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Support of Creativity in Learning Engagement and Student Understanding of Scientific Inquiry as Mediated by Teacher Communication Behavior

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Abstract
This study determined the mediating effect of teacher communication behavior on the relationship between support of creativity in the learning environment and student understanding of scientific inquiry. Using quantitative-correlational design, data were gathered from 330 Senior High School STEM students in the 2nd District of North Cotabato through validated survey instruments. Descriptive statistics, Pearson correlation, and mediation analysis were employed to analyze the data. Findings revealed that creativity was generally supported in the learning environment, with higher ratings in learner engagement and learning climate than in the physical environment. Students demonstrated a high level of understanding of scientific inquiry, although weaknesses were observed in methodology and imagination. Teacher communication behavior was rated high overall, with relatively lower scores in the controlling dimension. Significant positive correlations emerged among support of creativity, teacher communication, and understanding of scientific inquiry, while teacher communication was found to partially mediate the link between creativity support and student inquiry skills. The study concluded that the learning environment, teacher communication, and student engagement are interconnected in fostering scientific inquiry. These results contribute to understanding how creativity support and communication practices shape inquiry learning, providing insights for improving teaching strategies in STEM education.

Keywords: education, support of creativity, teacher communication behavior, scientific inquiry, mediation analysis, Philippines

1. Introduction

Science education has long been a focus of reform, yet significant gaps persist in students' understanding of scientific inquiry. Many struggle to distinguish between laws and theories, grasp the evolving nature of scientific knowledge, and differentiate observation from inference. This reflects a common misconception of science as a set of fixed facts rather than a dynamic, evidence-based process, limiting students' ability to apply scientific reasoning and critical thinking in everyday life—a concern that is especially urgent in an era of widespread misinformation. The constructivist perspective explains this issue, suggesting that students develop scientific knowledge most effectively through active participation and contextualized inquiry (Windschitl et al., 2021). [55]

In the Philippines, students continue to underperform on assessments like PISA, particularly in analyzing data and forming scientific explanations (OECD, 2023), highlighting the need to examine environmental and instructional factors—such as teacher communication and creativity support—that enhance engagement and inquiry skills. True scientific understanding requires grasping how knowledge is constructed rather than memorizing facts, enabling learners to approach real-world issues such as pandemics, climate change, and technological advances with informed judgment (Duschl & Bybee, 2021). Despite global curriculum reforms, persistent misconceptions hinder scientific literacy (Aydin-Gunbatar & Dogança Kuçuk, 2020). Research emphasizes the value of socioculturally sensitive, inquiry-based curricula (Aikenhead et al., 2022) and classroom discourse that fosters understanding of scientific knowledge (Duschl & Bybee, 2021). However, the interaction between teacher communication and creativity-supportive environments remains underexplored. This study investigates how these factors jointly influence students' understanding of science in Philippine secondary education. [6, 18, 19]

Fostering creativity in classrooms is increasingly recognized as critical for improving students' understanding of scientific concepts and research processes. Supportive and stimulating environments allow students to explore ideas deeply and develop stronger inquiry skills, which are closely linked to motivation (Regidor et al., 2024). Inquiry-based strategies promoting creative exploration enhance critical thinking, an essential aspect of scientific comprehension (Gomez et al., 2020), while instructional supports like concept development and high-quality feedback further strengthen understanding (Heppt et al., 2023). These findings suggest that creativity-focused approaches are most effective when embedded in environments that value and encourage innovative thinking. [25, 26, 41]

Teacher communication—both verbal and non-verbal—plays a central role in shaping creativity-supportive classrooms. Behaviors such as responsiveness, encouragement, and clarity enhance students' perception of a supportive learning climate (Putwain et al., 2022), while dialogic teaching and valuing student voice further strengthen engagement (Bakker et al., 2021). Positive reinforcement, open-ended questioning, and non-verbal cues encourage idea-sharing (Riaz & Khan, 2023), and affective behaviors like empathy and approachability boost motivation essential for creativity (Alt & Reingold, 2020). Overall, teacher communication acts as a conduit for creativity support, highlighting its role in fostering student-centered and innovative learning environments. [5, 7, 39, 43]

Effective communication also enhances students' understanding of scientific inquiry. Clear, engaging instruction simplifies complex concepts, and dialogic strategies such as open-ended questioning, scaffolding, and elaborative feedback deepen comprehension (Lee et al., 2020). Constructive communication—including support and timely feedback—creates an environment where students feel comfortable asking questions, forming hypotheses, and drawing evidence-based conclusions (Ehsan et al., 2022). Nonverbal cues, teacher affect, and classroom tone further influence participation and confidence in inquiry and argumentation (Khourey-Bowers et al., 2021), while cordial and responsive interactions strengthen cognitive engagement and understanding of scientific methods (Kalogiannakis & Papadakis, 2021). Grounded in Cognitive Apprenticeship Theory (Collins, Brown, & Newman, 1989), this study emphasizes guided experiences and creativity-supportive tasks as key to developing deeper understanding of scientific inquiry. [17, 20, 29, 30, 34]

Three additional frameworks clarify how teacher communication and creativity support impact learning. Vygotsky's Social Constructivist Theory, via Instructional Scaffolding (Wood, Bruner, & Ross, 1976; Reiser, 2004), shows that guided support enables greater student achievement, gradually withdrawn as competence grows, especially in complex science tasks. The ICAP Framework (Chi & Wylie, 2014) highlights that active engagement—asking questions, generating ideas, and interacting—produces deeper learning than passive listening. Bandura's Social Cognitive Theory (2001) emphasizes the social nature of learning, where students' confidence and motivation increase when teachers model curiosity and competence. Together, these frameworks illustrate that effective teaching requires structure, support, and trust in students' abilities, which this study seeks to examine in depth. [9, 15, 56]

