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Research Article

DESIGNING AND VALIDATING A PARENTAL INVOLVEMENT SCALE FOR STEM STUDENTS IN LEARNING SCIENCE: INSIGHTS FROM EXPLORATORY FACTOR ANALYSIS

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Abstract
Parental involvement plays a vital role in students' academic achievement, particularly in STEM-related disciplines such as science (Cox, 2012). Despite its importance, a lack of validated instruments remains to measure parental involvement in science learning among STEM students specifically. This study aimed to design and validate a Parental Involvement Rating Scale (PIRS) to assess the extent of parental engagement and its influence on students' learning in science. A quantitative research design utilizing Exploratory Factor Analysis (EFA) was employed to determine the factorial validity and reliability of the instrument. The study involved 200 STEM students from Compostela National High School and Nabunturan National Comprehensive High School in Davao de Oro. Data were gathered using a 60-item researcher-made questionnaire that underwent expert validation and pilot testing. The results of the EFA revealed four reliable factors: Parental Guidance and Support, Parental Provision of Physical Facilities and Environment, Parental Decision-making and Encouragement, and Parental Aspiration, explaining a total variance of 57.4%. The KMO value was high at 0.942, and the Bartlett's Test was significant ($p < .001$). The validated PIRS demonstrated strong psychometric properties and provides educators, researchers, and policymakers with a reliable tool for assessing parental involvement and enhancing Science learning among STEM students.

Keywords: Parental Involvement Rating Scale, Science Learning, STEM Education

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INTRODUCTION

Education is essential in helping students develop the skills they need for their future careers and in teaching them how to think critically and solve problems. Parental involvement plays fosters a vital role in students' academic success, particularly in STEM education, where support and encouragement are essential for developing skills in science learning. Parental involvement can be defined as the parents' active participation of in various aspects of their child's education, including engagement with schools, collaboration with teachers, support for learning activities at home, and fostering a positive educational environment (Hill, 2022; Hasanah et al., 2024). However, despite the extensive research on formal factors in STEM education, less attention has been given to the influence of informal factors, such as parents and social groups, on Science learning (Plasman et al., 2021). There is also a lack of reliable tools to measure the various forms of parental involvement in STEM education. Most existing measures, such as parental aspiration or homework support, focus on general engagement rather than Science-specific support. Mocho et al. (2025) noted that many scales are not thoroughly tested for reliability, and Pinneo and Nolen (2024) used general indicators instead of a Science-focused scale. It highlights the need for a tool that measures parental involvement among STEM students explicitly.

In the global landscape, Turkey ranked 34th among 35 OECD countries based on science literacy scores on the 2015 PISA. The relatively unsuccessful results of Turkey in international-level examinations like PISA have necessitated questioning various components of science education (Cansiz & Cansiz, 2019). Similarly, Bangladesh also suffers from the same problem. Science education is currently in a state of crisis, particularly in terms of students' proficiency levels in learning Science (Yeasmin & Mahmud, 2019). Across the globe, studies show that a negative home academic culture and a lack of family support contribute to learners' low achievement (Daucort et al., 2021).

The science curriculum in the Philippines aims to cultivate scientifically literate individuals who can effectively use scientific knowledge to address community issues. PISA results showed that the Philippines ranked near the bottom in scientific performance among participating countries and economies, with a mean Science score of 356, placing 78th out of 80 countries and economies. Acido and Caballes (2024) noted that Filipino students continued to rank the lowest in terms of proficiency in math, reading, and science. The Philippines has shown no significant improvement in its performance since the 2018 assessment.

In the local context, Quijano et al. (2023) in Davao Occidental explored the relationship between parental involvement and the academic performance of Grade 12 students, and the results found no significant correlation between parental involvement and academic performance. The findings highlight a gap in the research, suggesting that while parental involvement is beneficial, its specific effects on STEM students' science learning require further investigation. This underscores the need for more targeted research to understand how different forms of parental involvement might influence STEM students' success in science education, and to develop practical tools that can measure their impact. Such research is crucial, especially in light of challenges faced by students in the Philippines, as evidenced by low Science literacy scores in international assessments like PISA (Acido & Caballes, 2024).

