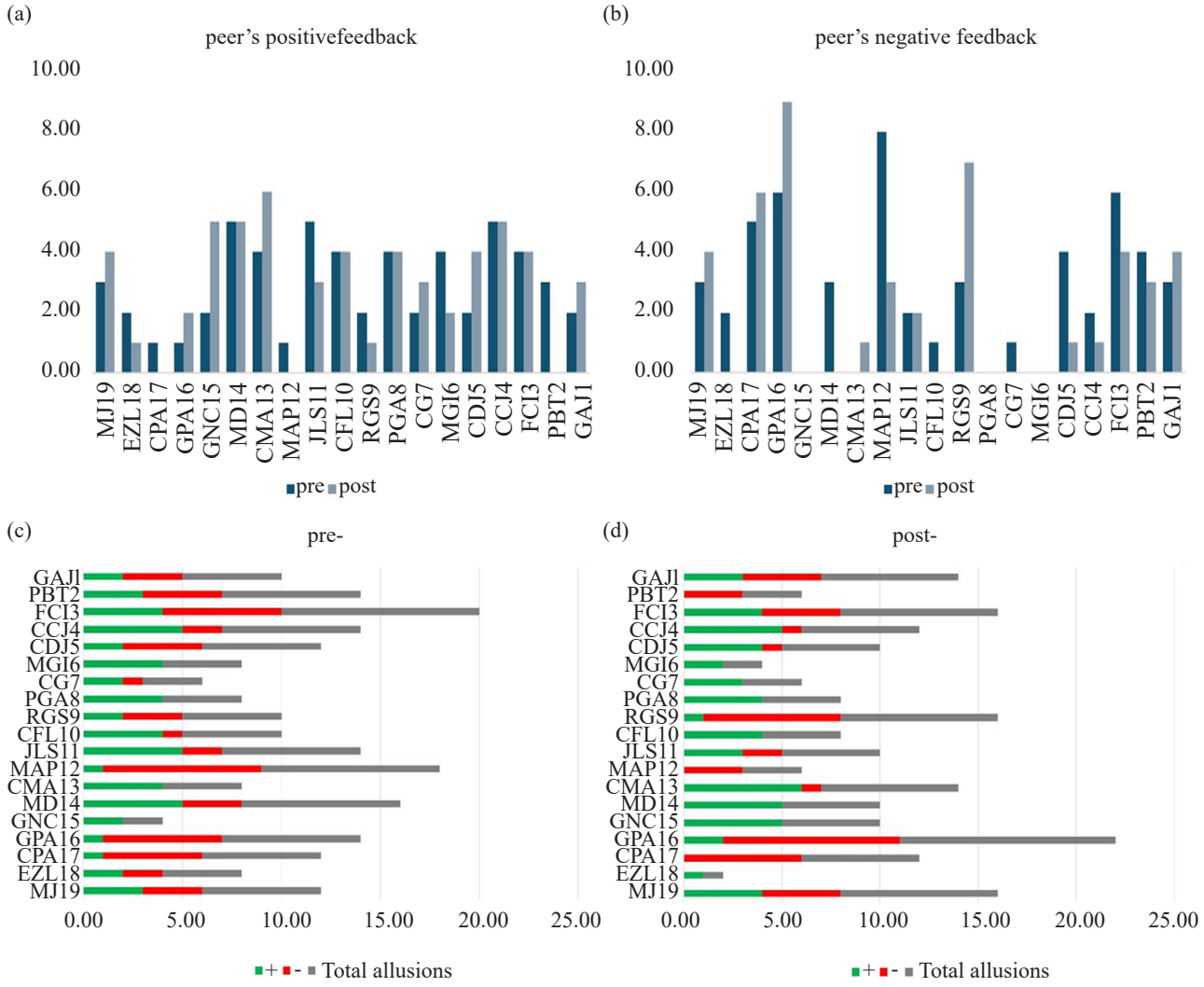


Figure 1. Pre- and post-intervention sociogram results: a) Distribution of peer positive feedback (pre and post); b) Distribution of peer negative feedback (pre and post); (c) Pre-intervention sociogram, showing total positive (green), negative (red), and total peer allusions (grey); (d) Post-intervention sociogram, showing corresponding values after implementation