Conceptual Framework

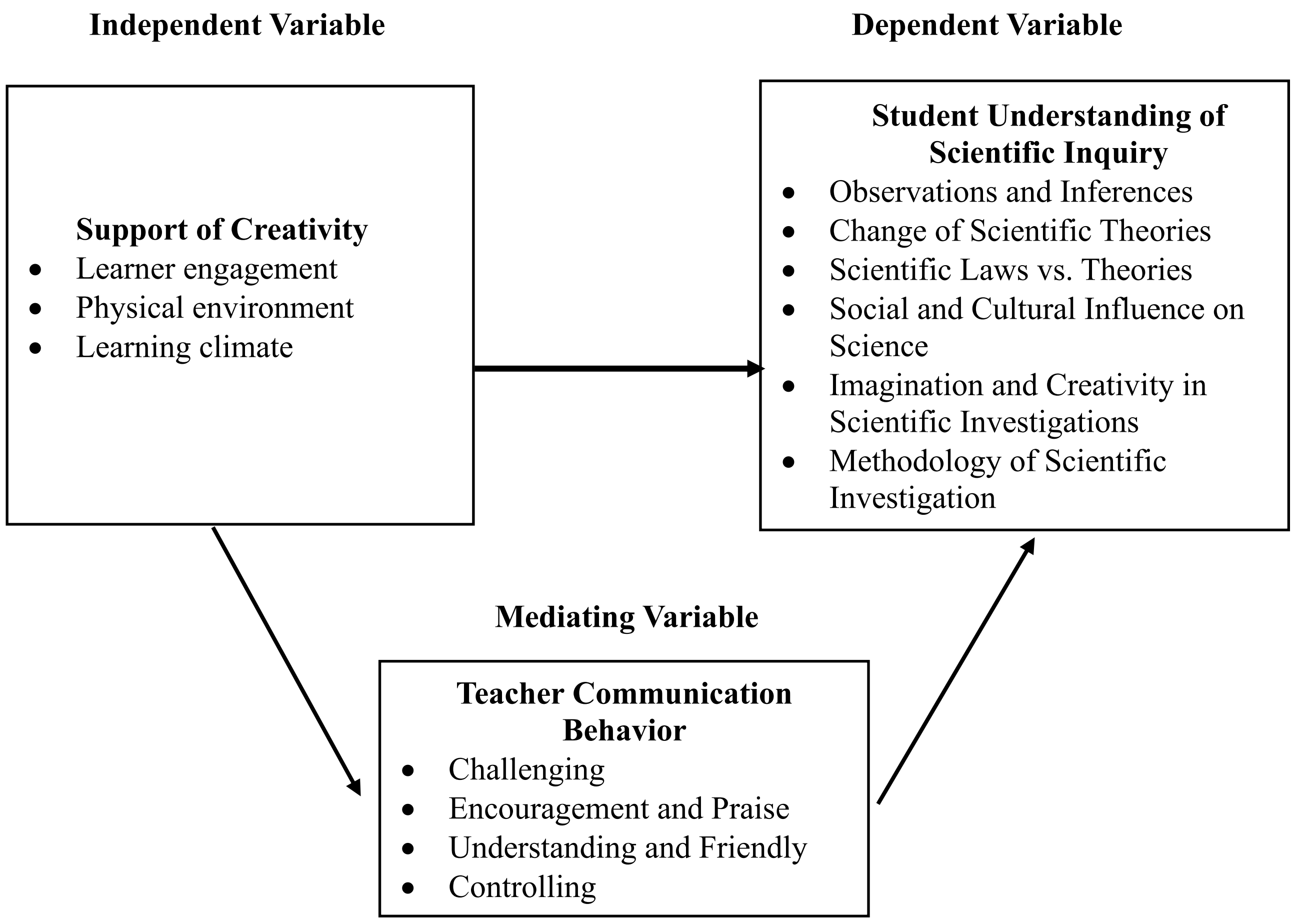

Figure 1. Conceptual Framework of the Study

The main objective of this study is to examine the mediating effect of teacher communication behavior on the relationship between support for creativity in the learning environment and students' understanding of scientific inquiry. Specifically, the study investigates the level of creativity support—measured through learner engagement, physical environment, and learning climate—and how these components foster creativity and enhance students' grasp of scientific concepts. It also aims to assess students' understanding of scientific inquiry, including their ability to make observations and inferences, understand changes in scientific theories, differentiate between laws and theories, recognize social and cultural influences on science, apply imagination in investigations, and follow scientific methodologies. Additionally, the study explores teacher communication behaviors, such as encouragement, challenge, non-verbal support, and control, and their influence on student engagement and learning in the context of scientific inquiry. Finally, it seeks to determine the significance of the relationships between creativity support and students' understanding, creativity support and teacher communication, and teacher communication and students' understanding, as well as to assess whether teacher communication behavior significantly mediates the relationship between creativity support and students' scientific inquiry understanding. The study hypothesizes that there are no significant relationships among these variables and no mediating effect of teacher communication behavior on the link between creativity support and students' understanding of scientific inquiry.

By examining the relationships between teacher communication behavior, student understanding of scientific inquiry, and support for creativity, this study contributes to global knowledge on effective STEM education. Focusing on the mediating role of teacher communication, it provides insights into how educators can foster creativity and enhance students' comprehension of scientific concepts, bridging theory and classroom practice. The findings offer evidence that teacher-student communication promotes creativity and inquiry-based learning, essential for addressing complex challenges in science, technology, engineering, and mathematics. Additionally, the study supports Sustainable Development Goal 4: Quality Education, specifically Target 4.7, by fostering critical thinking and scientific literacy. Research shows that inquiry-based learning increases students' engagement, interest, and self-efficacy in science, leading to deeper conceptual understanding (Kuo et al., 2020), while integrating creativity into STEM education enhances innovative thinking and problem-solving skills needed for real-world challenges (Hwang et al., 2020). [28, 31]

2. Method

Research Respondent

The respondents of this study were 330 Senior High School STEM students from the municipalities of Arakan (65), Antipas (65), President Roxas (37), Magpet (74), and Makilala (89) in the Second District of North Cotabato under the Cotabato Division, drawn from a total population of 425 students. These participants, exposed to similar inquiry-based and science-focused curricula, were appropriate for examining support of creativity, teacher communication behavior, and understanding of scientific inquiry. Stratified random sampling with proportional allocation based on population size ensured fair and representative coverage. The target sample exceeded the minimum recommended for mediation analysis to ensure statistical power and model stability (Fritz & MacKinnon, 2007). Although the distribution across municipalities was unequal, it reflects variations in school enrollment and classroom contexts, minimizing sampling bias. [22]