The study aimed to conduct an exploratory factor analysis (EFA) to design and validate a parental involvement scale for STEM students in learning science. The existing literature lacked a validated tool that measures the various aspects of parental involvement in STEM students' science education. This study aimed to fill this gap by developing a comprehensive scale that captures the different dimensions of parental involvement and its impact on the success of science education.

This study is anchored on Bronfenbrenner's Ecological Systems Theory and Epstein's Model of Parental Involvement. Conceptually reframing the original nine factors through these theories helps explain why the study yielded a parsimonious four-factor structure for the Parental Involvement Scale (PIRS).

Bronfenbrenner's framework emphasizes that a child's development is influenced by nested environmental systems, ranging from immediate family interactions to broader school contexts (Bronfenbrenner, 1979; Guy-Evans, 2024). A supportive home and school environment enhances students' motivation and cognitive growth (Wu et al., 2020). It suggests that many of the original factors overlap or interact within shared ecological layers rather than existing as discrete constructs.

Epstein's Model of Parental Involvement emphasizes the collaboration between families and schools to enhance students' educational experiences (Epstein, 2011; Nurhayati, 2021). It identifies six forms of involvement: parenting, communication, volunteering, learning at home, decision-making, and community collaboration, which align with PIRS indicators.

METHOD

Research Design

This study employed a quantitative research design to develop and validate the Parental Involvement Rating Scale (PIRS) for STEM students in science learning. The study employed Exploratory Factor Analysis (EFA) to examine the factorial validity and reliability of the developed instrument (Chen, 2009). The quantitative approach enabled the systematic collection of numerical data and the statistical interpretation of results to describe the underlying constructs of parental involvement in science education. This method is objective, presents findings in numerical form, and enables comparison and generalization from the sample to a larger population (Hassan, 2024).

Research Locale and Participants

The study was conducted at Compostela National High School and Nabunturan National Comprehensive High School, both located in the province of Davao de Oro, Philippines. These institutions were selected because they offer the STEM strand under the Academic Track and provide accessible respondents who meet the study criteria. A total of 200 students from the STEM field participated in the study. Following standard guidelines for Exploratory Factor Analysis (EFA), a sample size of 200 was considered sufficient to ensure reliable and stable factor solutions (MacCallum et al., 1999). Respondents were selected using convenience sampling, a non-probability sampling technique in which participants are chosen based on their availability and willingness to participate (Hassan, 2024). Inclusion criteria required that respondents be currently enrolled STEM students who voluntarily provided informed consent.

Research Instrument

The primary instrument used in this study was the researcher-developed Parental Involvement Rating Scale (PIRS). The scale comprises 60 items assessing nine dimensions of parental involvement derived and benchmarked from existing literature: parental acceptance, aspiration, attention, encouragement, guidance, influence, decision-making, provision of physical facilities, and care for physical fitness.

As part of the instrument development process, a pilot test was conducted with 30 respondents, and the reliability analysis yielded a Cronbach's alpha of 0.982 for the 60-item Parental Involvement Scale, indicating very high internal consistency. Therefore, no items were removed at this stage. After this, the instrument underwent exploratory factor analysis for further testing.

The questionnaire was evaluated and validated by field experts to ensure content validity and underwent pilot testing to assess reliability. A five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) was used to measure the level of parental involvement in science learning as perceived by STEM students.

Data Gathering Procedure

Prior to data collection, the researchers obtained ethical clearance from the Davao de Oro State College Research Ethics Committee and permission from the school principals of the participating institutions. Respondents were provided with informed consent forms that explained the study's purpose, the voluntary nature of their participation, and the confidentiality of their responses. Data were collected through printed and online questionnaires. Completed responses were compiled and analyzed statistically.