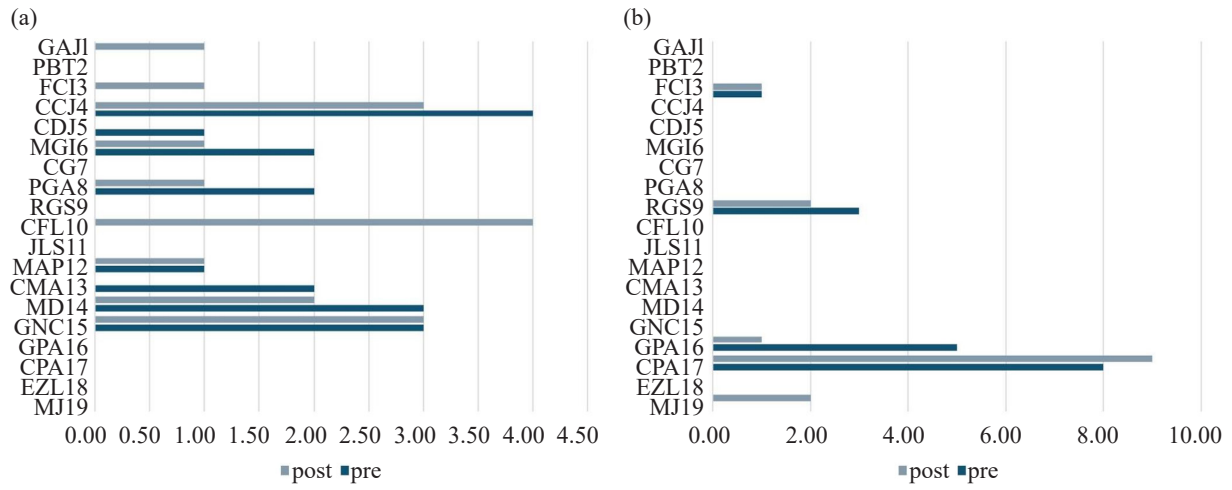


Figure 2. Changes in peer perceptions before and after the SSIBL intervention: a) Students identified as having the most friends; b) Students perceived as the least academically capable

Figure 2 illustrates the pre- and post-intervention changes following the SSIBL implementation, focusing on students' perceptions of which classmate had the most friends, and which was considered the least capable.

Panel a) (Figure 2) shows a diversification of responses in the post-intervention period: more students receive at least one mention, suggesting a more evenly distributed perception of popularity and a redistribution of social recognition. This shift may be interpreted as an improvement in social inclusion, with friendship networks perceived as more evenly spread across the group. Panel b) (Figure 2) depicts a general decrease in the number of negative mentions after intervention. Some students who were identified in the pre-test (e.g., CPA17 or GPA16), although continue to be mentioned, their appearance is less frequent. This may indicate a peer's mind changes related to the stigma associated with low academic performance of these students. Besides, other students are no longer mentioned in the post-test, also potentially reflecting a positive change in the perception of their abilities.

5.1.2 Index for Inclusion (IFI)

To evaluate pre/post intervention changes on inclusion level, data of the IFI test for items i2-i7, i12-i20; i28-i34 for the entire group were considered (Table 1).

Table 1. Wilcoxon signed-rank test results for changes in IFI data for dimension 1 (inclusion) pre- and post-intervention

item	N			Mean Rank		Sum of Ranks		Z-value	r	Asymp. Sig. (2-tailed)	p-value
	Neg.	Pos.	Ties	Neg.	Pos.	Neg.	Pos.				
i2	1	3	15	2.50	2.50	2.50	7.50	-1.00	0.50	0.317	0.628
i3	2	6	11	4.50	4.50	9.00	27.0	-1.41	0.49	0.157	0.292
i4	0	2	17	.00	1.50	.00	3.00	-1.34	0.95	0.180	0.501
i5	0	2	17	.00	1.50	.00	3.00	-1.41	0.99	0.157	0.502
i6	0	5	14	.00	3.00	.00	15.00	-2.07	0.92	0.038*	0.063
i7	0	0	19	.00	.00	.00	.00	0.00	0.00	1.000	
i12	1	1	17	1.50	1.50	1.50	1.50	0.00	0.00	1.000	1.000
i13	1	0	18	1.00	.00	1.00	.00	-1.00	1.00	0.317	1.000
i14	1	0	18	1.00	.00	1.00	0.00	-1.00	1.00	0.317	1.000
i15	1	8	10	5.00	5.00	5.00	40.00	-2.33	0.77	0.020*	0.040*
i16	1	14	4	4.00	8.29	4.00	116.00	-3.27	0.84	0.001*	< .001*
i17	0	3	16	.00	2.00	.00	6.00	-1.73	1.00	0.083	0.252
i18	2	5	12	3.00	4.40	6.00	22.00	-1.41	0.53	0.16	0.256
i19	1	0	18	1.00	.00	1.00	.00	-1.00	1.00	0.317	1.000
i20	2	5	12	3.50	4.20	7.00	21.00	0.00	0.00	0.206	0.363
i28	4	1	14	3.00	3.00	12.00	3.00	-1.34	0.60	0.180	0.379
i29	1	8	10	3.50	5.19	3.50	41.50	-2.32	0.77	0.020*	0.029*
i30	1	1	17	1.00	2.00	1.00	2.00	-0.45	0.32	0.655	1.000
i31	1	1	17	1.00	2.00	1.00	2.00	-0.45	0.32	0.655	1.000
i32	0	5	13	.00	3.00	.00	15.00	-2.12	0.95	0.034*	0.060
i33	0	15	4	.00	8.00	.00	120.00	-3.54	0.91	< .001*	< .001*
i34	0	16	3	.00	8.50	.00	136.00	-3.67	0.92	< 0.001*	0.000*