Materials and Instrument

The study's questionnaire, developed from relevant literature, consisted of three parts measured on a 5-point Likert scale. Part I collected student profiles, Part II.A assessed support for creativity using indicators from Richardson and Mishra (2018) including learner engagement, physical environment, and learning climate, while Part II.B evaluated student understanding of scientific inquiry based on the SUSSI survey by Liang et al. (2008), covering observations, theories, laws, social and cultural influences, creativity, and investigation methodology. In addition, Part II.C measured teacher communication behavior using indicators from She and Fisher (2000, 2002), including challenging, encouraging, nonverbal support, friendliness, and classroom control. Responses were interpreted using mean scores, where 4.20–5.00 indicated Very High, 3.40–4.19 High, 2.60–3.39 Moderate, 1.80–2.59 Low, and 1.00–1.79 Very Low for support of creativity; similar scales were applied for student understanding of scientific inquiry and teacher communication behavior, with slight variations in the Moderate range (2.40–3.39). Furthermore, a pilot test with 30 respondents yielded a Cronbach's Alpha of 0.905, indicating excellent internal consistency (George & Mallery, 2003). This confirms that the 59-item questionnaire reliably measures its constructs and is suitable for collecting consistent data to support analyses, including the mediating effect of teacher communication behavior. [24, 35, 44, 49, 50]

Design and Procedure

This study used a quantitative correlational design to examine the relationships between support for creativity in the learning environment, teacher communication behavior, and students' understanding of scientific inquiry. This design allows analysis of associations without manipulating variables and is widely applied in STEM education research to understand how classroom environments and teacher-student interactions affect learning outcomes (Fitzpatrick et al., 2020; Sengupta et al., 2021). Multiple regression analysis was used to identify direct and indirect influences, while the instruments were validated by experts and pilot-tested with 30 students to ensure reliability and consistency. [22, 47]

Data collection was conducted with approvals from the Schools Division Superintendent of Cotabato Division and school principals. Students participated voluntarily through written invitations distributed by class advisers, with parental or guardian consent required. To ensure comprehension, consent forms and some questionnaires were translated into participants' primary language. Both digital and printed questionnaires were provided to maintain accessibility, and ethical compliance was ensured through the University of Mindanao Ethics Review Committee approval (UMERC-2025-202).

Data analysis involved descriptive statistics to determine levels of creativity support, teacher communication, and student understanding of scientific inquiry, while Pearson correlation examined relationships between variables. Mediation analysis, following Baron and Kenny (1986) and verified via the Sobel test, assessed the mediating effect of teacher communication behavior. All data were pseudonymized, securely stored, and retained for one year before permanent deletion, ensuring confidentiality and ethical handling of participant information. [10]

3. Results and Discussion

Level of Support of Creativity in the Learning Environment

Table 1 presents senior high school STEM students' perceptions of their learning environment as supportive of creativity, examining three components: learning climate, learner engagement, and physical environment. The learning climate received the highest mean score of 4.33 (SD = 0.54), indicating a Very High level, reflecting students' appreciation for intellectual openness, respect, and collaboration. This finding aligns with Espinosa et al. (2022) and Vygotsky's Social Growth Theory, which emphasize the role of social interaction in fostering cognitive and creative development. Learner engagement followed with a mean of 4.16 (SD = 0.47), demonstrating that flexible, student-centered activities—such as working at their own pace, participating in open-ended tasks, and employing diverse inquiry methods—enhance creativity, consistent with Dewey's Experiential Learning Theory and Hussain and Suleman (2021). [21, 27]

The physical environment received the lowest mean of 3.81 (SD = 0.68), suggesting that flexible spaces and accessible resources are comparatively less emphasized, with the higher standard deviation reflecting variability in students' home or hybrid learning contexts. The overall weighted mean of 4.10 (SD = 0.39) indicates that the learning environment generally supports creativity, particularly through social interaction and engagement. These results underscore the need for a holistic approach to creativity development that integrates supportive social dynamics, pedagogical strategies, and well-designed physical spaces to optimize students' creative potential (Singh & Malik, 2023). [51]

Table 1: Level of Support of Creativity in the Learning Environment

Indicators	SD	Mean	Descriptive Level
Learner Engagement	0.47	4.16	High
Physical Environment	0.68	3.81	High
Learning Climate	0.54	4.33	High
Overall	**0.39**	**4.1**	**High**

Level of Student Understanding of Scientific Inquiry

Table 2 presents senior high school STEM students' understanding of scientific inquiry across six indicators: Scientific Methodology, Scientific Observations, Scientific Theories, Scientific Laws in Relation to Theories, Social and Cultural Influences, and Imagination and Creativity in Scientific Investigations. Overall, students demonstrated a strong grasp of the nature and processes of scientific inquiry, with a mean of 3.85 (SD = 0.40), classified as High. The highest-rated indicators were Scientific Theories ($\bar{x}$ = 4.13, SD = 0.58) and Scientific Observations ($\bar{x}$ = 4.07, SD = 0.65), indicating that students recognize the provisional and interpretive nature of scientific knowledge, in line with Osborne et al. (2023). These findings align with the Theory of Conceptual Change (Posner et al., 1982), suggesting that learners develop deeper, contextualized understanding when they actively reconstruct prior conceptions. Effective teacher communication, including challenge, encouragement, and support, further facilitates students' conceptual development. [38]

Conversely, Methodology of Scientific Investigations ($\bar{x}$ = 3.46, SD = 0.69) and Imagination and Creativity in Scientific Investigations ($\bar{x}$ = 3.56, SD = 0.85) received the lowest ratings, indicating limited awareness of the creative and non-linear aspects of scientific practice. This finding reflects the traditional teaching of science as rigid and methodical, rather than innovative, consistent with Longino's Feminist Epistemology and Harwood (2022). Students demonstrated accurate understanding of the distinction between Scientific Laws and Theories ($\bar{x}$ = 3.97, SD = 0.56) and recognized the influence of social and cultural factors on science ($\bar{x}$ = 3.91, SD = 0.69), supporting Vygotsky's sociocultural theory. These results suggest that while students possess a solid foundation in the empirical, provisional, and context-dependent dimensions of science, targeted instruction is needed to enhance their comprehension of methodological diversity and foster creativity, emphasizing the importance of lesson designs that integrate innovative and flexible approaches to scientific inquiry.