Data Analysis

Data were analyzed using Exploratory Factor Analysis (EFA) with Principal Axis Factoring and Varimax rotation to determine the factor structure of the Parental Involvement Rating Scale (PIRS). The Kaiser-Meyer-Olkin (KMO) Test and Bartlett's Test of Sphericity assessed sampling adequacy and factorability (Shrestha, 2021). Factors with eigenvalues above one were retained, and items with loadings below 0.50 were excluded (Goretzko et al., 2019). Reliability was measured using Cronbach's Alpha and McDonald's Omega (Malkewitz et al., 2022). Descriptive statistics and Pearson's correlation coefficient were used to interpret the data (Turney, 2022).

Ethical Considerations

The study strictly adhered to ethical research standards. Participation was voluntary, and informed consent was obtained from all respondents. Data privacy and confidentiality were maintained throughout the process in compliance with the Data Privacy Act of 2012. Participants were assured that their information would be used solely for research purposes and that they could withdraw at any stage without penalty. The study was conducted with transparency, respect, and integrity to protect the rights and welfare of all participants.

RESULTS AND DISCUSSION

Assumptions and Diagnostic Check

The Parental Involvement Rating Scale (PIRS) was initially developed to measure nine theoretically derived dimensions of parental involvement, benchmarked against the literature. However, Exploratory Factor Analysis (EFA) was conducted to examine the underlying factor structure of the scale. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy was 0.942, which exceeded the minimum acceptable value of 0.60, indicating that the sample was adequate for factor analysis. Bartlett's Test of Sphericity was significant ($p < .001$), confirming that the data were suitable for factor extraction.

Table 1. KMO and Bartlett's Test Summary

Kaiser-Meyer Olkin Measure of Sampling Adequacy		.942
	Approx. Chi-Square	10931.065
Bartlett's Test of Sphericity	df	1215
	Significance	<0.001

Table 2. Total Variance Explained Summary

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	26.821	44.1	44.1	15.259	25.4	25.4
2	4.559	6.9	51.0	8.938	14.9	40.3
3	2.768	3.8	54.	5.639	9.4	49.7
4	2.026	2.6	57.4	4.596	7.7	57.4

Extraction method: Principal Axis Factoring

As presented in Table 2, EFA using Principal Axis Factoring with varimax rotation yielded a four-factor solution based on the Kaiser criterion (eigenvalues >1) (Costello & Osborne, 2005; Tabachnick & Fidell, 2019). Factor 1 accounted for 44.1% of the variance, Factor 2 for 6.9%, Factor 3 for 3.8%, and Factor 4 for 2.6%, resulting in a cumulative explained variance of 57.4% (Hair et al., 2010; Field, 2013). Thus, although PIRS was originally conceptualized with nine factors, the empirical results supported a more parsimonious four-factor structure, which retained 57.4% of the common variance.

Following the exploratory factorial analysis, the factors were refined to ensure stability and interpretability. Only factors with at least four items and factor loadings of 0.50 and higher were retained (Hair et al., 2010; Costello & Osborne, 2005). As a result, eleven items with loadings below 0.50 were removed, yielding a final scale consisting of 49 items. The analysis supported a four-factor structure comprising: Parental Guidance and Support, Parental Provision of Physical Facilities and Environment, Parental Decision-Making and Encouragement, and Parental Aspiration. These four factors represent the empirically-derived core domains of parental involvement in STEM students' science learning.

Exploratory Factor Analysis of the PIRS

An exploratory factor analysis (EFA) was conducted using Principal Axis Factoring with oblique rotation to examine the underlying structure of the Parental Involvement Rating Scale (PIRS). As shown in Table 3, the analysis identified four distinct factors based on theoretical relevance and factor loadings, with all retained items meeting the minimum threshold of 0.50 for practical significance (Hair et al., 2010). These findings provide evidence of the scale's construct validity and highlight the multidimensional nature of parental involvement as perceived by STEM students.