Effect size (r) calculated for Z-value according to ($r = Z/\sqrt{N}$); * means that there are significant differences in responses after intervention (significance level set at $p < 0.05$ corresponding to 95% confidence level). The items were written in Spanish. Their translation into English is for reporting purposes and so does not have the same grammatical consistency.

As shown, most items in this category demonstrated improvement following the intervention. Notably items i6, i15, i16, i29, i32, i33, i34 exhibited statistically significant differences, all accompanied by large effect sizes ($r > 0.5$). Results from the Mann-Whitney U test over d-values are shown in Tables 2 and 3.

Table 2. Girls vs. boys Mann-Whitney U test results for changes in IFI data for dimension 1 (inclusion) pre- and post-intervention

item	Mean Rank		Sum of Ranks		Z-value	r	Asymp. Sig. (2-tailed)	p-value
	Boys	Girls	Boys	Girls				
d2	10.11	9.90	91.00	99.00	-0.115	0.026	0.909	0.456
d3	10.11	9.90	100.0	90.00	-0.093	0.021	0.926	0.560
d4	11.11	9.00	100.0	90.00	-1.532	0.351	0.126	0.219
d5	11.11	9.00	100.0	90.00	-1.534	0.351	0.125	0.208
d6	9.39	10.55	84.50	105.50	-0.581	0.133	0.561	0.295
d7	10.00	10.00	90.00	100.00	0.000	0.000	1.000	
d12	10.00	10.00	90.00	100.00	0.000	0.000	1.000	0.736
d13	9.44	10.50	85.00	105.00	-1.054	0.242	0.292	0.475
d14	9.44	10.50	85.00	105.00	-1.054	0.242	0.292	0.475
d15	9.89	10.10	89.00	101.00	-0.092	0.021	0.926	0.554
d16	9.89	11.00	80.00	110.00	-0.867	0.199	0.386	0.220
d17	10.61	9.45	95.50	94.50	-0.710	0.163	0.478	0.458
d18	10.83	9.25	97.50	92.50	-0.710	0.163	0.478	0.214
d19	10.50	9.55	94.50	95.50	-0.949	0.218	0.343	0.525
d20	10.56	9.50	95.00	95.00	-0.475	0.109	0.635	0.354
d28	10.33	9.70	93.00	97.00	-0.318	0.073	0.750	0.523
d29	12.38	7.45	115.50	74.50	-2.280	0.523	0.023*	0.018*
d30	10.00	10.00	90.00	100.00	0.000	0.000	1.000	0.736
d31	11.00	9.10	00.00	91.00	-1.378	0.316	0.168	0.254
d32	11.06	7.94	99.50	71.50	-1.578	0.362	0.115	0.116
d33	9.67	10.30	87.00	103.00	-0.269	0.062	0.788	0.516
d34	11.00	9.10	99.00	91.00	-0.829	0.190	0.407	0.164

$N_{boys} = 9$, $N_{girls} = 10$. Effect size (r) calculated for Z-value according to ($r = Z/\sqrt{N}$); * means that there are significant differences in responses after intervention (significance level set at $p < 0.05$ corresponding to 95% confidence level)

When comparing boys and girls, a statistically significant difference with a large-size effect (r = 0.523) was found for d29 (i29 post-pre change) indicating greater improvement among boys. Although no statistically significant differences were observed in the remaining items, changes for items i6, i13, i14, i15, and i16 showed greater improvement among girls, with small to moderate effect sizes.