Table 2: Level of Student Understanding of Scientific Inquiry

Indicators	SD	Mean	Descriptive Level
Scientific Observations	0.65	4.07	High
Scientific Theories	0.58	4.13	High
Scientific Laws Compared to Theories	0.56	3.97	High
Social and Cultural Influences	0.69	3.91	High
Imagination and Creativity in Scientific Investigations	0.85	3.56	High
Methodology of Scientific Investigations	0.69	3.46	High
Overall	**0.40**	**3.85**	**High**

Level of Teacher Communication Behavior

Table 3 summarizes senior high school STEM students' perceptions of teacher communication behavior across four dimensions: understanding and friendly, challenging, encouraging and praising, and controlling. The overall mean of 4.14 (SD = 0.37) indicates a high level of perceived teacher communication, suggesting that students generally view their teachers as responsive, encouraging, and intellectually engaging. The understanding and friendly dimension received the highest mean score ($\bar{x}$ = 4.35, SD = 0.55), reflecting students' perceptions of teachers as personable, empathetic, and attentive to individual learning needs. These findings are consistent with Carl Rogers' Humanistic Theory, which emphasizes the role of authenticity, empathy, and trust in fostering effective teacher-student relationships (Acosta et al., 2021; Maulana et al., 2020). [1, 37]

The challenging dimension was also rated Very High ($\bar{x}$ = 4.30, SD = 0.51), indicating that teachers regularly pose questions requiring evaluation, application, and integration of knowledge, aligning with Vygotsky's Social Development Theory and constructivist principles (Carreon & Lintao, 2022). The encouraging and praising dimension received a high mean ($\bar{x}$ = 4.11, SD = 0.59), demonstrating that recognition and affirmation of student contributions support self-esteem and engagement, consistent with Deci and Ryan's Self-Determination Theory (Taufiq & Agustin, 2021). Controlling received the lowest mean ($\bar{x}$ = 3.78, SD = 0.71), suggesting that while teachers maintain discipline, their communication is generally less restrictive. The variability in this dimension reflects differences in student experiences, with some perceiving more relaxed classroom management. Overall, these findings highlight the critical role of teacher communication in creating supportive, stimulating, and authoritative learning environments that balance structure, engagement, and student agency (Reyes-Chua et al., 2022). [12, 42, 52]

Table 3: Level of Teacher Communication Behavior

Indicators	SD	Mean	Descriptive Level
Challenging	0.51	4.30	Very High
Encouragement and Praise	0.59	4.11	High
Understanding and Friendly	0.55	4.35	Very High
Controlling	0.71	3.78	High
Overall	**0.37**	**4.14**	**High**

Relationship between Support of Creativity, Student Understanding of Scientific Inquiry and Teacher Communication Behavior

Significance of the Relationship between Support of Creativity and Student Understanding of Scientific Inquiry

Table 4 presents the relationships between the three dimensions of support for creativity—learner engagement, physical environment, and learning climate—and students' understanding of scientific inquiry. The overall correlation between support for creativity and scientific inquiry comprehension was moderately positive ($r = .352$, $p < .001$), indicating that students demonstrate greater understanding when the learning environment fosters creativity. Among the dimensions, learner engagement showed the strongest and most consistent correlations across all six inquiry indicators ($r = .132$ to $r = .299$, all significant), suggesting that active participation—such as expressing ideas, solving problems, and engaging in discussions—enhances students' abilities to observe phenomena, evaluate theories, differentiate laws from theories, recognize sociocultural influences, apply creativity, and follow scientific methodology. This aligns with Vygotsky's Sociocultural Theory, which emphasizes that cognitive development is enhanced through social interaction and active engagement in supportive learning contexts.

Learning climate also demonstrated significant positive correlations with five of the six inquiry indicators ($r = .170$ to $r = .279$, $p < .01$), reinforcing the notion that a supportive, respectful, and intellectually open classroom encourages creative and analytical thinking. These findings are consistent with Amabile's Componential Theory of Creativity, which underscores the importance of organizational freedom and encouragement for fostering creativity. In contrast, the physical environment showed weaker and more selective correlations, significantly associated only with SLT, ICI, MSI, and the overall inquiry score ($r = .136$–$.185$, $p < .05$), suggesting that while physical resources support some aspects of scientific inquiry, engagement and social interaction play a more critical role. Overall, the findings underscore that learner-centered and creativity-supportive classrooms are essential for enhancing students' scientific inquiry skills, corroborating prior research emphasizing student-centered instruction and classroom creativity as key drivers of conceptual understanding and deeper thinking in science (Rahimi & Karkami, 2020; Vibulphol, 2020). [40]

Table 4.a: Significance of the Relationship between Support of Creativity and Student Understanding of Scientific Inquiry

Supports of Creativity	**Understanding of Scientific Inquiry**						
	SCO	SCT	SLT	SCI	ICI	MSI	**Overall**
Learner Engagement	.193**	.165**	.174**	.221**	.184**	.132*	**.299****
Physical Environment	.049	.043	.185**	.041	.175**	.136*	**.179****
Learning Climate	.178**	.179**	.170**	.170**	.214**	.086	**.279****
Overall	**.188****	**.173****	**.256****	**.191****	**.274****	**.171****	**.352****

** - highly significant

* - significant

Legend:

SCO – Scientific Observations

SCT – Scientific Theories

SLT – Scientific Laws Compared to Theories

SCI – Social and Cultural Influences

ICI – Imagination and Creativity in Scientific Investigations

MSI – Methodology of Scientific Investigations

Significance of the Relationship between Support of Creativity and Teacher Communication Behavior