Table 3. Factor Loadings Table

Statements	Factor			
	1	2	3	4
Factor 1: Parental Guidance and Support				
My parents…				
Item 27. check my science homework and assist me in completing Science activities and experiments.	.872			
Item 31. teach me effective study habits and techniques for learning Science.	.842			
Item 26. guide me in organizing my study schedule for me to accomplish or prioritize Science projects and assignments.	.834			
Item 25. help me practice and review Science lessons to assess my understanding.	.831			
Item 29. recommend learning materials and resources to support my science education.	.791			
Item 28. suggest hobbies that can improve my knowledge and skills in science.	.782			
Item 14. actively monitor my progress and performance in science subjects.	.768			
Item 30. help me prepare for science competitions or presentations.	.761			
Item 33. helped me develop my curiosity in science by incorporating daily activities such as cooking and planting into science learning.	.746			
Item 17. engage with my teachers to better understand my academic needs daily	.730			
Item 52. regularly provide Science books, magazines, or newspapers to aid my education.	.717			
Item 18. encourage me to review and reinforce what I learn in science.	.708			
Item 15. encourage me to collaborate with my classmates to enhance my science learning.	.693			
Item 12. regularly check whether I have completed my homework, especially in science.	.684			
Item 55. exposed me to fun Science experiments and videos online.	.671			
Item 32. explain ways to manage stress and stay focused on science studies.	.648			
Item 22. celebrate even my small successes in science assignments and tests.	.641			
Item 16. provide supervision during group studies, Science projects, and experiments.	.634			
Item 24. provide reassurance and support during challenging Science topics.	.616			
Item 34. advise me on handling time and responsibilities effectively, especially for science projects.	.614			
Item 13. give me extra care and support during science exams.	.579			
Item 19. motivate me to join Science fairs and academic competitions.	.550			
Item 23. celebrate even my small successes in science assignments and tests.	.540			
Item 36. reading habits encourage me to develop a routine for reading Science materials.	.522			
Factor 2: Parental Provision of Physical Facilities and Environment				
My parents …				
Item 56. allow breaks during study hours for recreation to keep me re-freshed for science learning.		.703		
Item 54. ensure I can access technology for online Science learning and research.		.687		
Item 57. motivate me to participate in physical activities to stay healthy and focused on science.		.670		
Item 58. ensure I get enough sleep to maintain academic focus, especially in science subjects.		.654		
Item 59. promote a healthy lifestyle to enhance my overall learning, including Science.		.648		
Item 53. provide the financial support needed for science projects or activities.		.635		
Item 51. set up a conducive space for me to study and work on science-related activities and assignments.		.607		

Table 3. *Continued*

Statements	Factor 1	Factor 2	Factor 3	Factor 4
Item 60. encourage outdoor activities for relaxation, such as nature trips, visits to museums and zoos, and attending science fairs, which helps me stay focused on my science learning.		.602		
Item 47. talk to me about opportunities for higher education in science.		.599		
Item 49. allow me to express my thoughts about my learning choices, especially in science.		.583		
Item 42. My parents' motivation helps me stay committed to my science learning goals.		.576		
Item 46. and I discuss extracurricular activities related to science that align with my interests.		.546		
Item 43. include me in discussions about my academic plans, especially in Science.		.517		
Item 40. are my role models for valuing Science education and lifelong learning.		.506		
Factor 3: Parental Decision-making and encouragement				
My parents …				
Item 45. consider my preferences while choosing my academic track.			.577	
Item 5. encourage me by allowing me to develop my own interests without implying any pressure.			.565	
Item 44. consult me when making decisions about my education.			.511	
Item 21. reward my efforts and achievements in science subjects.			.502	
Item 41. inspire me to remain positive even in challenging scientific activities.			.599	
Factor 4: Parental Aspiration				
My parents …				
Item 10. inspire me to set ambitious academic and career goals.				.624
Item 7. emphasize the value of academic achievements for my career.				.590
Item 4. set high but achievable goals for my academic performance.				.585
Item 9. express confidence in my potential to succeed academically.				.584
Item 11. consistently encourage me to aim for academic excellence.				.578
Item 3. always pay attention to my education through daily or constant follow-ups.				.556

Note: Applied rotation method is varimax.