Table 3. SESN vs. non-SESN Mann-Whitney U test results for changes in IFI data for dimension 1 (inclusion) pre- and post-intervention

item	Mean Rank		Sum of Ranks		Z-value	r	Asymp. Sig. (2-tailed)	p-value
	SESN	Non-SESN	SESN	Non-SESN				
d2	11.25	9.67	45.00	145.00	-0.703	0.161	0.482	0.450
d3	10.63	9.83	42.50	147.50	-0.284	0.065	0.776	0.368
d4	11.50	9.60	46.00	144.00	-1.125	0.258	0.260	0.215
d5	9.00	10.27	36.00	154.00	-0.751	0.173	0.452	0.619
d6	7.50	10.67	30.00	160.00	-1.295	0.297	0.195	0.256
d7	10.00	10.00	40.00	150.00	0.000	0.000	1.000	
d12	10.00	10.00	40.00	150.00	0.000	0.000	1.000	0.831
d13	10.50	9.87	42.00	148.00	-0.516	0.118	0.606	0.792
d14	10.50	9.87	42.00	148.00	-0.516	0.118	0.606	0.792
d15	6.50	10.93	26.00	164.00	-1,584	0.363	0.113	0.086
d16	6.50	10.93	26.00	164.00	-1.487	0.341	0.137	0.078
d17	8.50	10.40	34.00	156.00	-0.949	0.217	0.343	0.467
d18	8.50	10.40	34.00	156.00	-0.696	0.160	0.487	0.282
d19	8.13	10.50	32.50	157.50	-1.936	0.444	0.053	0.208
d20	10.50	9.87	42.00	148.00	-0.233	0.053	0.816	0.554
d28	11.50	9.60	46.00	144.00	-0.780	0.179	0.436	0.354
d29	9.88	10.03	39.50	150.50	-0.055	0.012	0.956	0.487
d30	12.25	9.40	49.00	141.00	-1.688	0.387	0.091	0.178
d31	12.25	9.40	49.00	141.00	-1.688	0.387	0.091	0.178
d32	10.67	9.27	32.00	139.00	-0.529	0.121	0.597	0.269
d33	7.75	10.60	31.00	159.00	-0.989	0.227	0.323	0.208
d34	7.25	10.73	29.00	161.00	1.241	0.285	0.215	0.175

N_{SESN} = 4, N_{noSESN} = 15. Effect size (r) calculated for Z-value according to ($r = Z/\sqrt{N}$); * means that there are significant differences in responses after intervention (significance level set at $p < 0.05$ corresponding to 95% confidence level)

Similarly, no statistically significant differences were observed for the items when comparing SESN to non-SESN students. However, a considerable set of items (i2, i3, i4, i13, i14, i20, i28, i30, i31, i32) showed greater improvement among SESN students with small to moderate size effects.

5.2 Perception of natural science classes

To evaluate pre/post intervention differences on perception of Natural Science classes, the Wilcoxon signed-rank test was applied considering data of the IFI questionnaire (items i1 and i24) for the entire group segregated for sex and SESN status (Table 4).

Table 4. Test results for changes in IFI data for dimension 2 (perception of Natural Science) pre- and post-intervention

Wilcoxon signed-rank test (entire group)											
item	N			Mean Rank		Sum of Ranks		Z-value	r	Asymp. Sig. (2-tailed)	p-value
	Neg.	Pos.	Ties	Neg.	Pos.	Neg.	Pos.				
i1	0	2	17	.00	1.50	.00	3.00	-1.414	0.99	0.157	0.249
i24	0	5	14	0.00	3.00	.00	15.00	-2.236	1.00	0.025*	0.031*
	Mann-Whitney signed-rank test (boys vs. girls)										
$d1_{boys/girls}$		9/10		10.06/9.95		90.50/99.50		-0.077	0.02	0.939	0.968
$d24_{boys/girls}$		9/10		8.56/11.30		77.00/113.00		-1.390	0.44	0.165	0.315
	Mann-Whitney signed-rank test (SESN vs. non-SESN)										
$d1_{SESN/non-SESN}$		4/15		9.00/10.27		36.00/154.0		-0.751	0.37	0.452	0.736
$d24_{SESN/non-SESN}$		4/15		7.50/10.67		30.00/160.0		-1.309	0.34	0.190	0.357

Effect size (r) calculated for Z-value according to ($r = Z/\sqrt{N}$); * means that there are significant differences in responses after intervention (significance level set at $p < 0.05$ corresponding to 95% confidence level). The items were written in Spanish. Their translation into English is for reporting purposes and so does not have the same grammatical consistency

Item 24 showed a statistically significant improvement following the intervention, accompanied by a very large effect size. Item 1 improved as well after intervention although no statistically significant difference was observed. In other to evaluate possible differences between the groups under study, the Mann-Whitney U test was conducted over the so-called delta. No statistically significant differences were found. However, when comparing boys and girls, the results suggest a greater improvement in item d24 among girls with a moderate size effect. The same observation goes to the comparison of SESN and non-SESN students.