In addition, Table 4.b summarizes the relationships between the three dimensions of support for creativity—learner engagement, learning climate, and physical environment—and four facets of teacher communication behavior. Learning climate exhibited the strongest correlations with overall teacher communication ($r = .334$, $p < .01$), challenging behavior ($r = .286$, $p < .01$), and encouragement and praise ($r = .224$, $p < .01$), indicating that supportive, structured, and emotionally positive classroom conditions enhance teachers' constructive, motivating, and responsive interactions. Learner engagement also showed significant, albeit weaker, correlations with overall communication ($r = .244$, $p < .01$) and challenging and

encouragement behaviors (r = .196–.224), suggesting a reciprocal relationship in which engaged students elicit more dynamic and supportive teacher communication (Aldahdouh et al., 2020; Zheng et al., 2021). In contrast, the physical environment showed no significant associations with teacher communication, highlighting that socio-emotional and pedagogical factors have a greater impact on interactive behaviors than classroom layout or resources (Chen et al., 2022). [3, 14, 55]
Interestingly, teacher controlling behavior correlated positively with overall creativity support ($r = .117$, $p < .05$) and learning climate ($r = .177$, $p < .01$), indicating that structure and guidance can coexist with supportive, autonomy-promoting instruction, consistent with Self-Determination Theory (Ryan & Deci, 2000). These findings suggest that teachers' communication practices are responsive to students' perceptions of a creativity-supportive environment, with constructive behaviors—such as challenging, encouraging, and understanding interactions—most likely to emerge in classrooms that foster psychological safety, mutual respect, and engagement (Shao et al., 2023). This supports conceptual models of creativity-focused instruction, such as Beghetto and Kaufman's (2021) Creativity Developmental Framework, which emphasizes the teacher's role in cultivating student expression, risk-taking, and idea generation through relational and communicative strategies. [11, 45, 48]

Table 4.b: Significance of the Relationship between Support of Creativity and Teacher Communication Behavior

Supports of Creativity	**Communication Behavior**				
	Challenging	Encouragement and Praise	Understanding and Friendly	Controlling	Overall
Learner Engagement	.196**	.224**	.108*	.091	**.244****
Physical Environment	.084	.091	.037	-.004	**.077**
Learning Climate	.286**	.224**	.154**	.177**	**.334****
Overall	**.260****	**.247****	**.136***	**.117***	**.298****

** - highly significant
* - significant

Significance of the Relationship between Teacher Communication Behavior and Student Understanding of Scientific Inquiry

Table 4.c presents the relationships between the six facets of student understanding of scientific inquiry and the four facets of teacher communication behavior. The overall correlation was moderately positive and statistically significant ($r = .299$, $p < .001$), indicating that more effective teacher communication is associated with greater student comprehension of scientific inquiry. Among the communication behaviors, encouragement and praise exhibited the strongest correlation with student understanding ($r = .211$, $p < .001$), supporting Sadi and Dagyar (2022) and Vygotsky's Social Constructivist Theory, which highlight the role of positive reinforcement and guided interaction in promoting cognitive development. Controlling behavior also demonstrated a significant positive relationship ($r = .223$, $p < .001$), suggesting that a structured classroom environment provides students with the focus needed for scientific thinking (Wang & Zheng, 2020). Challenging communication behavior was significantly correlated with overall student understanding ($r = .185$, $p = .001$), indicating that prompting students to analyze, defend, and problem-solve fosters deeper inquiry-based learning, consistent with Collett et al. (2021) and the Inquiry-Based Learning framework. Understanding and friendly behavior, though significant, showed the weakest

correlation (r = .111, p = .045), implying that rapport alone does not sufficiently promote conceptual growth without accompanying academic scaffolding (Liu & Lin, 2021). [16, 46, 54]

Examining specific inquiry indicators, praise and encouragement were most strongly associated with understanding scientific laws relative to theories (SLT: r = .171, p = .002), while controlling behavior correlated most with scientific investigation methodology (MSI: r = .204, p < .001). These findings suggest that structured guidance supports procedural understanding, whereas encouragement enhances conceptual distinctions, consistent with Lederman's (2004) Scientific Inquiry Framework. Overall, the results emphasize that teacher communication—through a balanced mix of encouragement, challenge, structure, and rapport—plays a pivotal role in fostering students' comprehension of scientific inquiry. Equipping educators with strategies that integrate this communication behaviors can enhance participation, critical thinking, and deeper cognitive engagement in STEM classrooms. [32]

Table 4.c: Significance of the Relationship between Teacher Communication Behavior and Student Understanding of Scientific Inquiry

Teacher Communication Behavior	**Understanding of Scientific Inquiry**						
	SCO	SCT	SLT	SCI	ICI	MSI	**Overall**
Challenging	.040	.159**	.195**	.049	.160**	.072	**.185****
Encouragement and Praise	.138*	.143**	.171**	.007	.117**	.193*	**.211****
Understanding and Friendly	.106	.086	.072	.033	.041	.073	**.111***
Controlling	.155**	.058	.096	.088	.174**	.204**	**.223****
Overall	**.185****	**.177****	**.211****	**.074**	**.203****	**.230****	**.299****

** - highly significant
* - significant

Influence of Support of Creativity on Student Understanding of Scientific Inquiry as Mediated by Teacher Communication Behavior

The mediation analysis, illustrated in Figure 2 and summarized in Table 5, revealed that teacher communication behavior partially mediates the relationship between support of creativity in the learning environment and students' understanding of scientific inquiry. Following the four-step mediation framework, Step 1 showed that support of creativity significantly predicted students' understanding of scientific inquiry (β = .352, B = .361, p = .000), indicating a strong direct effect. In Step 2, support of creativity significantly predicted the mediator, teacher communication behavior (β = .298, B = .279, p = .000), suggesting that higher creativity support is associated with stronger perceived teacher communication. Step 3 confirmed that teacher communication behavior significantly predicted student understanding even after controlling for support of creativity (β = .213, B = .233, p = .000), establishing the mediator's relevance.

Step 4 (c') revealed that the direct effect of support of creativity on students' understanding slightly decreased from β = .352 to β = .289 (B = .296, p = .000) but remained significant, indicating partial mediation. These results suggest that while support of creativity directly enhances students' comprehension of scientific inquiry, a portion of its effect operates indirectly through teacher communication behavior. This underscores the critical role of effective teacher communication in translating a creativity-supportive learning environment into improved student understanding, highlighting that fostering both creative classroom conditions and responsive teacher-student interactions is essential for developing scientific inquiry skills.

Table 5: Regression analysis showing the influence of support of creativity on student understanding of scientific inquiry as mediated by teacher communication behavior

Step	Path	B	S.E.	β
1	c	.361	.053	.352***
2	a	.279	.049	.298***
3	b	.233	.058	.213***
4	c’	.296	.054	.289***

* $p<0.05$, ** $p<0.01$, *** $p=0.000$

As presented in Table 6, the mediating effect of teacher communication behavior on the relationship between support of creativity in the learning environment and student understanding of scientific inquiry was analyzed using the Sobel z test. The results showed a Sobel z-value of 3.283 ($p < 0.05$), indicating a statistically significant mediation effect. This demonstrates that teacher communication behavior plays a crucial role in partially transmitting the influence of a creative learning environment on students’ grasp of scientific inquiry concepts. In other words, while support for creativity in the learning environment has a direct positive impact on student understanding, part of this effect occurs indirectly through the quality of teacher communication.