Factor 1: Parental Guidance and Support

This factor integrates parental guidance and support into a single dimension, reflecting the combined influence of setting clear expectations and providing emotional support, both of which have been shown to play critical roles in students' academic achievements. Parental guidance, such as establishing structured routines, setting high but attainable goals, and monitoring academic progress, has been linked to higher student motivation and improved academic outcomes (Tan et al., 2025). Emotional support from parents

Factor 2: Parental Provision of Physical Facilities and Environment

This factor reflects parents' provision of educational resources, a supportive home learning environment, and care for children's physical well-being, all of which are critical for effective engagement in STEM learning. Research indicates that access to science-related materials, such as books, digital tools, and laboratory kits, the availability of quiet and structured spaces, and parental support for healthy routines all enhance students' cognitive engagement, persistence, and performance in science and STEM subjects (Bradley & Corwyn, 2002; Hill & Tyson, 2009).

Moreover, the integration of physical well-being with academic support is particularly relevant in STEM contexts. The observed overlap of this factor with other dimensions of parental involvement underscores the interconnected nature of practical, emotional, and cognitive support, reflecting parents' holistic investment in their science learning (Davis-Kean et al., 2021).

Factor 3: Parental Decision-Making and Encouragement

Decision-making and encouragement emerged as a combined construct, reflecting parents' role in guiding children's choices while actively motivating them toward academic and personal growth. Parental decision-making involves scaffolding and offering perspectives to support informed choices (Rodriguez, 2021), whereas encouragement emphasizes motivation and reinforces effort and achievement (Fayaz, 2023). Together, they demonstrate an integrated and supportive approach to parental involvement.

Factor 4: Parental Aspiration

This factor represents parents' goals and expectations regarding their child's educational and career achievements (Schörner & Bittmann, 2023). Items within this factor exhibit strong inter-item correlations, indicating that students internalize parental aspirations as a motivation for achieving academic success and attaining long-term goals.

Table 4: Extracted Factors of the Parental Involvement Rating Scale (PIRS)

Factor	Number of Items	McDonald's omega (ω)	Internal Consistency
Parental Guidance and Support	24	.975	Excellent
Parental Provision of Physical Facilities and Environment	15	.949	Excellent
Parental Decision-making and Encouragement	4	.718	Acceptable
Parental Aspiration	6	.841	Good

The reliability results in Table 4 indicate that all four factors of the Parental Involvement Rating Scale (PIRS) exhibit acceptable to excellent internal consistency. Factor 1, Parental Guidance and Support, and Factor 2, Parental Provision of Physical Facilities and Environment, demonstrated excellent reliability with McDonald's omega values of 0.975 and 0.949, respectively. Factor 3, Parental Decision-Making and Encouragement, showed acceptable reliability ($\omega = 0.718$), while Factor 4, Parental Aspiration, achieved good reliability ($\omega = 0.841$). These values align with established benchmarks in the literature, where $\omega \geq 0.70$ is acceptable, ≥ 0.80 is good, and ≥ 0.90 is considered excellent (Dunn et al., 2014; Hayes & Coutts, 2020). Overall, the findings confirm that the items within each factor consistently measure their respective constructs, supporting the internal consistency and quality of the PIRS.

CONCLUSION

The study aimed to design and validate the Parental Involvement Rating Scale (PIRS) to measure the extent and nature of parental engagement among STEM students in learning science. Through Exploratory Factor Analysis, four distinct factors were extracted: Parental Guidance and Support, Parental Provision of Physical Facilities and Environment, Parental Decision Making and Encouragement, and Parental Aspiration. These factors collectively explained 57.4% of the total variance. These findings confirm that the developed scale possessed strong construct validity and high internal consistency, as reflected by Cronbach's alpha and McDonald's omega values exceeding 0.80.

The validated PIRS provides a reliable tool for assessing various dimensions of parental involvement that influence students' Science learning. Its application can help educators, researchers, and policymakers identify specific parental behaviours that foster academic motivation and achievement among STEM learners. Future research may extend this work by testing the scale in other learning areas, validating it through Confirmatory Factor Analysis, and exploring cross-cultural comparisons to strengthen its generalizability.

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Conflict of Interest

The authors declare that there are no known financial, professional, or personal conflicts of interest that could have influenced the conduct or interpretation of this study.

Ethical Statement

This study was conducted in accordance with established ethical standards and was approved by the DDOSC-REC under Protocol 561-02-2025.

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