5.3 Learning and metacognition

To evaluate pre/post intervention differences on learning and metacognition, the Wilcoxon signed-rank test was applied considering data of the IFI questionnaire (items i8-i10, i21-i23, i25-i27) for the entire group (Table 5).

Table 5. Test results for changes in IFI data for dimension 3 (learning and metacognition) pre- and post-intervention

Wilcoxon signed-rank test (entire group)											
item	N			Mean Rank		Sum of Ranks		Z-value	r	Asymp. Sig. (2-tailed)	p-value
	Neg.	Pos.	Ties	Neg.	Pos.	Neg.	Pos.				
i8	0	2	17	.00	1.50	.00	3.00	-1.414	0.99	0.157	0.249
i9	0	11	8	.00	6.00	.00	66.00	-3.207	0.97	0.001*	< .001*
i10	0	5	14	.00	3.00	.00	15.00	-2.121	0.95	0.034*	0.032*
i21	2	5	12	3.00	4.40	6.00	22.00	-1.406	0.53	0.16	0.123
i22	0	1	18	.00	1.00	.00	1.00	-1	1	0.317	0.494

i23	1	0	18	1.00	0.00	1.00	0.00	-1	1	0.317	0.506
i25	1	5	13	2.50	3.70	2.50	18.50	-1.730	0.71	0.084	0.080
i26	0	3	16	.00	2.00	.00	6.00	-1.732	0.99	0.083	0.123
i27	1	11	7	2.00	6.91	2.00	76.00	-3.05	0.88	0.002*	< .001*
					Mann-Whitney signed-rank test (boys vs. girls)						
$d8_{boys/girls}$		9/10			10.06/9.95		90.50/99.50	-0.077	0.03/0.02	0.939	0.968
$d9_{boys/girls}$		9/10			10.56/9.50		95.00/95.00	-0.462	0.15/0.15	0.644	0.720
$d10_{boys/girls}$		9/10			10.50/9.55		94.50/95.50	-0.477	0.16/0.15	0.633	0.720
$d21_{boys/girls}$		9/10			11.33/8.80		102.00/88.00	-1.136	0.38/0.36	0.256	0.356
$d22_{boys/girls}$		9/10			9.50/10.45		85.50/104.50	-0.949	0.32/0.30	0.343	0.720
$d23_{boys/girls}$		9/10			9.44/10.50		85.00/105.00	-1.054	0.35/0.33	0.292	0.720
$d25_{boys/girls}$		9/10			11.06/9.05		99.50/90.50	-0.943	0.31/0.30	0.346	0.447
$d26_{boys/girls}$		9/10			10.61/9.45		95.50/94.50	-0.710	0.24/0.22	0.478	0.661
$d27_{boys/girls}$		9/10			10.44/9.60		94.00/96.00	-0.355	0.12/0.11	0.722	0.480
					Mann-Whitney signed-rank test (SESN vs. non-SESN)						
$d8_{SESN/non-SESN}$		4/15			9.00/10.27		36.00/154.00	-0.751	0.38/0.19	0.452	.736
$d9_{SESN/non-SESN}$		4/15			7.00/10.80		28.00/162.00	-1.357	0.68/0.35	0.175	.262
$d10_{SESN/non-SESN}$		4/15			7.50/10.67		30.00/160.00	-1.3	0.65/0.34	0.194	.357
$d21_{SESN/non-SESN}$		4/15			5.00/11.33		28.00/170.00	-2.319	1.16/0.60	0.02*	.049*
$d22_{SESN/non-SESN}$		4/15			9.50/10.13		38.00/152.00	-0.516	0.26/0.13	0.606	.885
$d23_{SESN/non-SESN}$		4/15			10.50/9.87		42.00/148.00	-0.516	0.26/0.13	0.606	.885
$d25_{SESN/non-SESN}$		4/15			12.63/9.30		50.50/139.50	-1.277	0.64/0.33	0.202	.307
$d26_{SESN/non-SESN}$		4/15			10.88/9.77		43.50/146.50	-0.553	0.28/0.14	0.58	.736
$d27_{SESN/non-SESN}$		4/15			6.50/10.93		26.00/164.00	-1.523	0.76/0.39	0.128	.185

Effect size (r) calculated for Z-value according to ($r = Z/\sqrt{N}$); * means that there are significant differences in responses after intervention (significance level set at $p < 0.05$ corresponding to 95% confidence level). The items were written in Spanish. Their translation into English is for reporting purposes and so does not have the same grammatical consistency

Statistically significant differences with very large effect sizes were observed for items i9, i10, and i27. Items i8, i21, i25, and i26 also showed improvement following the intervention with not statistically significance. Potential differences among the target groups were assessed using the Mann-Whitney U test. Generally, no statistically significant differences were found between the groups for the items under study. However. when comparing boys and girls. the results suggest greater gains in items d8. d10. d22. d23 and d27 among girls with moderate size effects. Considering SESN and non-SESN students, statistically significant large-size effects differences were found after intervention in d21 among the non-SESN students while items d23, d25 and d26 showed larger gains among the SESN students with moderate-to-large-size effects, but no statistical significance.