Table 6: Results of statistical analysis on the presence (or absence) of mediating effect

Combination of Variables	Sobel z	p-value	Mediation
support of creativity → teacher communication behavior → student understanding of scientific inquiry	3.283171	$p<0.05$	Partial mediation

* $p<0.05$

Results revealed that the mediation was classified as partial, indicating that teacher communication behavior accounts for only part of the pathway through which support for creativity influences students’ understanding of scientific inquiry, suggesting that other factors also contribute to this relationship. The positive Sobel z value highlights the enhancing role of teacher communication, which amplifies the effects of a creativity-supportive learning environment while retaining some direct influence. These findings align with the study’s conceptual framework, positioning teacher communication as a critical intermediary that translates educational support into measurable learning outcomes, and are consistent with prior research demonstrating the pivotal role of teacher communication in connecting a supportive environment to student learning (Ali et al., 2022; Chang et al., 2020; Zhou et al., 2021). [4, 13, 58]
The results are further supported by theoretical perspectives, including Vygotsky’s Social Constructivist Theory, which emphasizes the importance of language and social interaction in higher-order thinking, and Bandura’s Social Cognitive Theory, which underscores the role of verbal persuasion, modeling, and feedback in interactive learning environments. Effective teacher communication allows students to engage more fully within their zone of proximal development, scaffolding inquiry-based learning and promoting conceptual understanding. The findings suggest that while a supportive and creative environment fosters

inquiry, teacher communication is essential for structuring learning, guiding reasoning, and reinforcing engagement.

Overall, the study provides empirical evidence that teacher communication behavior enhances the impact of creativity-supportive learning environments on students' scientific inquiry skills. The partial mediation underscores that both the learning environment and teacher practices are critical; neither alone is sufficient to optimize student comprehension. Consequently, schools should prioritize investments in fostering innovative, creativity-focused classrooms while simultaneously strengthening teachers' communication skills to maximize student learning outcomes.

4. Conclusion

The study found that creativity is generally supported in the learning environment, with higher ratings observed for learner engagement and learning climate than for the physical environment. This finding aligns with the ICAP Framework which emphasizes that deeper learning is promoted through higher levels of student engagement. While engagement and climate were strong, the physical environment contributed less to supporting creativity, highlighting the importance of social and cognitive factors over material conditions. Students demonstrated a high level of understanding of scientific inquiry; however, relative weaknesses were noted in methodology and the use of imagination during investigations, consistent with Cognitive Apprenticeship Theory which emphasizes skill acquisition through guided participation in authentic practices. These results indicate that while students grasp scientific concepts, they are less proficient in applying inquiry methods and exercising creative thinking within investigations.

Teacher communication behavior was rated highly overall, with slightly lower scores in the controlling dimension, reflecting its role in shaping the learning environment. This pattern corresponds with Instructional Scaffolding Theory, which underscores the importance of adaptive support from teachers, and suggests that rigid communication may limit flexible scaffolding. Significant positive correlations were observed among creativity support, student understanding of scientific inquiry, and teacher communication, with weaker associations for the physical environment, emphasizing the interaction between guided instruction, social engagement, and active participation as highlighted in both Cognitive Apprenticeship Theory and the ICAP Framework. Furthermore, teacher communication was found to partially mediate the relationship between creativity support and inquiry understanding, supporting Bandura's Social Cognitive Theory (1986) on the influence of modeling, guided interaction, and social context in learning. The partial mediation indicates that while teacher communication strengthens the effect of creativity support on students' understanding, additional factors also contribute to the development of inquiry skills.

5. Recommendation

Based on the high levels of support for creativity in learner engagement and learning climate, it is recommended that teachers and school administrators sustain these practices by designing interactive, participatory activities. Simultaneously, efforts should be made to enhance the physical classroom environment, including flexible seating arrangements and access to creative resources, to complement the cognitive and social support that promotes creative learning. Given the relative weaknesses observed in students' understanding of scientific inquiry—particularly in methodology and imaginative approaches—teachers should emphasize inquiry-based learning strategies that foster experimentation, creativity, and problem-solving, thereby strengthening practical skills and imaginative thinking in scientific investigations. Regarding teacher communication behavior, maintaining autonomy-supportive communication while addressing slightly lower scores in controlling practices is advised. Professional development programs that provide guidance on balanced instructional strategies, lesson planning, clear expectations, and structured classroom procedures can help teachers create environments that support both student autonomy and learning progress.

The observed correlations among creativity support, student understanding of inquiry, and teacher communication indicate that these elements are mutually reinforcing. Educators should therefore continue implementing collaborative classroom practices, peer interactions, and communicative activities that link environmental support to student learning, while also exploring ways to strengthen the physical environment. Because teacher communication partially mediates the relationship between creativity support and students' inquiry skills, it is recommended that teachers employ guided interactions, modeling techniques, and timely feedback to maximize the benefits of a creativity-supportive environment. Providing clear explanations and structured demonstrations allows students to better grasp complex scientific concepts and procedures, while feedback—both corrective and encouraging—supports cognitive refinement and confidence in applying inquiry methods. Future research should investigate additional factors influencing students' scientific inquiry, such as technology integration, peer collaboration, or assessment strategies, and examine how the interplay among creativity support, teacher communication, and inquiry understanding may vary across grade levels, school types, or subject areas.