6. Analysis and discussion

This section provides a point-by-point discussion of the findings, contextualized and contrasted with relevant scholarly literature.

6.1 RQ1. Does the implementation of a Socio-Scientific Issues Inquiry-Based Learning (SSIBL) approach foster effective inclusion in primary education classrooms?

In relation to this question, there are several key observations that support the claim of SSIBL being promising to foster better classroom climates. The most outstanding being the overall reduction in negative feedback and an increase in positive peer feedback, which produce a more evenly and equitably distribution of both positive nominations and perceptions. This observation may suggest an interesting outcome: more balanced perceptions of what popularity stands for and requires, and expansive friendship networks across the group and a considerable proportion of students with specific educational support needs which are no longer perceived as less capable. This may reflect a reduction in the stigma typically associated with low academic performance among SESN students and appears to be directly related to the implementation of the SSIBL approach. In this regard, it is important to note that the sociograms were not used solely for research purposes: pre-test results were carefully analyzed to create intentionally heterogeneous collaborative groups. These groupings considered peer relationships, perceived academic ability, gender, student needs, and learning pace, and were maintained throughout the eight-week SSIBL intervention.

Moreover, these observations are further endorsed by the IFI results, which showed remarkable and statistically significant improvements (accompanied by very large effect sizes) after intervention in 14 items pertained to peer dynamics in the classroom, such as feeling comfortable expressing one's own ideas, feeling respected and accepted by the group, feeling heard when speaking, and perceiving kindness among classmates. Results' intergroup comparison did not yield statistically significant differences. However, it is interesting to note that items associated with feelings of belonging (e.g., feeling part of the group [i2], having good friends in the group [i4], being happy in the classroom [i30], enjoying the group as it is [i31], and perceiving classmates as kind [i32]) showed greater improvement following the intervention among girls and, especially, among SESN students. This observation may be interpreted as positive outcome from the combination of the SSIBL approach and intentionally grouping for promoting inclusion.

It is important to notice d29 results (My classmates are interested in listening to my ideas). Boys reported higher scores for this item. However, this finding does not necessarily contradict the more favorable results observed among girls in other inclusion-related parameters. Rather, these results suggest that gender differences in perceived inclusion may vary across its different dimensions. While boys seem to perceive greater peer interest in listening to their ideas, girls report more favorable perceptions in other aspects of inclusion. Therefore, we suggest understanding inclusion as a multidimensional construct, being these findings interpreted as reflecting different facets of students' experiences rather than a single, uniform gender pattern. Nevertheless, it is encouraging that all students, regardless of gender, showed improvements in inclusion-related perceptions following the intervention.

Altogether, these observations show how the employed approach can effectively meet current demands in education regarding inclusion (Ainscow, 2020; Slee, 2019) which have stated that inclusive approaches should improve both learning outcomes while enriching educational experience of every student in the classroom, by means of promoting empathy, respect, and a sense of belonging. Nonetheless, these gains should not be solely attributed to the grouping strategy. The intervention was designed as a combined strategy integrating SSIBL with an intentionally inclusive collaborative grouping approach. Heterogeneous student groups were established on the basis of sociogram data to promote the integration and participation of students with specific educational support needs (SESN), strengthen interpersonal relationships within the classroom, and facilitate collaborative science learning that considered the potential of all learners, irrespective of gender or educational needs. Accordingly, the outcomes observed in the study should be understood as resulting from the combined implementation of the SSIBL approach and the heterogeneous grouping strategy. Indeed, some of the improvements (e.g. in i6, i16, i28, and i29) are more plausibly explained by the nature of the teaching approach itself in agreement with its interrelated pedagogical principles (Knippels & van Harskamp, 2018; Levinson, 2018). Aspects such as feeling comfortable expressing one's opinion or respecting differing viewpoints, are fostered within instructional contexts that promote dialogue and debate around issues with no single correct answer and that need a multifactorial analysis from different perspectives. This is precisely the hallmark of socio-scientific issues (Dolan et al., 2009; Romero-Ariza et al., 2018), and the rationale for selecting this approach in the present intervention. Studies on this topic have already suggested the potential of engaging students in discussion and debate around complex, real-world issues (genetic modification, climate change, vaccine policies) for encouraging the consideration of diverse viewpoints and, hence, supporting the development of respect, and mutual understanding among peers (Högström et al., 2025; Zeidler & Nichols, 2009). In this regard, it is important to highlight that while SSI promotes a shift from monologic to dialogic discourse in science classrooms, creating a space where all students-regardless of background, academic performance or personal characteristics-are encouraged to participate, be heard and respected, it is essential to convey also the message that not all opinions are inherently respectable. The educational aim of the SSIBL approach is precisely to foster students' argumentative skills through the selective and critical search for evidence-based information. Thus, an opinion should be considered worthy of respect insofar