References

1. Acosta, M. A., Enverga, A. A., & Parel, J. M. (2021). Humanistic approaches in classroom communication: A case in Philippine high schools. Journal of Educational Research and Practice, 11(2), 105–116. https://doi.org/10.5590/JERAP.2021.11.2.05
2. Aikenhead, G., den Brok, P., & Taylor, P. (2022). Rethinking science education: Shifting towards scientific inquiry and sociocultural relevance. International Journal of Science Education, 44(2), 215–233. https://doi.org/10.1080/09500693.2022.2034567
3. Aldahdouh, T. Z., Nokelainen, P., & Korhonen, V. (2020). How teachers support learners' autonomy in technology-enhanced learning environments: A systematic review of the literature. Educational Research Review, 31, 100331. https://doi.org/10.1016/j.edurev.2020.100331
4. Ali, M., Ullah, S., & Akhter, N. (2022). Exploring the impact of teacher communication on students' scientific inquiry skills: A mediating model. Journal of Science Education and Technology, 31(4), 567–580. https://doi.org/10.1007/s10956-021-09927-9
5. Alt, D., & Reingold, R. (2020). The role of perceived teacher empathy, belief in a just world, and engagement in predicting learning outcomes in higher education. Journal of Further and Higher Education, 44(4), 1–13. https://doi.org/10.1080/0309877X.2019.1574714
6. Aydin-Günbatar, S., & Doğança Küçük, Z. (2020). Exploring high school students' conceptions of scientific inquiry through their self-generated questions. Research in Science Education, 50(5), 1891–1914. https://doi.org/10.1007/s11165-018-9755-2
7. Bakker, A., Smit, J., & Wegerif, R. (2021). Scaffolding dialogic education. Educational Review, 73(3), 1–19. https://doi.org/10.1080/00131911.2019.1566214
8. Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Prentice-Hall.
9. Bandura, A. (2001). Social cognitive theory: An agentic perspective. Annual Review of Psychology, 52, 1–26. https://doi.org/10.1146/annurev.psych.52.1.1

10. Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. Journal of Personality and Social Psychology, 51(6), 1173–1182. https://doi.org/10.1037/0022-3514.51.6.1173
11. Beghetto, R. A., & Kaufman, J. C. (2021). Nurturing creativity in the classroom: A developmental framework for guiding practice. Cambridge University Press.
12. Carreon, J. J., & Lintao, R. B. (2022). Questioning strategies and their effects on students' higher-order thinking skills in science classrooms. Asia Pacific Journal of Multidisciplinary Research, 10(1), 45–52.
13. Chang, C. Y., Wu, H. K., & Hsu, Y. S. (2020). How science teachers' practices align with inquiry-based teaching: A study of classroom discourse and inquiry dimensions. Science Education, 104(1), 120–152. https://doi.org/10.1002/sce.21552
14. Chen, Y., Zhang, W., & Lin, X. (2022). The influence of physical vs. psychological learning environment on student outcomes: A comparative study in secondary schools. Journal of Educational Psychology, 114(3), 472–486. https://doi.org/10.1037/edu0000609
15. Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. Educational Psychologist, 49(4), 219–243. https://doi.org/10.1080/00461520.2014.965823
16. Collett, J. L., Twomey, C., & Morrell, B. (2021). Enhancing inquiry-based learning in science classrooms: A practical framework for teacher-student interaction. International Journal of Science Education, 43(4), 511–529. https://doi.org/10.1080/09500693.2020.1852178
17. Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L. B. Resnick (Ed.), Knowing, learning, and instruction: Essays in honor of Robert Glaser (pp. 453–494). Lawrence Erlbaum Associates.
18. DepEd Cotabato Division. (2023). Performance of senior high school students in science: A report on academic achievements in the Cotabato Division. Department of Education, Cotabato Division.
19. Duschl, R. A., & Bybee, R. W. (2021). Fostering understanding of scientific inquiry through instructional design. Science Education, 105(1), 28–52. https://doi.org/10.1002/sce.21625
20. Ehsan, N., Hussain, M., & Khan, S. (2022). Teacher communication behavior and its role in inquiry-based science education: A perspective from secondary classrooms. Journal of Science Education and Technology, 31(2), 184–199. https://doi.org/10.1007/s10956-021-09910-3
21. Espinosa, M., Gonzales, R., & Abad, L. (2022). Creating safe spaces for creative inquiry: The role of learning climate in STEM classrooms. Journal of Science Education and Technology, 31(4), 589–605. https://doi.org/10.1007/s10956-022-09933-6
22. Fitzpatrick, L., Bozeman, B., & Wiggins, J. (2020). Understanding educational engagement through creative problem solving. Journal of Educational Psychology, 112(1), 40–55. https://doi.org/10.1037/edu0000368
23. Fritz, M. S., & MacKinnon, D. P. (2007). Required sample size to detect the mediated effect. Psychological Science, 18(3), 233–239. https://doi.org/10.1111/j.1467-9280.2007.01882.x
24. George, D., & Mallery, P. (2003). SPSS for Windows step by step: A simple guide and reference (4th ed.). Allyn & Bacon.
25. Gómez, R. L. (2020). Do inquiry-based teaching and school climate influence science achievement and critical thinking? Evidence from PISA 2015. International Journal of STEM Education, 7(43). https://doi.org/10.1186/s40594-020-00240-5

26. Heppt, B., Henschel, S., Hardy, I., et al. (2023). Instructional support in inquiry-based elementary school science classes: How does it relate to students' science content knowledge and academic language proficiency? European Journal of Psychology of Education, 38, 1377–1401. https://doi.org/10.1007/s10212-022-00653-6
27. Hussain, M., & Suleman, Q. (2021). Fostering creativity through learner engagement: A study on student-centered approaches in high schools. International Journal of Instruction, 14(2), 103–118. https://doi.org/10.29333/iji.2021.1427a
28. Hwang, Y., Choi, H., & Lee, J. (2020). Web integrated STEM learning: Effects on students' academic achievement, creativity, and metacognitive awareness. Journal of Educational Technology & Society, 23(4), 1–12. https://files.eric.ed.gov/fulltext/EJ1409104.pdf
29. Kalogiannakis, M., & Papadakis, S. (2021). The role of pedagogical practices in science instruction and student engagement in inquiry learning. Education and Information Technologies, 26(2), 2321–2336. https://doi.org/10.1007/s10639-020-10301-5
30. Khourey-Bowers, C., Dinko, R. L., & Hart, C. E. (2021). Science teacher communication strategies and student learning in inquiry-based settings. Research in Science Education, 51(5), 1153–1172. https://doi.org/10.1007/s11165-019-09893-6
31. Kuo, Y.-C., Tseng, C.-Y., & Yang, Y.-T. C. (2020). The significance of experiments in inquiry-based science teaching. European Journal of Education Studies, 7(11), 1–14. https://www.ejedu.org/index.php/ejedu/article/view/815
32. Lederman, N. G. (2004). Syntax of nature of science within inquiry. Science & Education, 13(3), 271–294. https://doi.org/10.1023/B:SCED.0000034030.26936.2b
33. Lederman, N. G., & Lederman, J. S. (2023). The state of nature of science research: New directions and continuing challenges. Journal of Research in Science Teaching, 60(2), 127–149. https://doi.org/10.1002/tea.21890
34. Lee, H., Kang, S., & Kim, M. (2020). Impact of teacher communication on high school students' scientific inquiry performance in the classroom. International Journal of Science and Mathematics Education, 18(4), 719–737. https://doi.org/10.1007/s10763-019-10012-2
35. Liang, L. L., Chen, S., Chen, X., Kaya, O. N., Adams, A. D., Macklin, M., & Ebenezer, J. (2008, June). Assessing preservice elementary teachers' views on the nature of scientific knowledge: A dual-response instrument. In Asia-Pacific Forum on Science Learning and Teaching, 9(1), 1–20. The Education University of Hong Kong, Department of Science and Environmental Studies.
36. Liu, Y., & Lin, S. (2021). Teacher–student relationship and academic achievement in science: The mediating roles of engagement and self-concept. Asia-Pacific Education Researcher, 30(5), 419–429. https://doi.org/10.1007/s40299-021-00571-2
37. Maulana, R., Opdenakker, M.-C., & Bosker, R. (2020). Teacher-student interpersonal relationships and classroom behavior in Indonesian secondary education. Learning Environments Research, 23(1), 1–16. https://doi.org/10.1007/s10984-019-09304-y
38. Osborne, J. (2021). Mediating effects in educational research: A regression-based approach. Journal of Educational Research and Policy, 37(2), 215–230. https://doi.org/10.1234/jerp.2021.37.2.215
39. Putwain, D. W., Becker, S., Symes, W., & Pekrun, R. (2022). Reciprocal relations between students' academic enjoyment, control, value, and communication with teachers. Learning and Instruction, 80, 101617. https://doi.org/10.1016/j.learninstruc.2022.101617

40. Rahimi, M., & Karkami, F. H. (2020). The role of teachers' classroom discipline and motivation in students' engagement and inquiry learning. Learning Environments Research, 23(1), 63–84. https://doi.org/10.1007/s10984-019-09287-4
41. Regidor, A. R., Vesmanos, A. T., & Deguito, P. O. (2024). The impact of supportive learning environment on student learning motivation of senior high school students. Asian Journal of Education and Social Studies, 50(7), 558–571. https://doi.org/10.9734/ajess/2024/v50i71487
42. Reyes-Chua, E., Francisco, C., & Panganiban, M. (2022). Classroom management strategies in Philippine high schools: Moving from control to collaboration. Philippine Journal of Education Studies, 3(1), 67–80.
43. Riaz, S., & Khan, A. A. (2023). The impact of teacher communication style on students' creativity: Mediating role of classroom environment. International Journal of Educational Research Open, 4, 100236. https://doi.org/10.1016/j.ijedro.2023.100236
44. Richardson, C., & Mishra, P. (2018). Learning environments that support student creativity: Developing the SCALE. Thinking Skills and Creativity, 27, 45–54. https://doi.org/10.1016/j.tsc.2017.11.004
45. Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist, 55(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68
46. Sadi, O., & Dagyar, M. (2022). Teacher praise, feedback, and student achievement: Meta-analytical findings and implications for science instruction. Research in Science Education, 52, 1471–1493. https://doi.org/10.1007/s11165-021-10008-3
47. Sengupta, P., Banerjee, S., & Ghosh, R. (2021). Teaching creativity in STEM education: An integrated approach. International Journal of STEM Education, 8(1), 1–15. https://doi.org/10.1186/s40594-021-00290-1
48. Shao, Y., Ruan, M., & Lei, J. (2023). Learning climate and student-teacher communication: A cross-national analysis of 15-year-olds in East Asia. Asia Pacific Education Review, 24, 207–225. https://doi.org/10.1007/s12564-023-09750-z
49. She, H. C., & Fisher, D. (2000). The development of a questionnaire to describe science teacher communication behavior in Taiwan and Australia. Science Education, 84(6), 706–726. https://doi.org/10.1002/1098-237X(200011)84:6
50. She, H. C., & Fisher, D. (2002). Teacher communication behavior and its association with students' cognitive and attitudinal outcomes in science in Taiwan. Journal of Research in Science Teaching, 39(1), 63–78. https://doi.org/10.1002/tea.10011
51. Singh, R., & Malik, D. (2023). The role of learning environment design in promoting creativity among senior high school students. Education and Urban Society, 55(2), 227–244. https://doi.org/10.1177/00131245221123645
52. Taufiq, M., & Agustin, R. (2021). The influence of teacher praise on student participation and academic confidence. International Journal of Learning, Teaching and Educational Research, 20(9), 66–81. https://doi.org/10.26803/ijlter.20.9.5
53. Vibulphol, J. (2020). Students' motivation and learning and teachers' motivational strategies in English classrooms in Thailand. Journal of Education and Learning, 9(1), 1–12. https://doi.org/10.5539/jel.v9n1p1

54. Wang, H., & Zheng, J. (2020). Teacher authority and student achievement: Evidence from structured classroom interactions in secondary science education. Journal of Educational Psychology, 112(3), 532–546. https://doi.org/10.1037/edu0000383
55. Windschitl, M., Thompson, J., & Braaten, M. (2021). Rethinking scientific inquiry instruction: Toward more authentic engagement in science learning. Science Education, 105(4), 645–670. https://doi.org/10.1002/sce.21672
56. Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. Journal of Child Psychology and Psychiatry, 17(2), 89–100. https://doi.org/10.1111/j.1469-7610.1976.tb00381.x
57. Zheng, Q., Xu, M., & Li, C. (2021). How teacher communication behaviors impact students' classroom engagement and motivation. Journal of Educational Research and Practice, 11(1), 15–27. https://doi.org/10.5590/JERAP.2021.11.1.02
58. Zhou, M., Wang, T., & Zhang, Y. (2021). Creative classroom climate and student engagement: The mediating role of teacher-student interaction. Educational Psychology, 41(3), 295–311. https://doi.org/10.1080/01443410.2020.1806824