as it is well-reasoned and properly supported.

To the best of our knowledge, no experimental study has provided research evidence of the impact of the SSIBL methodology on inclusion levels in the classroom before. Our results show that, when combined with intentional heterogeneous grouping, SSI-based instruction can help reduce social stigma and strengthen students' sense of belonging and acceptance. As such, the evidence suggests that SSI is not only effective for promoting scientific literacy but also holds promise as a socially responsive approach to fostering inclusion and equity in education.

6.2 RQ2. Does the use of the SSIBL methodology influence primary students' perceptions and interest in natural sciences, learning and metacognition?

In a context of differentiated interest and implication of boys and girls in science and science-related fields (Avraamidou, 2020; Avraamidou & Schwartz, 2021; Evagorou et al., 2024; UNESCO, 2019), it is interesting to focus this analysis from a gender perspective. Our results show better improvements among girls and are consistent with the effectiveness of the approach employed in fostering girl's interest in science by using approaches that emphasize the socio-constructivist perspective and its social relevance. Such perspectives have been reported to be particularly effective in nurturing scientific interest among girls (Abril Gallego et al., 2025), an area where motivation and engagement have historically been lower compared to boys (Ceci et al., 2009; Grañeras et al., 2022; Hill et al., 2010; Master & Meltzoff, 2016). By highlighting the societal and ethical dimensions of science, SSIBL may provide meaningful contexts that resonate with students (girls) lived experiences, thereby contributing to their interest and participation in science. Moreover, as was previously discussed, attitudes towards science are strongly intertwined with self-efficacy, being this association even stronger among girls. (Abril Gallego et al., 2025; Baker, 2013; Mao et al., 2021). The implementation of the SSIBL instructional unit here explored (which require students to articulate scientific practices such as pose questions, research, gather and discuss information, contrast data to construct evidence-based arguments, etc.) may be related to the interest improvement observed among girls through a strengthen of their self-efficacy in science, which is typically lower than in boys (Baker, 2013). Nevertheless, the analysis of this construct falls out of the scope of the present study, but, considering our observations, could open a new path for scientific research regarding the impact of SSIBL instruction. In any case, irrespective of gender, and following one on the aspects considered in the theoretical grounding of the present study, our results reveals a promising pathway to overcome one of the current and more important challenges for science education nowadays, i.e., the persistent and progressive decline in both interest and performance in science (OECD, 2026; Putri et al., 2024; Scholes & Stahl, 2022; Sjøberg & Schreiner, 2019; Toma & Meneses Villagrá, 2019).

Learning outcomes and metacognition were also an element for discussion regarding the use of SSIBL approaches. In this sense the observed changes in specific IFI items revealed notable improvements, particularly with respect to the ability to learn independently, to understand the meaning of democracy, and to recognize the impact of one's own actions and decisions on others. These improvements further confirm the effectiveness of the applied methodology in fostering learning outcomes that extend beyond the conceptual understanding of scientific content which, indeed, are in line with one of the main pedagogical principles that characterize SSIBL instructions, that is citizenship education that highlight the democratic values of participation, the respect for others opinions, and evidence-based reasoning (Knippels & van Harskamp, 2018; Levinson, 2018). Besides, these results were more noticeable (i.e., greater size effects) among girls and SESN students which, as for our consideration, may be considered as a promising indicative of possible pathways to design tailored strategies for promoting inclusive environments of science teaching through SSIBL.

7. Conclusions

This study provides valuable insights into the potential of Socio-Scientific Issues Inquiry-Based Learning beyond science teaching. Our work shows how the use SSIBL promotes more inclusive classroom climates, enhance students' sense of belonging, and foster deeper engagement with science learning in elementary education. The mixed-methods approach, combining sociogram analysis and validated instruments, offers a comprehensive perspective on classroom dynamics.

The integration of SSIBL with intentional heterogeneous grouping and co-teaching strategies appears particularly effective in reducing negative peer dynamics and improving perceptions of equity and respect among students, including those with specific educational support needs. Furthermore, the intervention yielded promising improvements in students' autonomy and metacognitive awareness, especially among girls, suggesting SSIBL's relevance in addressing persistent gender disparities in science interest.

8. Limitations

The robustness of the conclusions described above must be taken considering the limitations of the work carried out (exploratory pilot study with a small sample size), which logically condition the generalization of the results and conclusions. These results emerge from a pilot study framed within a Design-Based Research (DBR) approach, where iterative refinement and contextual sensitivity are

essential components. Besides, the qualitative information available to contextualize the quantitative findings is limited. Although classroom observations were conducted and used to contextualize the IFI test and sociogram responses, they were not systematically recorded, coded, or analyzed. Future studies should incorporate systematic qualitative data collection, such as structured observations and interviews, to strengthen triangulation and explore the mechanisms underlying the observed inclusive outcomes. While the findings are encouraging, they must be interpreted with caution due to the small and context-specific sample, the absence of a control group, the ongoing full validation of the instrument and the limited duration of the intervention (8 weeks). Moreover, because SSIBL and heterogeneous grouping were implemented as a combined intervention, their independent effects on the observed outcomes cannot be disentangled. Nonetheless, the stark contrast between pre-intervention practices (textbook-centered, teacher-led instruction without collaborative grouping) and the implemented SSIBL-based approach supports the attribution of observed gains to the intervention itself. Future iterations of this work are already in progress, specifically addressing the identified limitations. These include the implementation of longitudinal designs, the inclusion of instruments targeting affective and attitudinal dimensions of science learning, and the development of strategies to minimize bias in student self-report data.

Overall, this study highlights the educational and social value of integrating SSIBL into primary science education and lays the groundwork for broader applications aimed at advancing inclusive, meaningful, and socially responsive teaching practices.

Appendix 1

Table A1. Adapted IFI questionnaire (Cronbach's alpha was 0.665)

item	Item description
i2	I feel part of this group
i3	The classmates get along well
i4	I have some good friends here
i5	I like my teachers
i6	I feel comfortable standing up for what I think is right in class
i7	It's good to have classmates from different backgrounds
i8	In this class I learn to relate to people
i9	In this class you learn what democracy means
i10	I have learned how my actions affect other colleagues
i12	In this class, I am respected regardless of my skin colour
i13	I feel part of the class regardless of my religion
i14	I don't discriminate against others based on what they're wearing
i15	The classmates in this class get along well
i16	All people in the class are respected and accepted
i17	I avoid calling other colleagues by aggressive names
i18	Teachers do not show favouritism among students
i19	I think teachers are fair when they praise students
i20	I think teachers are fair when it is appropriate to admonish a classmate
i21	In this class, I learn how to resolve disagreements by listening, discussing, and making decisions
i22	In this class, we help each other when working in pairs and small groups

i23	In this class, I share what I know with my peers
i24	I like what I learn in this class
i25	In this class, I learn about what's going on in the world
i26	In this class I have learned to respect opinions contrary to my own
i27	In this class I am given the opportunity to learn on my own
i28	I'm interested in the ideas of my classmates
i29	My classmates are interested in listening to my ideas
i30	I'm happy in this class
i31	I like how my group is
i32	Colleagues are kind to me
i33	Peers are not beaten
i34	Classmates are not insulted

AI use/disclosure statement

Artificial intelligence tools were used solely to assist with language editing and improving the clarity and readability of the manuscript. They were not used to generate research data. conduct data analysis. or interpret the research findings. The authors take full responsibility for the content of the manuscript.

Institutional review board statement

Formal approval by the Ethics Committee of the authors' institution was not required under the institutional procedures applicable at the time the study was conducted. Nevertheless, the study was conducted in accordance with the applicable ethical principles for research involving human participants. Authorization to conduct the study was obtained from the participating educational center, and informed consent was obtained from all participants and, where applicable, from their legal guardians. Participation was voluntary, and the confidentiality of the information collected was ensured throughout the study.

Informed consent statement

Informed consent has been obtained from all subjects participating and from parents/legal guardians in the study in written form prior to data collection.

Author contributions

PGRO: Conceptualization; Methodology; Writing–original draft (lead); Formal analysis (lead); Supervision; Writing–review and editing. AJCR: Resources; Methodology; Investigation; Data Curation; Formal analysis; Writing–review and editing. JJRM: writing–review and editing. LSV: Writing–review and editing.

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Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request. Due to ethical restrictions related to the inclusion of minors. raw datasets cannot be made publicly available.

Conflict of interests

We have no interests to declare.

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